PROCEEDINGS
OF
THE FIFTH JAPAN-U.S. WORKSHOP
ON GLOBAL CHANGE

Uses of Improved Global Change Information

March 10-12, 1997
Honolulu, Hawaii
United States

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JOINT COMMUNIQUE

5th U.S.-Japan Workshop on Global Change
Joint Communiqué

I. Preamble

This workshop, held under the framework of the U.S -Japan Science and Technology Agreement, was the fifth in a series of U.S -Japan Workshops on Global Change Research that have contributed to the promotion of joint research on global change and the establishment of cooperative relationships among the scientists of both Japan and the United States through information exchange and discussion.

The fifth U.S.-Japan Workshop was held at the East-West Center on the campus of the University of Hawaii- Manoa in Honolulu, Hawaii, on 10-12 March 1997. The workshop focused on the topic of ***Uses of Improved Global Change Information.***

Fifty individuals participated in the workshop, including researchers, scientists, and science managers from government agencies and ministries, national institutions and universities of both Japan and the United States. The workshop was sponsored by the U.S. Global Change Research Program and the Science and Technology Agency of Japan. Preparation and coordination of the meeting was carried out in cooperation with the U.S. National Science Foundation (NSF), the University Corporation for Atmospheric Research (UCAR), the East-West Center of Honolulu, HI, the National Institute for Resources and Environment (NIRE) of Japan, and the Japan International Science and Technology Exchange Center (JISTEC).

II. The Current State of Research Related to Prediction of Global Change; Social System Response to Global Change; Understanding Effects of Global Change for Managed and Unmanaged Systems; and Technology for Adaptation and Mitigation to Global Change.

(1) Global Change Prediction

Comprehensive models of the Earth's climate system are being developed and used to predict the extent and potential consequences of climate change. At present, the models are able to simulate the Earth's climate, but uncertainties exist for some of the important variables. Due to limitations of available computing power, the models are formulated with moderately coarse resolution. Important features of the climate system, such as regions of enhanced precipitation related to mountain ranges, are not well simulated. There is a compelling need for improved models with increased resolution. Some high resolution models are being developed, and they show marked improvement in some of their characteristics. Coupling of advanced component models is not presently feasible due to the computation limitations mentioned above.

Ocean field programs have produced important data sets that are fundamental for the understanding of global change. Coordination of the measurements being planned will result in increased value of data to the scientists interested in different aspects of global change research. Ocean biogeochemical research scientists are now using the data obtained in large-scale field experiments (e.g. JGOFS, WOCE) in ocean circulation models, and are making predictions of the future carbon state of the ocean. The recent success of Japan's flight of OCS has benefited researchers through the provision of important datasets which would not otherwise be available. These newly available datasets will be used to calibrate the models and test the reliability of the model runs in simulating conditions defined by field and satellite observations. New cost effective

instruments for remote data acquisition at time series sites will make important contributions to future modeling advances.

(2) Social System Response to Global Change

Critical variables for human dimensions research have been clearly articulated by the IHDP (International Human Dimensions Program). Important variables for a better understanding of human dimensions of global change include population dynamics (including morbidity and mortality), patterns of production and consumption, allocation of resources (including equity considerations), attitudes, and behavior. To date, however, the knowledge of social system response to global change lacks essential understandings that will enable predictive capability'.

Integrated assessments of global change, such as climate change, require unprecedented, comprehensive consideration of issues, involving a broad array of social impacts and responses, including human health and other effects, many of which are difficult to quantify. There is a need to strengthen the link between science and policy development in global climate change mitigation. Important advancements have been and continue to be made on many fronts. Despite the fact that new integrated assessments approaches are still needed, current integrated assessment modeling capabilities represent one of the most important contributions towards improved understanding of global climate and environmental change.

(3) Effects of Global Change on Managed and Unmanaged Systems

The role of effects research in understanding, responding, and adapting to global change is critical. Advances related to effects on managed and unmanaged systems are occurring on both regional and global scales. Integrated assessment approaches are beginning to incorporate these important variables by modeling feedbacks from and evaluating impacts on marine and terrestrial ecosystems and resources, including agricultural systems, fisheries, water resources and other important resource sectors.

Current research efforts focus on responses to climate variabilitv from seasonal to decadal time scales; responses on a variety of spatial scales; experimental studies using closed chambers, open topped chambers and mesocosms and other experiments designed to examine the combined effects of environmental stressors; assemblage of high quality, high resolution, global datasets of relevant environmental variables; and examination of agricultural productivity from the point of view of sustainability.

(4) Research and Technology for Adaptation and Mitigation to Global Change.

Research and technology for adaptation and mitigation of global change is an essential component of any investment to counter adverse effects of global environmental changes. Although there has been a significant amount of effort expended in the area of research and technology for adaptation and mitigation to global change, many important problems remain to be addressed. There is no clear consensus on the most promising approaches. The complexity of the issues demand interdisciplinary and international collaboration to expedite progress.

III. Summaries from Working Groups

(1) Global Change Prediction

The working group on global change prediction discussed the state of modeling at their respective institutions and recognized that continued improvements were necessary. Present models can simulate a recognizable climate but with systematic errors, missing key components and features of the climate system. Credible and useful prediction of global change will require models with higher resolution and with more physical processes realistically included. A more thorough comparison of results among modeling groups will be useful in speeding progress. The working group formed two subgroups, one dealing with climate change prediction and the other dealing with prediction of changes in global biogeochemical cycles.

The subgroup on climate change prediction developed and recommended two proposals for cooperation between scientists from the U.S. and Japan:

· A workshop on the development and use of coupled models with participation of all major coupled modeling research groups in Japan and the U.S.
· A U.S.-Japan workshop to facilitate extensive ocean modeling collaboration and progress in high-resolution studies for climate prediction. This could be held in concert with the coupled model workshop.

The subgroup on prediction of change in global biogeochemical cycles identified three critical areas in biogeochemistry that are ripe for cooperative research:

· Establishment of a joint time series station in the high latitude Northwest Pacific for detection of global change.
· Creating the novel advanced instrumentation necessary for large scale, cost effective acquisition of ocean biogeochemical data.
· Research on the effect of ocean warming on the stability of sub-sea gas hydrates.

(2) Social System Response to Global Change

More complete information needs to be developed about the direct and indirect effects of climate and environmental change on human populations, with emphasis on urban populations. Direct effects of climate change include: combined exposures to higher temperatures and air pollutant concentrations; and, greater exposure to shorter wavelength UV radiation as a result of stratospheric ozone depletion. Higher temperatures and air pollutant concentrations have been linked with heat stress, cardiovascular and respiratory morbidity and mortality. Greater exposure to shorter wavelength UV radiation has been linked with increased incidence of non-melanoma and melanoma skin cancers and eye disorders such as cataracts. In addition, it is unclear how increased exposure to shorter wavelength UV radiation affects both the cutaneous and systemic immune systems, and how dysfunction of these two systems affects susceptability to infectious and non-infectious diseases and the development of chronic diseases.

Human systems are currently adapting to both anticipated and actual global climate change. These Japan-US workshops are an example of social arrangements emerging in response to anticipated change. A potentially important area for research is in the evaluation of institutional arrangements by which each country goes about responding to anticipated problems. It may be beneficial to research the institutional basis for considering the human-environmental connections/response in each country to see how these institutional arrangements could be better linked to meet the needs of both countries in the global climate change arena. Another important area for research is to determine how people respond to information on causes of climate change and its impacts on the environment and human health. To address the above concerns, one of the most promising methods is integrated assessment.

Specific recommendations on issues of common research interest were identified by the working group:

- Studies of direct and indirect impacts on human health as a result of climate and environmental change
- Comparative institutional analysis of environmental assessment in the United States and Japan to enhance global change assessment, monitoring, communication, and mitigation
- Comparison of public perceptions, attitudes, and behaviors concerning global change issues
- The effects of public, interest group, and other societal involvement in global change decision making in the United States, Japan, and other countries: and
- Exploration of nontraditional ways to incorporate social dimensions into integrated assessments.

(3) Effects of Global Change for Managed and Unmanaged Systems

Much of the discussion of this working group focused on vegetative effects and feedbacks related to global changes, including the effects of carbon dioxide on plant growth, net primary productivity of vegetation and net carbon emissions in Asian regions, the effects of ozone and enhanced UV radiation on rice plants, crop response to changes in the mean level and variability of precipitation and temperature, and the effects of climate change on forest succession and migration. Understanding the effect of global change on the hydrological cycle requires closing the water balance of ocean and atmospheric modeling by improved routing of water in rivers. Most of the studies reviewed by this group utilized gridded environmental data on climate and land surface properties, and improving the accuracy of these studies requires improvement of the quality and spatial resolution of these basic data sets. A number of proposals were identified for future collaboration between Japanese and US researchers.

- A joint U.S.-Japan network of phytotron experiments to study individual and combined effects of ozone and UV flux on terrestrial plants and ecosystems.
- Implementing modeling studies to examine the effects of combined stresses of climate change and air pollution on crops.
- Determine response of rice crop models to changes in the mean and variances of climate in Japan
- A study to develop ecosystem models of carbon dynamics in soils, focusing on land uses in controlling tropical carbon cycling.
- Improving methods for detection and classification of potential arable lands by studying environmental requirements for crops under varying climatic conditions.
- Formation of a joint U.S.-Japan task force on the development and use of gridded environmental data sets for global change research.

(4) Research and Technology for Adaptation and Mitigation to Global Change

Research and Technology for adaptation and mitigation to global change are of paramount importance to Japan, the US and the world. This is a very broad topic and a large number of projects related to this area could be proposed. Identifying the key issues is unrealistic given the diversity of approaches possible. The Working Group, after listening to member presentations and considering the expertise and interest of its members identified three areas for proposal development:

- Biomass Energy Conversion for C02 Mitigation.
- Methods for Evaluation of Technological Response Options.
- Development and Evaluation of New Chemical Substances for the Mitigation of Global Change.

Five proposals for collaborations in these areas were developed. Participants felt that all of the identified proposals would make important contributions to the future global change adaptation and mitigation efforts.

IV. Recommendations for Cooperative Research Between Japan and the U.S.

Each of the working groups gave careful consideration to the identification of mutually beneficial cooperative research projects among the U.S. and Japan. The scope of some of these projects is described in the above paragraphs describing outcomes of the working group sessions.

V. Workshop Conclusions

Workshop participants from both Japan and the United States agree that there are important opportunities for cooperation between the two countries to enable more effective use of improved global change information. This workshop has identified many of these opportunities, and the workshop proceedings will be distributed both in Japan and in the U.S. for further consideration. Dissemination of the workshop proceedings to scientists who were not in attendance at the workshop will enable broader identification of scientists who might benefit from cooperative activities. Consensus conclusions of workshop participants were:

- A set of well posed research problems exist which would benefit from cooperative research.
- A much improved understanding of climatic changes and their predictability can be attained through bilateral collaborations involving high-resolution coupled modeling and validation against global datasets.
- A need exists to include human dimensions into quantitative integrated assessments of global change, requiring new analysis methods.
- A need exists for interdisciplinary research on the dynamics of information flow between researchers, the public, decision makers, and other societal sectors.
- There is a need to produce summarized forms of global change data. These reduced form datasets should be expressed at consistent spatial and temporal frameworks.
- There is a set of identified topics essential for improved carbon cycle prediction.
- There is a need to identify linkages between physical models and economic and social models in order to define the full range of global change impacts.
- Efforts need to be made to identify key mitigation technologies and to obtain international agreement on these areas for future research and development.
- There is a need for development of technological options for global change mitigation, and to exchange information on these options.

Workshop participants also agree that continued dialogue among scientists in Japan and the United States on topics identified in other sections of this Communiqué and in specific research project descriptions is important. It is also agreed that further efforts to encourage collaboration among scientists from the two countries should be pursued.

12 March 1997
East-West Center
Honolulu, Hawaii

Chair from Japan:

Dr. Koji KITABAYASHI
Director General
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Agency of Industrial Science and Technology

Acting Chair from U.S.A.

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PRESENTATION PAPERS

PLENARY SESSION

GLOBAL ENVIRONMENTAL RESEARCH IN JAPAN (Research in National Institutes)

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1. Aspect of global environmental research in Japan

Research studies on science and technology related to global environment have been vigorously promoted after 1989 in Japan even though some basic researches started since 1970's in Tohoku University, Meteorological Research Institute and some of universities.

The Japanese government proposed Earth Regeneration Program "The New Earth 21" (Fig. I) in 1990. The program aims to improve the global environment which has been damaged in the past 200 years through human activities. Development of innovative environmental technologies and introduction them to practical use are required to regenerate the Earth Environment before the Age of Industrial Revolution. The program consists of following terms:

promotion of global energy conservation;
increase of clean energy demand;
innovative environmental technologies;
expansion of $C0_2$ absorption sources; and
development of next generation energy technologies.

The program include the technologies almost developed as well as highly innovative ones and require not only technology development but clarification of $C0_2$ absorption and global warming mechanisms.

2. Research for global environmental issues

Many national institutes now collaborate on to global environmental research projects in Japan. The research projects are funded by governmental agencies or ministries such as the Environmental Agency (EA), the Agency of Industrial Science and Technology (AIST), and the Science and Technology Agency (STA). Researches related to the mechanism and environmental impacts of global warming, ozone depletion, marine pollution are supported mainly by the funds of EA and STA. Research and development of innovative technology are supported by the AIST funds.

The fields of research project by the agencies are shown as follows:

Environmental agency

* depletion of stratospheric ozone layer
* global warming
* acid precipitation
* marine pollution
* tropical deforestation
* loss of biodiversity
* desertification
* human dimensions of global environmental problems
* integrated research

Agency of Industrial Science and Technology (MITI)

* research on countermeasures for global warming
* global environmental research

Science and Technology Agency

* ocean development and earth sciences
* cloud and climate

Other than these projects, most institutes are conducting their own projects related to global environment by their own budget.

3. Research projects in AIST

AIST has started "New Sunshine Program" in 1993. It is the comprehensive R&D program on energy and environmental technologies and aims to promote the development of innovative technology for creating sustainable growth while solving energy and environmental issues.
In the program six major projects are running in 1996. Those are as follows:

* renewable energy
* advanced utilization of fossil fuels
* energy transportation and storage
* environmental technology
* systematization technology
* basic and fundamental technology related to energy and environment

Institutes in AIST, private sectors and universities are jointly cooperated to these projects.

In NIRE, we are conducting fixation of $C0_2$ by artificial photosynthesis. $C0_2$ disposal in deep sea Sequestering North West Pacific Carbon cycle study life cycle assessment and another several projects. The details of the studies will be given at the presentation.

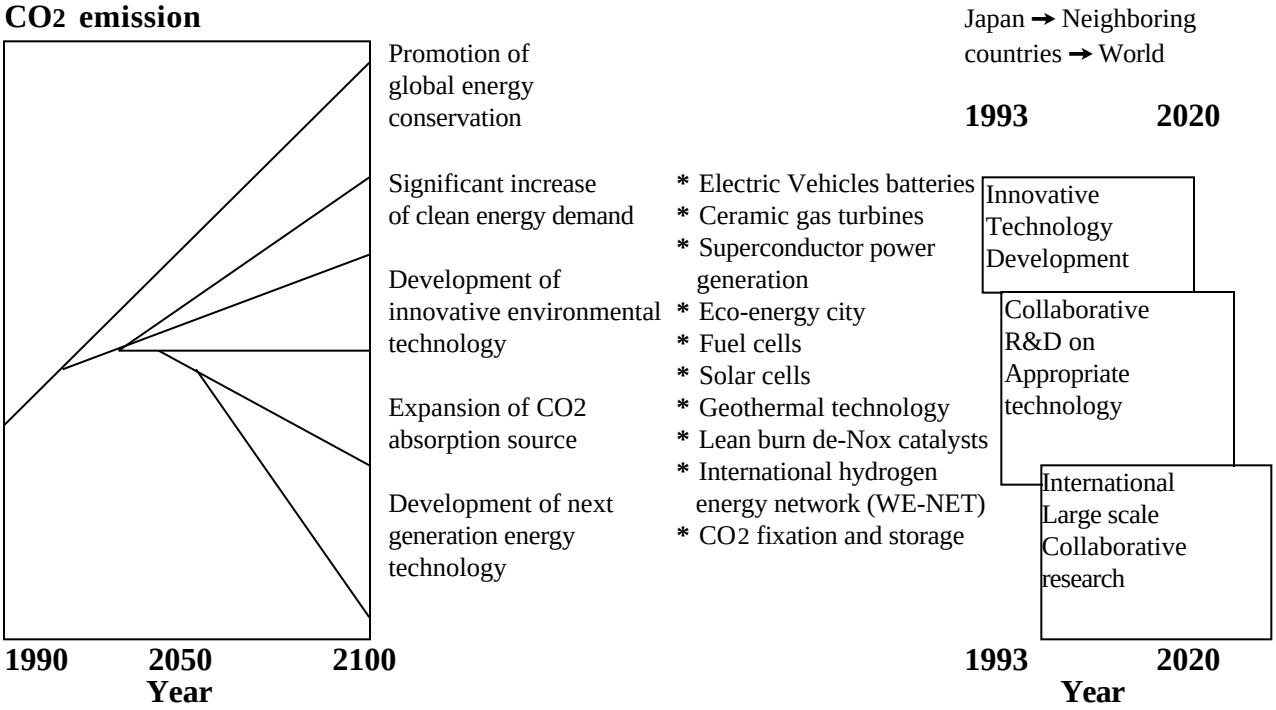


Fig.1.The New Earth 21 Program

Toward the Realization of Global Change Prediction

-Summary Report by Subcommittee on Earth Science and Technology, Council for Aeronautics, Electronics and other Advanced Technologies-

July 9, 1996
Subcommittee on Earth Science and Technology,
Council for Aeronautics,
Electronics and other Advanced Technologies

1. Background understanding

(1) Importance of global change prediction

Solving problems of global scale, such as the global environmental concerns, preventing natural disasters, and using natural resources efficiently, is an important and urgent subject. Therefore, giving hope to our future by means of attacking these problems, is one of Japan's responsibilities as we have become a major economic power. We have great expectations from both the domestic and international communities.

If global change prediction (i.e. to make highly accurate prediction based on scientific understanding of global phenomena) becomes possible, it would also become possible not only to respond to the global environmental concerns and natural disasters but also to utilize the capability for managing water resources properly or applying it to agriculture, forestry and fisheries, bringing immense benefits to humanity.

(2) Present state of research and development of global change prediction

Large-scale observation systems such as earth observation satellites are under development. A considerable amount of scientific knowledge has been accumulated and it appears we are really beginning to understand some mechanisms of global phenomena. Nevertheless, the lack of researchers and budget is impeding needed cooperation between processes research and observation systems. In general, we cannot say that comprehensive and coordinated research and development efforts for global change prediction are carried out at the moment.

(3) Future responsibilities of Japan

i) Earth as one integrated system

In order to realize highly accurate prediction of global scale phenomena, it is particularly important that complex interactions between the atmosphere, the ocean and the land be understood.

ii) Setting targets for a comprehensive and coordinated project

To proceed with comprehensive and coordinated research and development work to be led by Japan with all-out cooperation of organizations both inside and outside of Japan, it is important to set specific targets, which will lead to socially significant contributions, and to establish a strategic program to attain the targets.

iii) Drastic expansion in budget and man-power

Compared with the U.S., our budget is *114,* and the number of researchers in terms of scientific society members is assumed to be less than 1/8. These figures show our nation's effort at the subject is deplorably smaller than the U.S., the leading nation in the field. It is our responsibility to see that drastic measures will be taken to expand budget and man-power without delay.

2. Proposal for a global Change prediction program

(1) Target setting

i) Climate change prediction in the Asia-Pacific region

In order to become able to respond effectively to climate changes such as cool summers or droughts in the Asia-Pacific region, the proposed program will cover the Asian land area and tropical-North Pacific-Arctic seas and coastal zones, and then aim to support balanced and stable social economic activities by realizing highly accurate predictions of climate change in time scales longer than seasonal. Such predictions should become as familiar in our ordinary life as the existing weather forecasting services.

ii) Prediction of hydrologic cycles in the Asian region

In order to respond to abnormal water shortage, or to too much rain or too much snow as we in Japan and other Asian regions experience, and also to prevent water related disasters and to make better use of the water resources, prediction of phenomena related to hydrologic cycles is to be realized.

iii) Prediction of global warming

In order to take effective measures against global warming, we will have to develop an adequate understanding of circulation of warming materials such as carbon dioxide and capabilities to predict the density of warming materials based on anthropogenic discharge scenarios. Then, finally, accurate predictions of global-scale climate change brought about by global warming, e.g., that of sea level rise, are to be realized.

iv) Prediction of atmospheric component change in the Asia-Pacific region

The starting point of our global environment concerns was the atmospheric component change caused by humanity's socio-economic activities. Our knowledge about trace elements in the atmosphere is still so limited however that previously unknown problems may come to our attention. In order to forestall such incidence, atmospheric components including nanno-trace reactive particles are to be studied and then prediction of changes in atmospheric components taking account of reaction processes of such particles is to be realized.

v) Prediction of ecosystem change in the Asian region

In order to respond properly to ecosystem changes caused by global warming and deforestation caused by acid rain etc. in the Asian region including Japan, and also to keep agriculture, forestry and fisheries on a sustainable level, prediction of ecosystem change including vegetation is to be realized.

vi) Understanding the change mechanisms of Earth's interior

Earth's interior change mechanism and interaction between the mantle and the crust is to be understood and models for earth's interior change to be developed. The ultimate objective is the realization of predictions for earthquakes and volcanic activity based on an Earth's interior change assessment system which is also to be built.

(2) Proposal for strategic programs

To justify the large investments, the most effective research and development based on the existing knowledge must be carried out. It is necessary to establish a basic time schedule and direction-what to achieve by when. Research and development must proceed in well coordinated and balanced ways with 3 elements working together, that is, processes study, observing system and simulation. Therefore, each strategic program for each objective is proposed. (Refer to Attachment 1 and Attachment 2)

(3) Research and development 10-year plan

In carrying out 6 strategic programs, each program is divided into 2 stages. For the first stage, with close cooperation between organizations concerned, research and development in a 10-year plan is proposed.

3. Promotion of global change prediction plan

(1) Strengthening the existing research and development promotion system

i) Strengthening cooperation between organizations concerned

Cooperation between organizations is very important. Such cooperation includes cooperation between 3 functions, i.e., (1) processes study, observing system and simulation, and (2) cooperation among functions and finally (3) cooperation between the organizations who actually run the prediction system and the research organizations. In order to strengthen such cooperation, it is necessary to foster an organization specifically committed to give support to promotion of research and development planning for global change prediction, to promotion of man-power support, to promotion of research and development programs, and to promotion of distribution and utilization of research information.

ii) Construction of a new research system

An organization as core researcher for each strategic program and an organization which is committed to cross-strategic program research are necessary, and then funds and talents for such organizations are to be prioritized. For highly interdisciplinary fundamental study, adoption of researchers on contract basis is to be encouraged and the 21st century's new research systems are to be established. In such new studying systems, it is important that universities and national research organizations all collaborate where there will be active exchange of researchers. Also, strengthening the research supporting system, such as setting up a special organization which supports research activities and fostering engineers, and realizing flexible administration of the budget system and creation of a competitive research environment are necessary.

iii) Development and application of systematic and continuous earth observation systems

Following the strategic programs, an over-all systematic and continuous earth observation program needs to be developed. As part of this program, Japan could actively join the Integrated Global Observation Strategy (IGOS) advocated by NOAA and NASA of the U.S., thus fulfilling Japan's role in the world's effort for the observation of Earth.

iv) Development of prediction models and simulation Systems

As a substitute for global scale experiment which is impossible to carry out, developing modeling and assimilation techniques for reproducing and predicting global scale complex phenomena which occur as a chain reaction of varied processes needs to be pursued. In addition, because the simulation is carried out at precision of approx..lOkm at global range and of approx. 1km at local range, computing systems, which can handle such calculations, and related modeling need to be developed.

v) Promoting circulation and utilization of earth observation data and results of research and development

A specialized organization for planning research and development to realize global change prediction is to be fostered to promote circulation and utilization of research information. This organization is also to support the effort of the concerned organizations to organize the information they possess into appropriate databases.

vi) Constructing prediction system and realizing predictions

Earth observation data and results of research and development from the 3 functions of strategic programs are to be provided to organizations who construct prediction systems and actually run the Systems. By doing so, the organizations can provide us with any problems as feedback, which is important to operate the program effectively. Also, high-accuracy atmospheric and oceanic data sets being provided by meteorological service organizations inside and outside of Japan are important and useful for other researchers and laboratories.

vii) Evaluation of research and development work

In order to activate research and development work and make good results, research and development subjects, research and development organizations and researchers are to be evaluated by well-informed persons inside and outside of Japan in terms of their objectives, characteristics and roles. The evaluation results need to be reflected on the distribution of research budgets.

(2) Securing talents and budget

In order to meet the expectations inside and outside, Japan, as one of the advanced nations in the Asia-Pacific region, should play as important a part as the United States. Because of that, in the next 5 years, 600 billion yen *(US$5.5* billion) of the budget is estimated. Also, through expanding the existing system of inviting high caliber researchers inside and outside of Japan to Japanese research organizations and by establishing a new research system involving researchers employed on contract basis, talents from around the world are to be encouraged to come, and exchange of personnel in industrial-academic-government circles needs to be encouraged inside and outside of Japan.

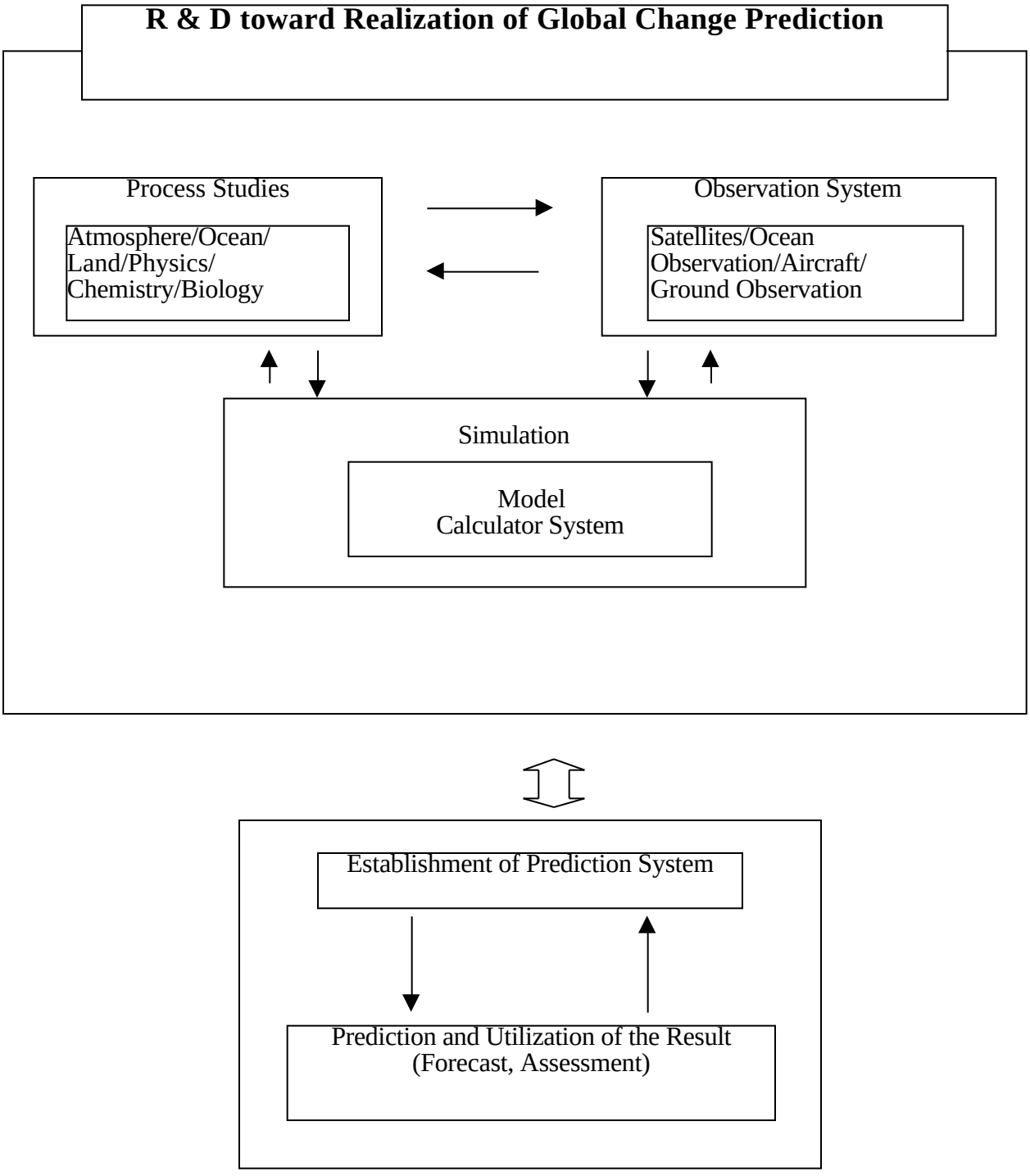
(3) Construction of international cooperation system

For international research and observation collaboration which will agree with the strategic programs to be executed, we should act subjectively and actively. Because international research centers need to be established at key geographical locations, besides the International Arctic Research Center, for example, in the central North-Pacific, the equatorial area and the central Asian continent may become local points of research activities in the respective regions. These centers need to be established in cooperation with the countries involved.

(4) Review of strategic programs

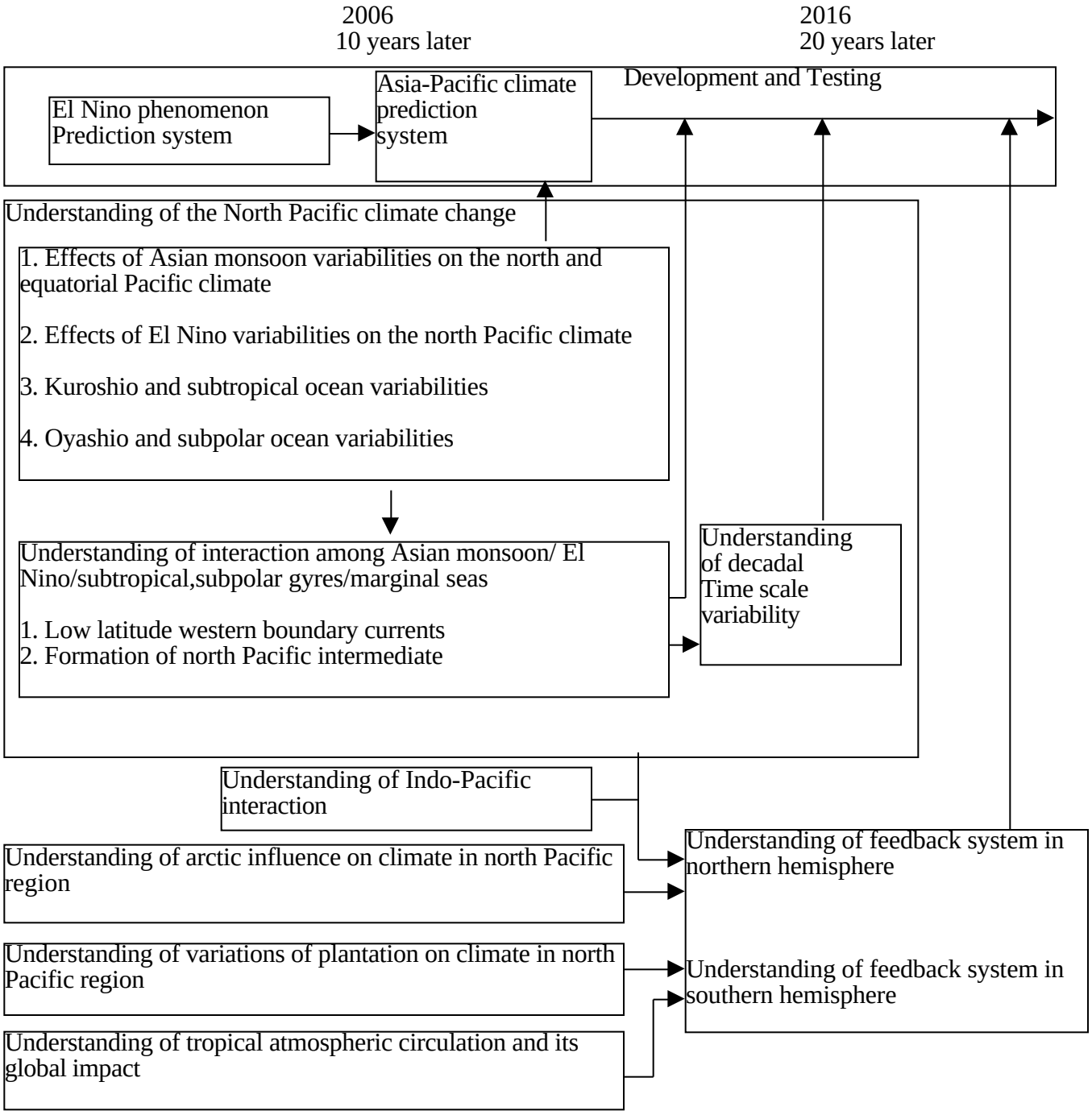
Strategic programs should be reviewed periodically with accurate assessment made of the state of progress of research and development at the involved organization, its scientific knowledge, the level of technology development, as well as surrounding social circumstances.

Attachment 1

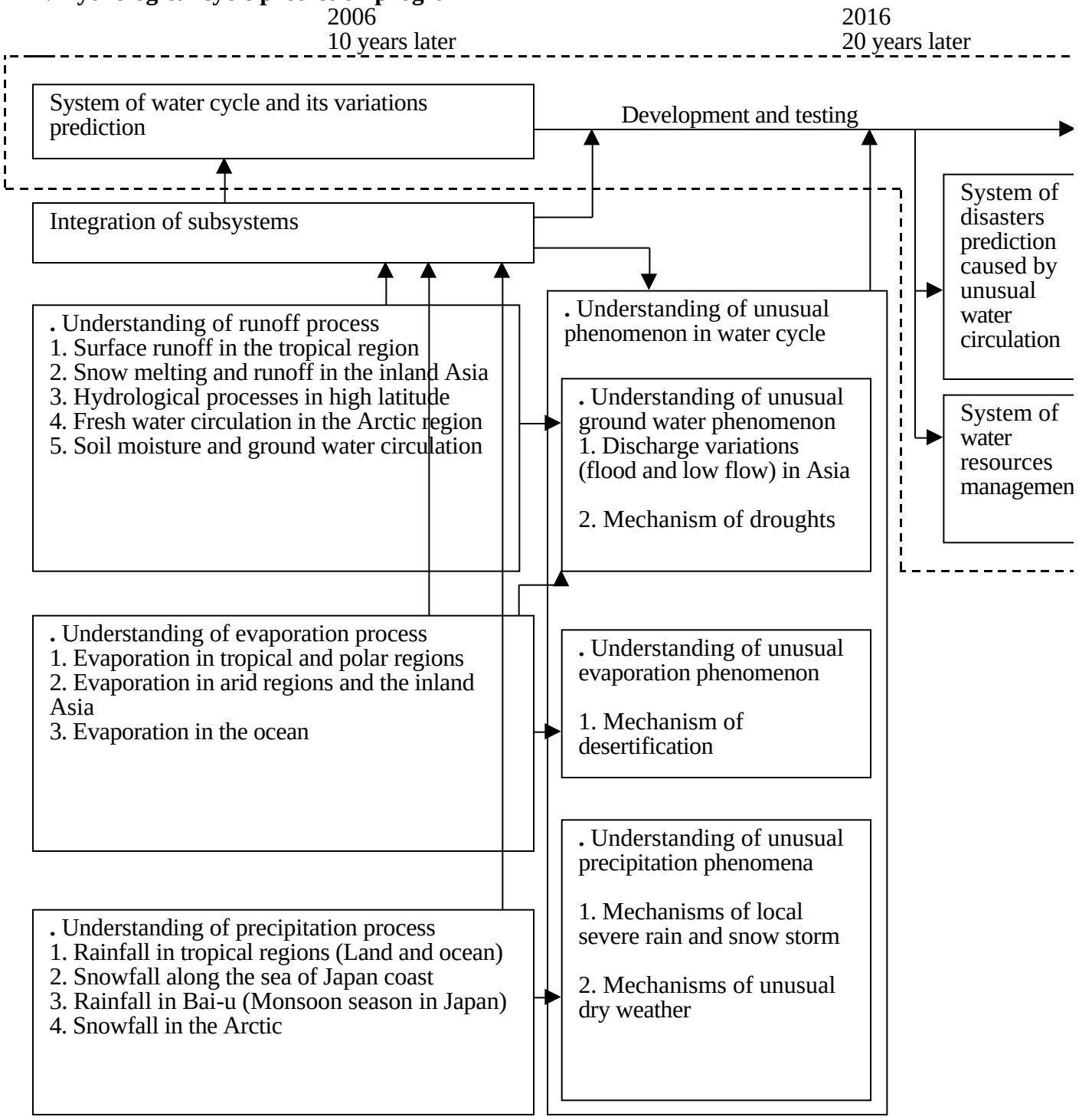


Attachment 2

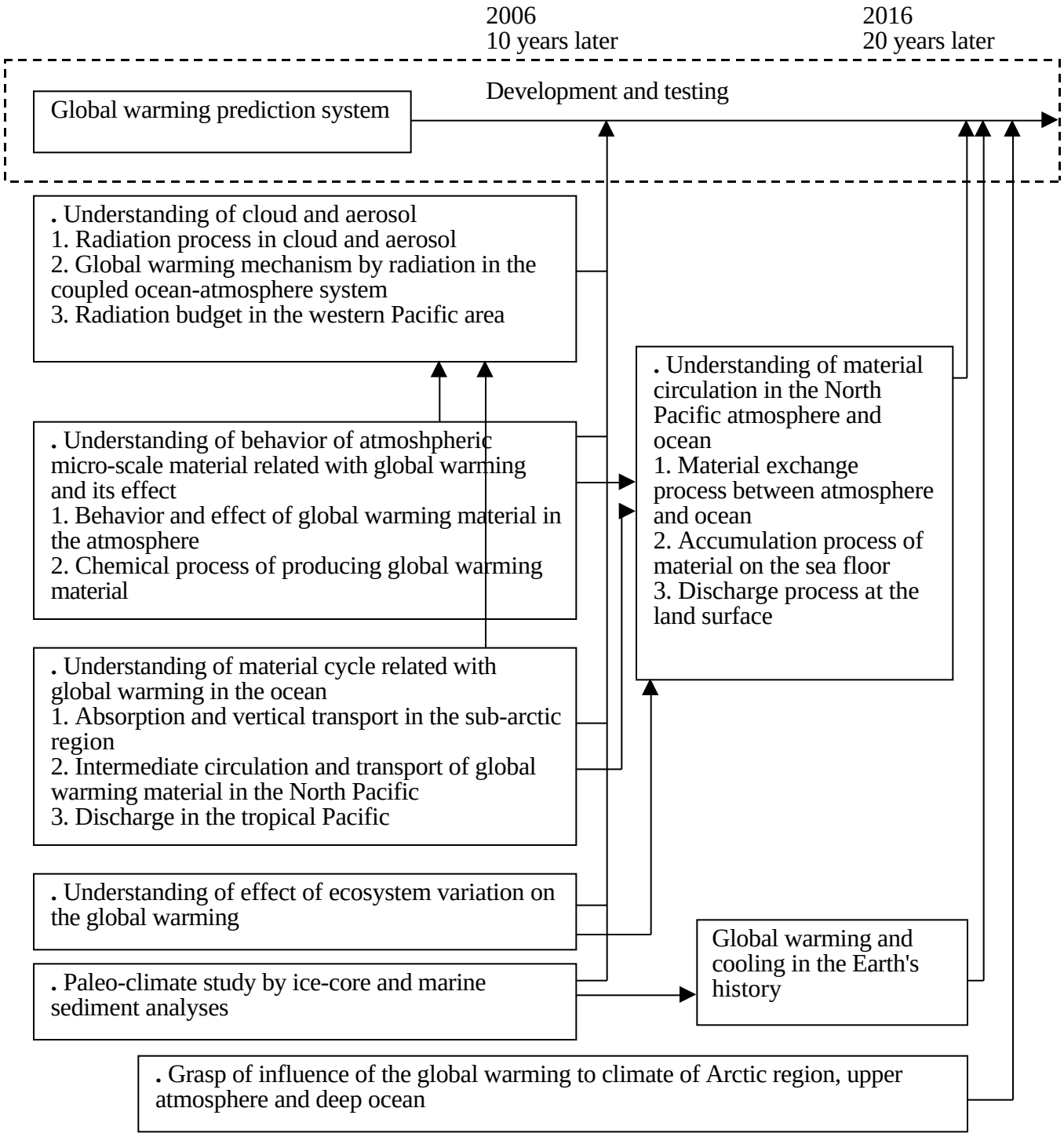
1. Asia-Pacific climate prediction program



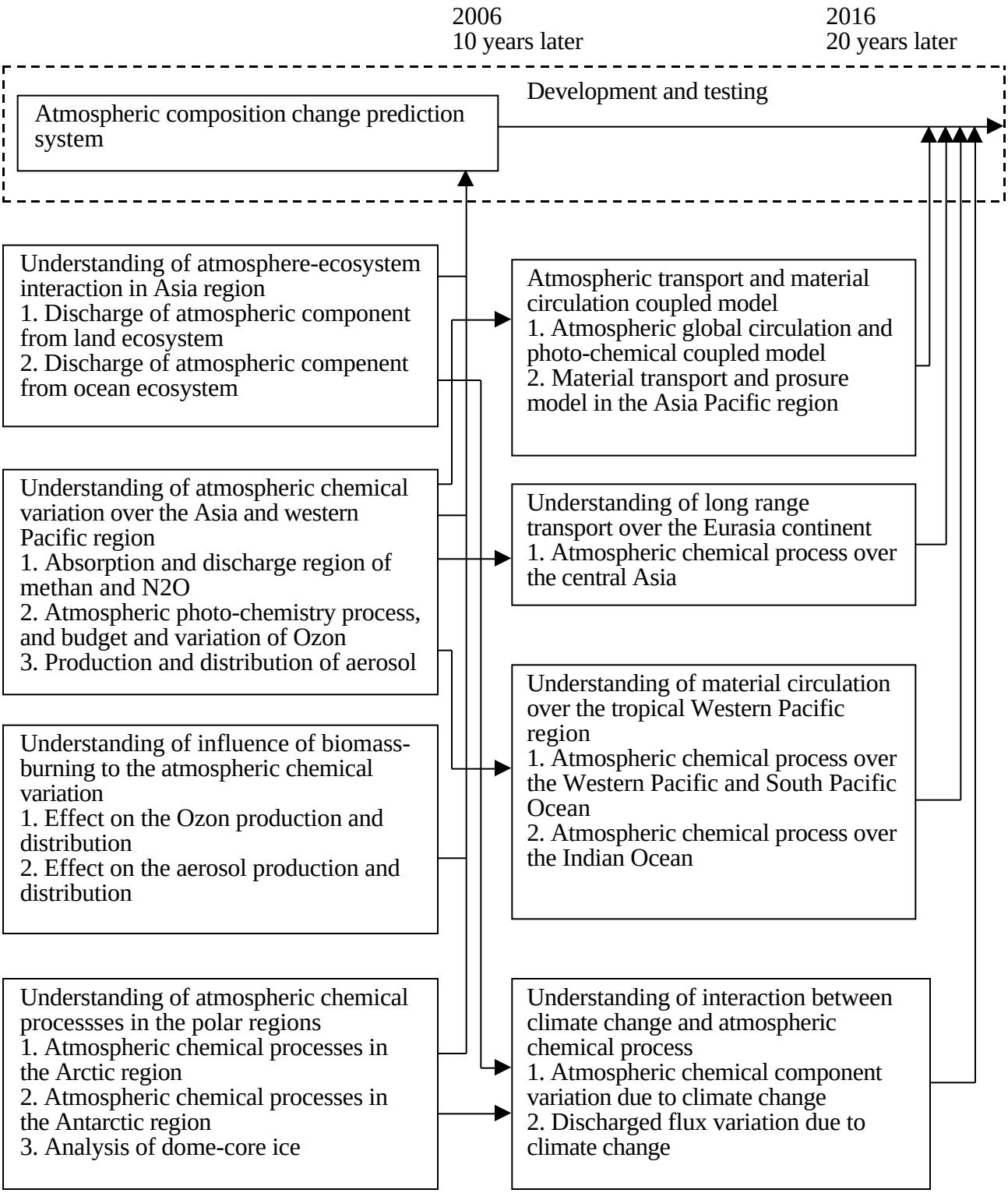
2. Hydrological cycle prediction program



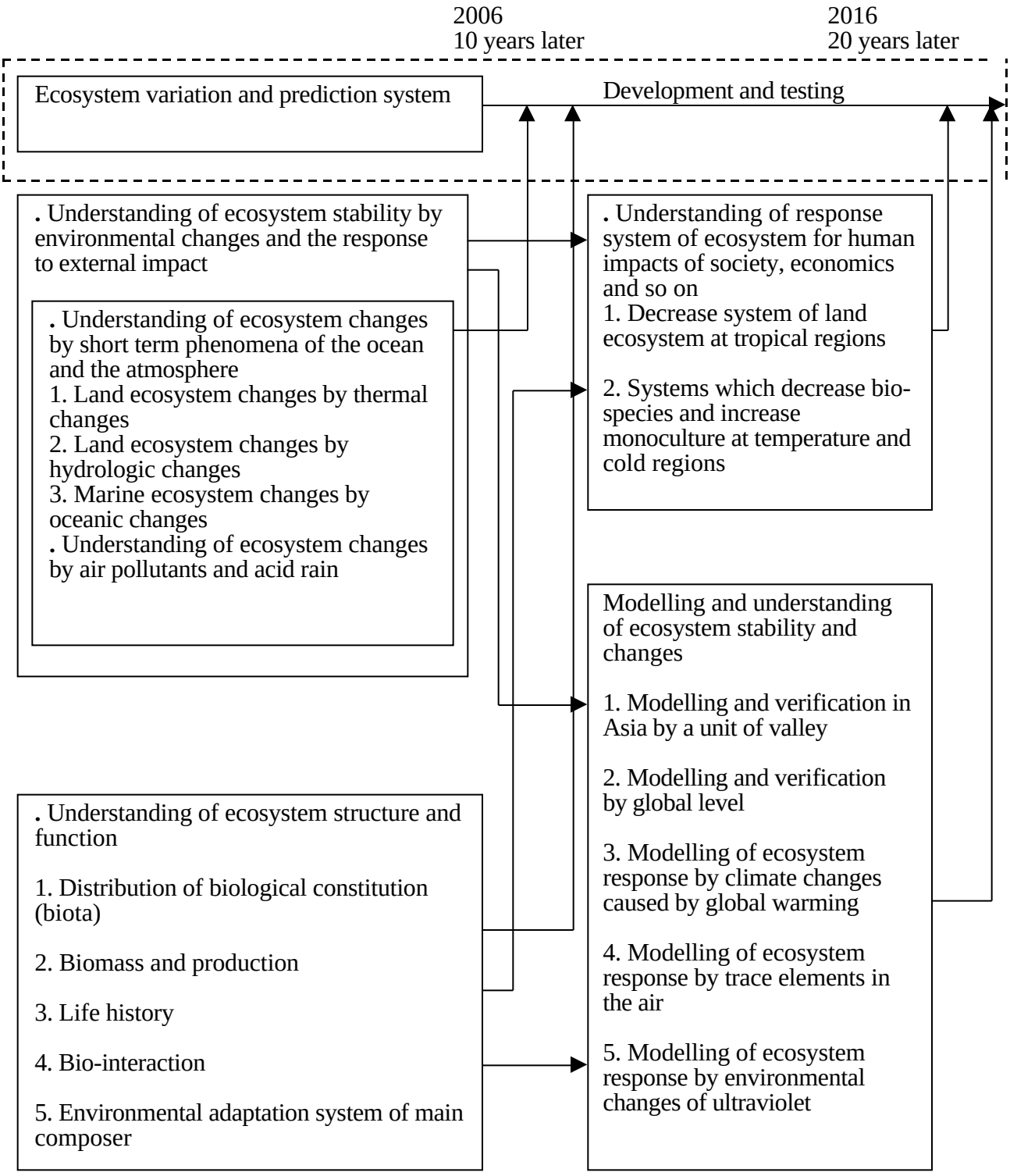
3. Global warming prediction program



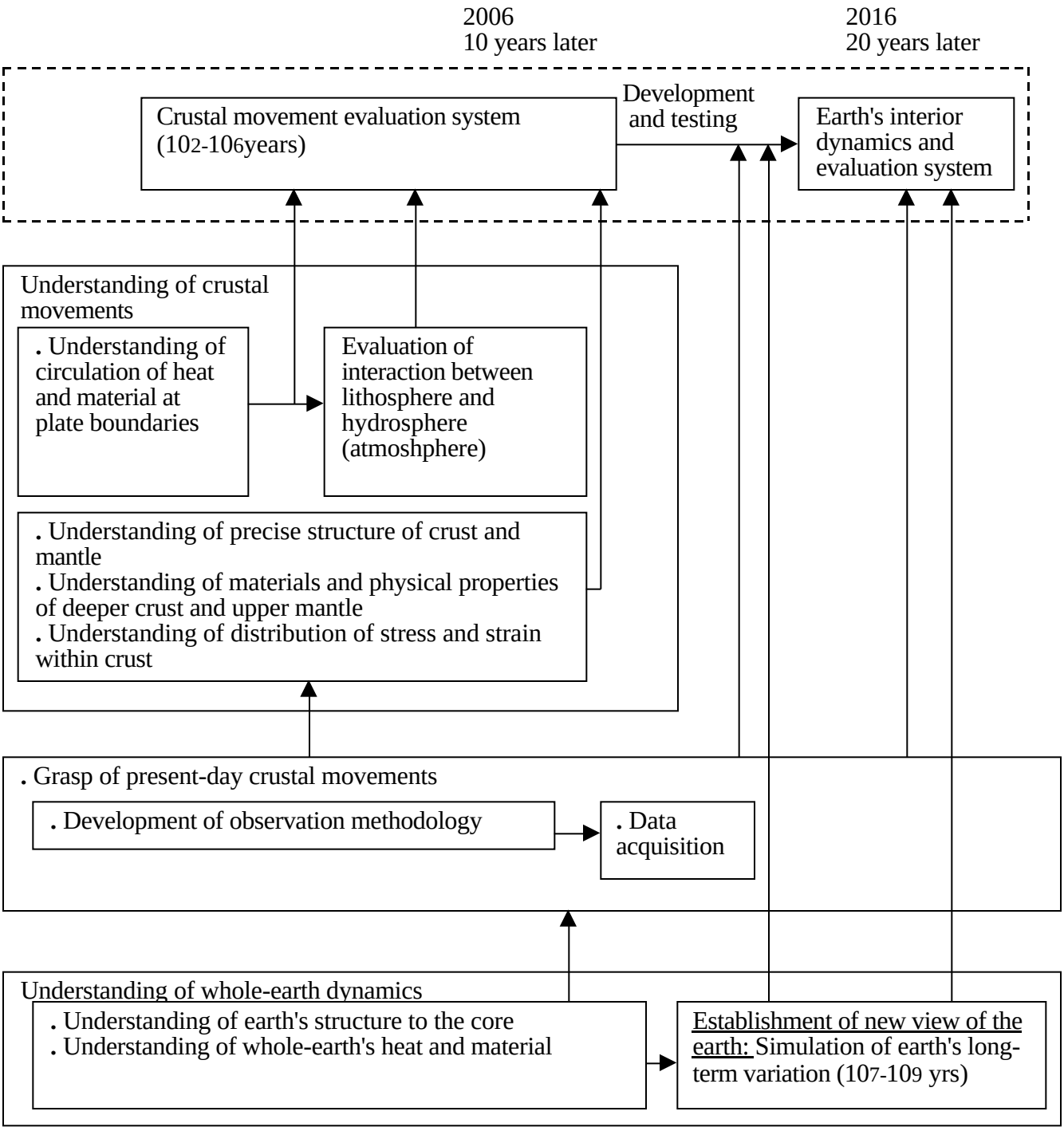
4. Atmospheric composition change prediction program



5. Ecosystem variation and prediction program



6. Earth's interior dynamics and evaluation program



WORKING GROUP 1

Statement for Working Group 1
Maurice Blackmon

PERSONAL INTERESTS AND INSTITUTIONAL INTERESTS

I am a climate research scientist interested in observational studies and climate modeling studies. Much of my past observational work has been concerned with the behavior of the midlatitude circulation and how it changes. My work on climate modeling has primarily been devoted to examining the atmospheric response to sea surface temperature anomalies, mostly in the tropical Pacific but to a lesser degree also in the midlatitude Pacific. More recently, I have collaborated with Clara Deser on studies on air-sea interactions in the North Atlantic and North Pacific Oceans. The work on the Atlantic concerns decadal and longer time variability.

I am also presently the Director of NCAR's Climate and Global Dynamics Division (CGD). The remainder of this document represents both my views and the views various scientists in CGD, and concerns the research interests of a substantial part of the division.

Scientists in CGD have been developing a Climate System Model (CSM) for the past three years. The CSM uses the most recent version of the Community Climate Model CCM3 for the atmospheric component; a global ocean model based on GFDL's Modular Ocean Model (MOM) code version 1 with the Gent-McWilliams eddy-parameterization scheme and the KPP mixing parameterization included, a land surface model developed by Bonan and a sea-ice model due to Flato and Hibler. This model does not use "flux adjustment" or "flux correction."

The primary topics of interest are related to global climate change, but we are also interested in seasonal to interannual climate prediction. We have a version of CSM that includes a high resolution, tropical Pacific Ocean model due to Gent and Cane. We have also run this model using no "flux corrections." However, due to the systematic biases in e model in the Pacific, the predictions of sea surface temperature can be improved by using flux corrections.

We have run several simulations with the atmosphere model forced by observed sea surface temperatures and several simulations with the ocean model forced by observed winds. We have also run a 300 year coupled model simulation. We are presently analyzing the coupled model run. I will be able to show some of the most basic statistics from this run at the workshop. We are in the process of beginning a run in which carbon dioxide will be specified to increase at 1% per year. We expect to perform experiments with a variety of forcings, including aerosols and important trace gases in the near future.

FUTURE RESEARCH TOPICS IN CGD AND POSSIBLE COLLABORATIONS

We are beginning a project called Climate of the Twentieth Century which we expect to provide a major research focus for CGD for the next several years. We will try to initialize the CSM (primarily the ocean component) to conditions appropriate for the late 1800s and run a model simulation in which the concentrations of greenhouse gases I prescribed to increase according to our best estimate of how this occurred in the twentieth century. We expect to do this piecewise, including one component or a few of the components, of the greenhouse gases at a time. This will necessitate multiple runs, but we feel it is important to do the problem by including what we have most confidence in first and move to more uncertain components later. We expect to specify three-dimensional distributions of the gases and aerosols but we will probably start with somewhat simplified distributions; such as zonally averaged distributions. We would be happy to collaborate on aspects of this project of mutual interest.

We are also beginning to include new components in *CSM* such as river routing, simple atmospheric chemistry and ocean geochemistry. We are also beginning to experiment with different parameterizations and numerical schemes. We are developing a lower resolution version of CSM for use in paleoclimate experiments. We would be happy to collaborate on any of these activities.

We are definitely interested in participating in research on seasonal to interannual climate prediction using the modified CSM. Our main interest is in model development so that we do not have to use flux corrections, but if in the interim potential collaboration developed, we would be willing to use a flux corrected model to examine prediction skill for some test cases. We will be happy to furnish our work to the newly forming International Research Institute or any other institute that wants to do operational prediction. Our role should be one of support of operational prediction, but not direct participation in the operational activities.

In order to see what possibilities for collaboration and interaction exist, we should perhaps think of a joint U.S./Japan workshop pin the not-too-distant future on coupled modeling. We would focus the invitation list to groups that are working actively in this area. If this is too large a list, we might focus further on global change modeling and exclude the seasonal to interannual prediction component.

I am not sure how much further I can go in defining areas of participation until I know what other groups are interested in doing. NCAR/CGD has a long, successful visitor program both for U.S. and foreign visitors. We want to maintain that and expand it, if desirable.

The CSM is freely available to any interested person or group on the web. We are trying to increase our collaboration with scientists in the U.S. in this activity. Groups outside of NCAR have already taken one or more of the component models, or the entire CSM, and have begun to use it, modify it, etc., for their own purposes. In fact, the CSM has been ported to Japan, and an experiment is being run on an NEC SX-4 supercomputer there. We would be happy to have any potential collaborators in Japan take the model for their use, as well.

5th Japan - US Workshop on Global Change
Working Group 1 - Prediction
Peter G. Brewer

The oceanic signature of global warming. Can we make a tracer connection?

I pose this topic as a query because we absolutely do not have an answer; and moreover we are usually too embarrassed to ask the question. There is now widespread agreement that we can measure and model the penetration of greenhouse gas tracers into the sea. The oceanic signature of fossil fuel C02 is now quite large, approximating *50* micromol kg-i in surface waters, and were it to be considered somehow as a separate species it would be one of the major ions of sea water (Brewer, 1997).

The original description of the procedure for detecting the fossil fuel signature in sea water was given by Brewer (1978). Today detailed accounts of the signal have been given by many authors including Tsunogai et al. (1993) for the North Pacific, and Gruber et al. (1996) for the North Atlantic. Improved statistical procedures for estimating the field were developed by Brewer et al. (1995), and applied to estimating the fossil fuel invasion signal between cruise separated in time by Slansky et al. (1997). From these data we have a remarkably good, and growing, picture of the 20th century chemical invasion of the upper ocean.

At the same time the atmosphere has been warming, by approximately 0.8 degrees over the course of the century. The warming is somewhat less than is predicted, and one commonly given explanation for this is that the heat capacity of the ocean is so large, and the air-sea interaction so difficult to parameterize in models, that there is a substantial lag associated with the uptake of heat by the ocean. If this is so then the ocean is getting warmer. Can we infer, detect, or make any estimate at all, of this trend, at any point of societal interest? The problem is hard, but large-scale acoustic experiments are actively seeking to detect the warming trend (Munk et al., 1994).

There are many reasons why we would like an answer, even a rough approximation, beyond the big question of whether a fundamental shift in the geophysical circulation will occur, and yet we do not have an extended time series of measurements to turn to. Barry et al. (1993) observed a significant climate related change in the population of animals in the rocky inter-tidal zone. Have the animals at 10m depth experienced a change? Those at 100m? There are exposed beds of gas hydrates on the continental shelves at many locations (Brooks et. al., 1991), which are poised near their equilibrium point; are these being bathed in warmer water today?

We do not have the answer to these questions. We do know that the chemical artifacts of the 20th century have penetrated to these depths. We have no confidence in relating this to an estimate of the related thermal change, yet if we could do so it would be of great benefit to society. In order to achieve this we need to be explicit about the problem, and to devise experiments and models that place the rapidly emerging chemical and thermal signatures on the same observational and computational basis.

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Activity of climate research in NIED

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Major purpose of our institute is to know future states of climate and prevent supposed disasters as possible as minimum.
To approch this, we are doing following three research project.

a. Research on disaster prediction in global hydrological processes

b. Research on mechanism and impact of precipitation change accompanied with global warming

c. Research on rainfall system

Each of them is focusing on phenomena relating hydrological processes, because varius kinds of disasters are induced through water cycle over the Earth. A flood or a landslide often happens with a long spel or heavy rainfall. Weather phenomena such as stationaly front, developed cyclone or typhoon has a big role and their activities are greatly affected by climate change. To get good understanding and predict future state of climate, we arep now developing a coupled atmosphere-ocean model as one tool for advancing our research. In this model we intend to include river-network model and precise cloud processes in order to improve hydrological processes on land, raifall processes and cloud-radiation interaction processes.

Highly resolved local area model is also developed to evaluate details of raifall amounts and distribution, which need to know potential possibility of a flood or a landslide.
This model is also used to develope a cloud model including precise micro-physical processes of cloud formation and rainfall. By using Rader observatinal system, a project of special oservation of cloud system will be done under co-operation with Austrarian group.

Another co-operational study with Austrarian group is also done in the field of model simulation. By using the global climate model of CSIRO, we perform two 200-years simulations with the SST boundary of present and 2*C02.
Results are following:

· Precipitation and temperature changed aruptly in regional scale and multidecadal scale,
· Arupt change of precipitation was a causative factor of floods and water shortages,
– Increase dry weather or pluvial weather in the world.

5th Japan-U.S. Workshop on Global Change
March 10-12, 1997
Working Group on Prediction of Global Change

Statement by: Steven Emerson
School of Oceanography,
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1. *Suggestions for collaborative research and working group topics:*

The importance of upper-ocean time-series studies in global change research

Eventual Prediction of Global change will require that one understand environmental mechanisms that control concentrations and processes, and that we have some knowledge of temporal trends. The marine environment plays an important role in influencing the atmospheric concentration of important gases (e.g., O_2, CO_2, and DM5) and is the depository of about 40% of the anthropogenic $C0_2$ put into the atmosphere. One of the most effective and fruitful methods of studying how biological, physical, and chemical processes in the upper ocean influence both the atmospheric and oceanic environment has been by monitoring single locations repeatedly. This has been demonstrated recently by the studies that have been part of the U.S. Joint Global Ocean Flux Study (U.S.JGOFS) time-series stations near Bermuda and Hawaii and the Canadian JGOFS time-series work in the northeastern north Pacific ocean (Station P). Research at these locations has dramatically advanced our knowledge of the mechanisms that make up the "biological pump" and our confidence in the accuracy of methods for determining the value of chemical fluxes out of the surface ocean. Deep-sea mooring has been deployed at each of the time-series stations to monitor chemical constituents continuously and remotely.

From the point of view of the Pacific Ocean, probably the most dramatic deficiencies of the present time-series studies are that they cover only the eastern portion of the basin. I believe this problem could be addressed by collaborative time-series studies between Japan and the U.S. as part of the presently planned Japan JGOFS study in the western North Pacific Ocean. The topic was a subject of discussion in the recent lOBS Symposium in Mutsu, Japan (1'1ov. 12-14, 1996). It may be possible during the Japan JGOFS program to occupy a location in the western subarctic Pac~iic ocean at least four times per year and determine the appropriate tracers for monitoring the strength of the biological pump and $C0_2$ exchange between the atmosphere and ocean. We should also explore the possibility of establishing a mooring near the time-series location.

I would like to raise the topic of upper-ocean time-series studies in the Japan JGOFS program as a possible focus of collaborative study between 3apanese and U.S. scientists. The U.S. side has developed expertise and knowledge in this science from the JGOFS time-series studies that are now in their 8th year. The Japan side has the interest in investigating the western subarctic environment and several oceanographic studies are currently working in this area. It may be possible to coordinate the existing studies to recognize a time-series location. U.S. scientists with expertise in these studies could collaborate to enhance the program in research areas not yet fully developed in Japan.

2. *Abstracts of Recent Research:*

Submitted to Nature, 1997

The Carbon Pump in the Subtropical Pacific Ocean: Implications for the Global Carbon Cycle

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The flux of biologically produced organic matter from the euphotic zone of the ocean to the interior-4he biological carbon pump--is one of the main factors controlling the carbon dioxide partial pressure in the atmosphere and the driving force for most of the oxidation-reduction reactions in the sea. Accurate determination of this flux is critically important for understanding the global carbon cycle. Since there are no standards against which environmental fluxes can be measured, one must assess accuracy by other means such as mass balance. We present three independent approaches for measuring the net annual export of organic carbon from the euphotic zone at the U.S. JGOFS time-series station near Hawaii. Mass balances of dissolved inorganic carbon, oxygen, and organic carbon yield estimates of the organic carbon export in the range of 1.7 to 2.7 moles C m^{-2} yr^{1} and each have an uncertainty of about i *50%.* This is the first time three different analytical approaches have agreed on the value of the carbon export flux, and establishes the present state of methodological accuracy. If 2.0 moles C m^{-2} yr^{1} is typical of the subtropical ocean, then this vast region, previously considered to be a biological desert, is responsible for at least one third of the global ocean biological carbon pump. The challenge now is to determine the mechanisrns limiting nutrient supply to these areas in order to predict the response of the biological pump to changing ocean conditions.

Proceedings from the IGBP symposium in Mutsu, Japan

NET BIOLOGICAL OXYGEN PRODUCTION: A GLOBAL ESTIMATE FROM OCEANIC MEASUREMENTS

Steven Emerson

The flux of biologically produced organic matter from the euphotic zone of the ocean to the interior--the biological carbon pump--is one of the main factors controlling the carbon dioxide partial pressure in the atmosphere and the driving force for most of the oxidation-reduction reactions in the sea. Over annual time scales the organic carbon export flux is stoichiometrically related to Net Annual Biological Oxygen production which has been determined in three regions of the ocean--the subtropical western Atlantic, the eastern subarctic Pacific, and the eastern subtropical Pacific. In this paper I review the general methods used to determine net biological oxygen production, point out the main weaknesses of the interpretations, and surnmarize results from these three oceanic regions. I estimate the global net biological oxygen production using these measurements and recent evaluations of the importance of coastal primary production using Satellite Ocean Color measurements. Results are compared with global estimates of net biological oxygen production using measured changes in the $0_{2/}N_2$ ratio in the atmosphere. While uncertainties involved in both determinations are large, the surprising result of the comparison is that the net global biological oxygen production determined by these methods agree to ±30%, well within their confidence limits.

3. Research Interests:

Biographical Sketch
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Education

B.S., 1969, (Cum Laude) College of Wooster, Wooster, Ohio
Ph.D., 1974 Columbia University, New York
(Geochemistry, Oceanography, Environmental Sciences)
Dissertation: "Radium-226 and radon-222 as limnological tracers, the carbon dioxide gas exchange rate"

Employment

1974-1976	Post-doctoral Fellowship, Swiss Federal Inst.of Tech., Zurich
1976-1979	Research Assistant Professor, School of Oceanography, UW
1980-1982	Assistant Professor, School of Oceanography, UW
1982-1986	Associate Professor, School of Oceanography, UW
1986-present	Professor, School of Oceanography, UW

Research Interests

Cycling of metabolic gases and isotopes in the ocean surface waters, air-water C02 transfer in aquatic systems, organic carbon dynamics at the deep sea sediment water interface, calcium carbonate preservation in the sea, the effect of anoxic conditions on solubility of metals in seawater and tracers of past changes in the redox state of the ocean

Five Relevant Publications

Schudlich R., and S. Emerson (1996) Gas saturation in the surface ocean: the role of heat flux, gas exchange and bubbles. Deep-Sea Res. 43,569-590.

Emerson, S., P. Quay, C. Stump, D. Wilbur, and R. Schudlich (1995) Chemical tracers of productivity and respiration in the subtropical Pacific ocean. J. Geophys. Res., 100, 15,873-15,887.

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Effect of Short Wave Radiation on SST Simulation In an Atmospheric-Ocean Coupled Model

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National Research Institute for Earth Science and Disaster Prevention (NIED) has recently developed an Atmospheric-ocean coupled model to investigate a global water cycle. The atmospheric component of the coupled model is a spectral model used as a forecasting model at Japan Meteorological Agency. It has 21 levels in vertical and triangular 42 truncation in horizontal. The ocean part of the coupled model is the model developed at National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory / Princeton University.

We integrated the coupled model for 12 years. The coupled model simulates the realistic annual mean sea surface temperature (SST) distribution. However the simulated SST uniformly has about 2C higher than the observed one. The SST along the western coast of the major continents is too warm, and so the zonal contrast of SST is weaker. This may be partially due to the overestimation of incoming short wave radiation at the sea surface. In particular, their difference between the model and the observation is significant over the eastern Pacific and Atlantic due to the lack of marine stratus.

We have explored the sensitivity of SST simulated in the coupled model to marine stratus, which reduce surface short wave radiation. We evaluated amounts of marine stratus from the vertical profile of moisture below 850 hPa. Actually, we changed the albedo coefficient calculated on the basis of amounts of artificial marine stratus. The result shows that the zonal contrast of SST is larger than that without stratus. Such changes also modif"' the seasonal march of the simulated intertropical convergence zone (1TCZ) in the eastern tropical Pacific. This simple experiment suggests those cloud impacts on the distribution of SST in a coupled model. However, the decrease of incoming short wave radiation associated with the artificial marine stratus dose not improve the warm bias along the coasts of Peru and Ecuador. This may be due to the weakness of southerly wind along the Andes.

Estimate of anthropogenic $C0_2$ in the North Pacific

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Introduction

It has been pointed out that the post-industrial increase of $C0_2$ in the atmosphere should produce a higher temperature in the troposphere by the "greenhouse" effect and cause the global climate change. Therefore the reliable prediction of the magnitude of the temperature increase is a high priority scientific issue. Predicting global climate change as a consequence of $C0_2$ emissions requires coupled oceanlatmosphere carbon models that can estimate the rate of growth of $C0_2$ in the atmosphere as well as removal in the oceans and terrestrial biosphere. Today's estimate of the removal rate of the anthropogenic $C0_2$ from the atmosphere to the ocean, 2.0 ± 0.8 PgC yr^{-1} (IPCC, 1994), was mainly obtained from models. The estimates should be confirmed by filed data, however, it is still difficult because the field observation is limited by sparse temporal and spatial coverage.

Net transport rate of $C0_2$ from the atmosphere to the ocean can be determined from net sea-air $fC0_2$ differences, (ΔfCO_2) and gas exchange rates. High quality $AfCO_2$ observations in good spatial and temporal coverage are needed, although the gas exchange rates can be estimated from wind speeds.

Another approach to determine the transport rate of the $C0_2$ is to estimate amount of the anthropogenic $C0_2$ which have been stored in the ocean after the industrial revolution from records stored in seawater. To complete this work, precise measurements of carbon species and isotopes in seawater are needed.

Observation

To obtain precise data set of carbon species and estimate the anthropogenic $C0_2$ in the North Pacific, we conducted observational cruises of **R/V HAKUREI-MARU** from 1992 - 1997 in the Northwest Pacific Carbon Study (NOPACCS) program in collaboration with Kansai Environmental Engineering Center. Features of the NOPACCS observation were that fCO_2 measurements were carried out in almost whole West Pacific in two seasons, one was from April to June and the other was from August to October, and that hydrographic observations including fCO_2, total inorganic carbon, alkalinity and pH measurements were carried out repeatedly along a l75ºE line. The data obtained in the program will be stored in a data base of the Japan Oceanographic Data Center.

Results and Discussion

The fCO_2 in surface water and air were measured every one hour during all the cruises. Along the l75ºE line in surnmer (August to October), negative ΔfCO_2, lower fCO_2 in seawater than in air, was observed in very limited area around the subarctic boundary and high positive ΔfCO_2 was observed around 30ºN (Harada, 1996). This distribution pattern was essentially same in different year observation. However, the distribution on the line in spring (April to June) had completely different pattern. The negative ΔfCO_2 was observed in whole area of the line, except north of 45ºN.

In the area of 140 - l75ºE, negative value of the ΔfCO_2 was larger in the western part than the eastern one, showing the western North Pacific was large sink of the atmospheric $C0_2$.

Cross sections of total inorganic carbon, alkalinity, pH, dissolved oxygen, nutrients and some chemical tracers (CFCs) along the 175 ºN line were obtained to estimate concentration of oceanic excess $C0_2$ over "naturally" distributed inorganic carbon.

Judging from the estimation, a water column inventory of the excess $C0_2$ in the subarctic region has increased by more than 10 gC m^{-2} yr^{-1}, suggesting that this region would play an important role in the absorption of the anthropogenic $C0_2$ (Watanabe et al., 1996 and 1997). Total amount of excess $C0_2$ in the subarctic region of the North Pacific by 1993 was estimated to be 36.2 ± 8.0 PgC which was equal to about one tenth of that released by human activities after the pre-industrial era (Watanabe et. al., 1996).

Extrapolating the estimate on the l75 ºE using salinity and other chemical tracer distributions, an oceanic uptake of the anthropogenic $C0_2$ in the whole North Pacific was estimated to be 0.7 - 0.8 PgC yr^{-1}, which was about one third of the whole oceanic uptake of the $C0_2$, 2.0 PgC yr^{-1} predicted by the recent model calculations. This suggested that the North Pacific especially the western part of the region is an important place for the sink of the atrnospheric $C0_2$ or that the whole oceanic uptake of excess $C0_2$ is actually larger than 2.0 PgC yr^{-1} (Watanabe et al., 1996 and 1997).

Future Studies

To evaluate the conclusion of this study, we have to carry out further observations especially focused in the western and northern North Pacific. Since the area is known as a place where the North Pacific Intermediate Water, not only biogeochemical approach but also physical research are needed to predict the fate of the $C0_2$ entered in the region.

To document changes of the ocean in decadal time-scale, we need time series observational stations and re-occupied survey lines in the North Pacific.

We ourselves are planning a five-year program in which physical, biogeochemical studies of the intermediate and deep water in the western North Pacific are being conducted including a survey of the 175 ºE line. And, Japanese JGOFS group is also planning the time-series observational station at 43 ºN, l55 ºE in an international collaboration.

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Steric Sea Level Changes due to the Gradual Increase in Atmospheric CO_2 using a Coupled Ocean-Atmosphere Model

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Sea level changes associated with enhanced greenhouse warming are investigated with a global coupled ocean-atmosphere general circulation model. There are 15 hybrid layers between the surface and the model top at lhPa, with a horizontal resolution of 4º in latitude and 5º in longitude. The oceanic component consists of a world ocean general circulation model based on Bryan (1969) and Kimura and Endoh (1989). There are 21 layers from the sea surface to a depth of 5000m, with a horizontal resolution of 2.5º in longitude and 0.5º-2º in latitude. The vertical eddy viscosity and diffusivity are calculated by using the Mellor and Yamada turbulence closure scheme (Mellor and Yamada 1982).

A transient response experiment to the gradual increase in atmospheric carbon dioxide was performed after spin up of the atmosphere (3 years), ocean (1500 years) and coupled system (30 years) (Tokioka et al. 1995). The experiment consists of a control run with a fixed atmospheric carbon dioxide concentration (345 ppmv) and a transient run with a gradual increase in atmospheric carbon dioxide at a compound rate of 1%yr^{-1}. Both control and transient run were carried out for 140 years, using a flux adjustment for heat and water fluxes.

Figure 1 shows decadal mean changes in globally averaged sea level changes (cm) due to expansion of sea water (steric component). It should be noted that the contribution to the rise in sea level from changes in the mountain glaciers and ice sheets over land is not assessed because the model does not represent these factors. The model predicts that the rise in sea level caused by expansion is 12 cm by the time atmospheric carbon dioxide doubles (year 70). These results agree well with those from previous studies (Cubasch et al. 1992, Gregory 1993 and Bryan 1996).

The model is also useful for estimating the spatial distribution of the sea level change. Figure 2 shows absolute changes in local sea levels averaged over the years 66-75. It must be noted again that the predicted changes in Fig. 2 include the seawater expansion (steric component) due to enhanced greenhouse warming only, neglecting the background rise due to land ice changes. A rather small rise is estimated around Antarctica in agreement with Cubasch et al. (1992), Gregory (1993) and Bryan (1996). A minimum rise in the eastern tropical Pacific and a maximum rise in the North and South Pacific (triangle pattern) are predicted, similar to studies carried out by Bryan (1996).

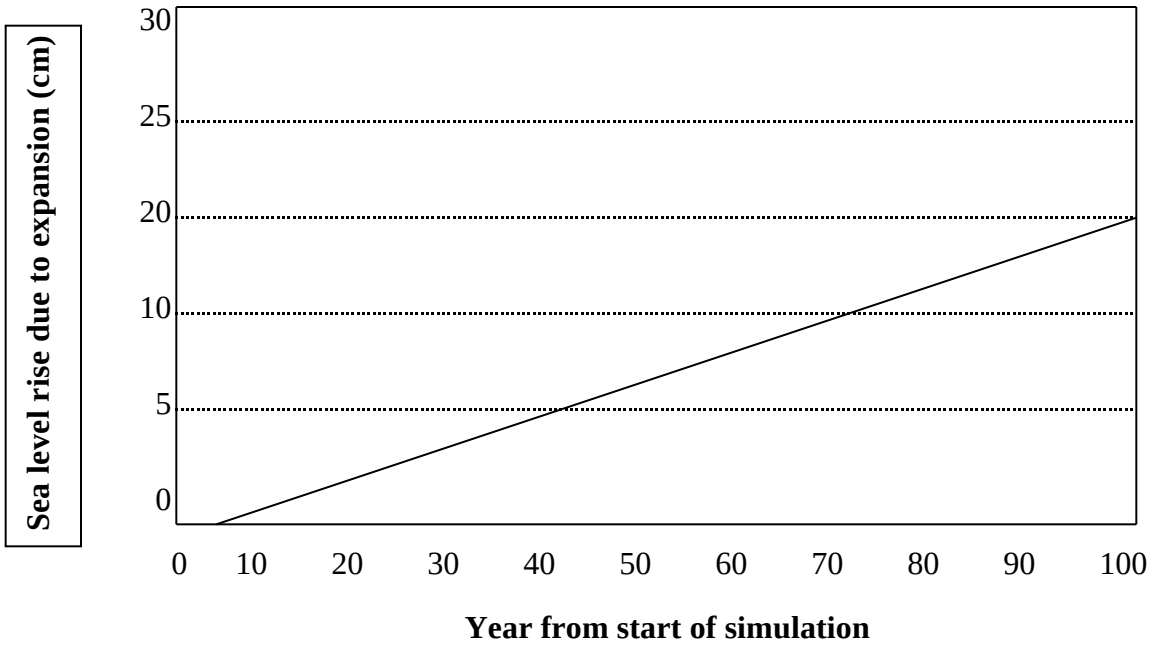

Fig.l The increase in decadally averaged values of global sea level (cm) due to seawater expansion. Contributions to the rise in sea level from changes in mountain glaciers and ice sheets are not included.

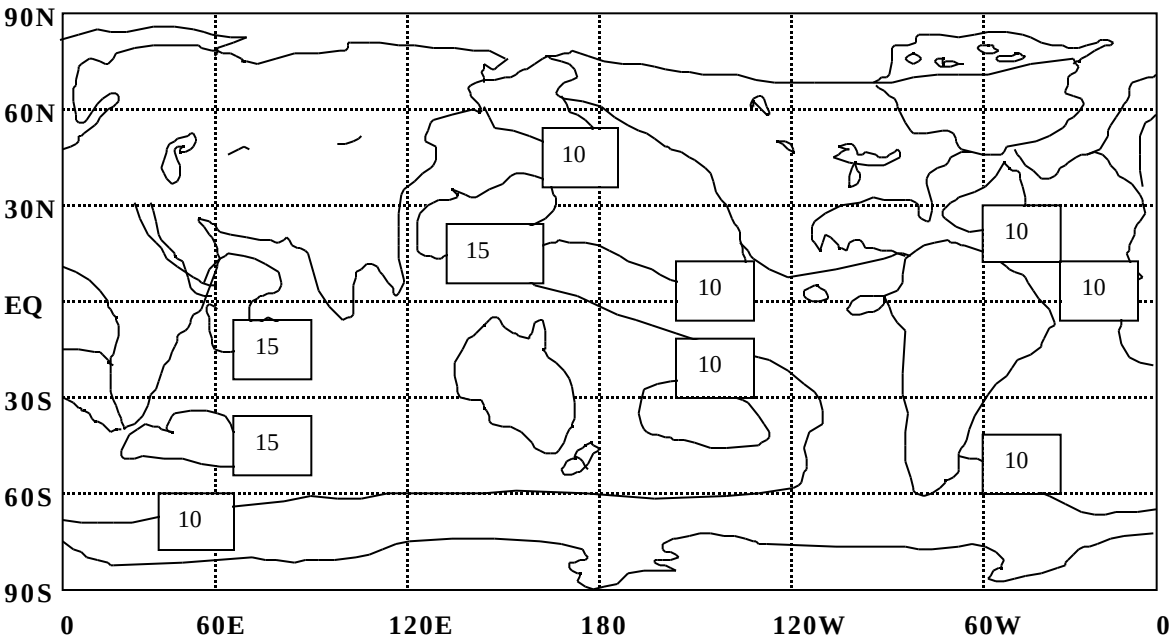

Fig.2 Absolute changes in sea surface topography (cm) due to seawater expansion averaged over the years 66-75. Contributions from changes in mountain glaciers and ice sheets are not included. The contour interval is 5 cm.

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Time series measurement of partial pressure of carbon dioxide in the North Pacific utilizing ship-of-opportunity

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Partial C02 pressure (pC02) of the surface ocean has been measured at the various locations in the world ocean for the estimation of the oceanic C02 uptake. The difference of pCO2 between air and sea drives the absorption of C02 from the atmosphere to the ocean, or the emission of C02 from the ocean to the atmosphere. Since pCO2 has large spatial and seasonal variability, the estimation of the truly averaged balance of oceanic influx and efflux needs intensive observations. The use of a ship-of-opportunity is an effective way to get pCO2 data set with the complete seasonal coverage along a transect of the ocean.

We started the monitoring of pCO2 in the northern North Pacific from March 1995 on a cargo vessel "M/S Skaugran" (belonging to Jahre Wallem Management AS, Norway, chartered by Seaboard Shipping Co., Canada) with the cooperation from the captain, crew, charterer and owners. This is a joint research program of the National Institute for Environmental Studies (NIES), Japan, and the Institute of Ocean Sciences (1OS), Canada, and one of the monitoring programs by Center for Global Environmental Research (CGER)/NIES. The ship sails between Vancouver and several Japanese ports with approximately 6-week intervals. Usually she transports Canadian lumber to Japan and returns back without cargo or sometimes transports Japanese or Korean cars to the United States and Canada. The ship route from Japan to Canada ranges in a latitudinal band between 35 and 52 degrees N. That from Canada to Japan is close to the big circle route, crossing the Bering Sea. Eight or nine round trips per year serve the measurement with complete seasonal coverage.

We installed a water intake line from the bottom of the ship. The depth of the intake from the sea surface changes between 8 and 12 m with the change of the load. Two types of the pCO2 measurement systems were installed at a space in the engine room. One has a conventional shower head type equilibrator with a circulating airflow. The other has a novel bubbling equilibrator with an open airflow, which facilitates the continuous pCO2 data acquisition with a very quick response time. Data of pCO2, temperature, salinity and other sensors are logged in a computer system with every one-minute interval. Atmospheric concentration of C02 is also monitored on board using the non-dispersive infrared analyzer (NDIR) of the shower head type pCO2 system. Two on board personnel operate the system and also take water samples to analyze nutrients, dissolved inorganic carbon species, phytoplankton pigments and so forth. GPS receiver, temperature, humidity and wind sensors with a data logger are installed on a container laboratory at the top deck.

We have already obtained pCO2 records of 16 round trips until February 1997. The complete seasonal data for pCO2 have been obtained. The seasonality of pCO2 in the Bering Sea was clear, having minimum in June and maximum in December to March, which indicates the summer influx and winter efflux of C02. The seasonal minimum in the east Bering Sea of June was lower than 270 ppm but the seasonal maximum of December was 470 ppm as the average in the longitudinal section of 5 degrees. The seasonal variation in the Alaskan Gyre is less significant, having a

seasonal amplitude of 50 ppm. Averaged pCO2 over the whole ship routes between Japan and Canada showed the evidence of oceanic uptake of C02 as the average of the complete annual cycle.

JGOFS (Joint Global Ocean Flux Study) is one of the core projects of IGBP. The objectives of the international JGOFS program is to measure and understand the time-varying fluxes of carbon and associated biogenic elements in the ocean. Thus, in order to accomplish the goals of JGOFS, it is necessary to determine not only the spatial variability of the upper ocean biological and chemical properties, but also the variability in time. Today it is particularly urgent to understand the role of upper ocean processes in ocean-atmosphere carbon exchange since industrialized countries have agreed to limit the atmospheric increase of anthropogenic carbon dioxide. JGOFS programs in the United States and Canada have established time series stations in the subtropical oceans at Bermuda and Hawaii and in the eastern subarctic Pacific at station P (in the Alaskan Gyre).

The ongoing activity of NPTT (North Pacific Task Team) as the international cooperative program between the countries around the North Pacific is to start the time series measurement in the western subarctic Pacific as the good comparative station of station P in the eastern subarctic Pacific. Participants from United States, Canada, Russia, Japan, Korea and China joined at Mutsu City, Japan to have an international symposium on "Biogeochemical Processes in the North pacific" in November 1996. We started the discussion about the strategy to start the new time series observation study within an international cooperative framework. To organize the time series measurement by research vessels occupying the target station, Japanese participants have started the campaign to gather the interests of oceanographers (spring annual meeting of Japanese Society of Oceanography, Apr.1997, Tsukuba, Japan) and to get funds to keep the measurement. Especially, the program seeks the link with the research program of the new worlds largest research vessel MIRAI, which can accomplish the winter observation of sub arctic area. The combination of frequent occupations in spring to autumn seasons by conventional research vessels belonging to various agencies in Japan and winter occupation of MIRAI will give a high quality time series measurement of geochemical cycles of carbon.

The target point of the time series survey, which international participants already agreed, is 43 degrees N and 155 degrees E. There is overlap of the ship route of the ship-of-opportunity monitoring program by NIES and IOS cooperation. The monitoring program gives a long-time series data set with wide spatial coverage, which is the necessary basic information for the new time series station measurement.

Summary of Ocean/Climate Research at the Naval Postgraduate School (NPS)

by A. Semtner, R. Tokmakian, J. McClean, W. Maslowski, and Y. Zhang

Exploration of global ocean circulation with eddies admitted at 1/2-degree became possible in the early 1 990s by exploiting the power of multi-processor computers such as the CRAY X-MP/4 and Y-MP/8. With resolved length scales near the Rossby radius of deformation, along with rather smooth bathymetry, initialization from climatological data, and forcing by atmospheric and surface ocean conditions, many aspects of global ocean circulation were depicted properly (Semtner and Chervin, 1992). A series of decadal calculations explored the effects of improvements in surface forcing, using observed winds from analyses of the European Centre for Medium-range Weather Forecasts (ECMWF).

Algorithmic improvement of the Parallel Ocean Climate Model (POCM) in 1993 included a free surface, mercator grid, better state equation, and Los Alamos speedups. The free surface was available from UK oceanographers; and the Mercator grid was adopted to better track the Rossby radius. Los Alamos modellers suggested pressure averaging and reduced diffusion at high latitude.

Starting in 1994, global simulations were conducted for the years 1987-onward with 1/4-degree (average) grid spacing, unsmoothed bathymetry, high-frequency ECMWF winds, and ECMWF heat fluxes. Limits on the total computer memory of CRAY Y-MP machines at the National Center for Atmospheric Research (NCAR) allowed increased resolution only to 1/4-degree on a latitudinal average; and this became the configuration (along with 20 levels) for further simulations. Smoothing of bathymetry was no longer needed for numerical stability; so geometry could be specified quite accurately. ECMWF daily wind stresses and climatological heat fluxes were used; and a very successful simulation of the period 1987-1994 was reported in Semtner (1995) and Stammer et al. (1996).

Collaboration with Los Alamos began in 1994 on eddy-resolving global runs for 1985-95 at approximately 1/6-degree (latitude average) using the parallel ocean program (POP) on the massively parallel CM-5. Semtner (1995) reported early results in a review article; and impressive results of simulations with various specifications of atmospheric forcing are reported in Maltrud et al. (1997).

Comparisons of output from models is made against satellite, hydrographic, and tide-gauge data (sometimes collaborating with observationalists). Major efforts are made to evaluate models as well as to understand global dynamics. Comparisons involve both the 1/4- and 1/6-degree models. The ocean models can now reproduce the detailed time variations that are observed, as well as depicting eddy effects and boundary transports at their observed length scales and with magnitudes that are only slightly smaller than those observed.

Wieslaw Maslowski and a PhD student, Rost Parsons, built a high-resolution model of the Arctic Ocean and subpolar North Atlantic, in order to complete the global domain relative to earlier modeling studies. The new model has 1 8-km grid spacing and 30-levels; and it can smoothly join to near-global models at the equator or simply overlap them in the North Atlantic. The model runs on vector-parallel and massively parallel computers; and it has been successfully validated on both regional and local spatial scales.

Yuxia Zhang adopted new efficient Hibler ice dynamics and produced an 18-km ice model with thermodynamics as well. In collaboration with Maslowski, she joined this to the Arctic ocean-model for coupled simulations of 1990-94. These simulations exhibit many features found in recent observations, such as large episodic polynyas and interannual eddy-related ice patterns in the northern Greenland Sea. Zhang also joined a southern-hemisphere ice model to the 1/4-degree near-global ocean and ran it with 1990-94 ECMWF forcing.

Better physical treatments continue to be implemented. Methods of reducing the aliasing of high-frequency inertial waves have been found. Surface boundary conditions on bouyancy are better

specified, and methods of deep convection are being implemented. Exploration of overflow dynamics will lead to better treatments of processes in narrow passages such as the Denmark Strait in both the Arctic and global ocean models. A Kraus-Turner mixed-layer model has been implemented in the 1/4-deg. model and successfully tested. Finally, the Cox-Redi isopycnal mixing tensor is installed, if future applications should require parameterization of subgrid-scale effects.

Collaboration began in 1996 to develop a massively parallel climate model in concert with Warren Washington's group at NCAR. Thanks to the availability of POP and the parallelization of the Community Climate Model Version 3 (CCM-3) at NCAR, this could be completed by building on ice modeling efforts of Zhang at NPS. Over the last six months, the model has been successfully brought to production status on a CRAY T3D at NCAR. This is the first successful parallel-coupled model -- and one with sufficiently high resolution in both atmosphere (T42) and ocean (2/3-degree) to portray climate states and climate variability with greater accuracy than was previously possible. Additional physical components will be tested as part of bringing the model to maturity.

Construction of a fully global POCM ocean and ice model for studies of ocean circulation and decadal variability using ECMWF reanalyzed data has just been completed in early 1997. New multidecadal integrations are in progress on a CRAY C-90 machine at NCAR. The Arctic and 1/4-degree global ocean models with sea ice are being run with continual exchanges of lateral boundary information in the region of overlap (the subpolar North Atlantic). Data from the ECMWF reanalysis project are now available at NCAR for the years 1979-93; and together with the operational analyses of 1993-96, eighteen years of forcing data are being prepared to run an ensemble of experiments. These experiments will help determine the predictability of ocean climate changes out to decadal time scales, as well as the relative roles of wind variability and thermohaline-forcing changes in producing climatic variations. The high resolution of both the ice and ocean models is expected to allow better representations of both mean circulations and low-frequency variability than is possible using coarser-grid ocean models. The opportunity exists also to make comparisons with observations that may lead to identification of decadal climate variations in progress. The NPS group is eager to interact with and collaborate with other groups that are interested in similar climate problems.

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Influence of Global Warming on Tropical Cyclone Climatology --- An Experiment with the JMA Global Model

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Influence of the global warring on tropical cyclone climatology has been studied using two ten-year integrations of the Japan Meteorological Agency (JMA) global model at T106 horizontal resolution. First integration (CNTL run) forced with observed sea surface temperature (SST) for the period from 1979-1988, could simulate current tropical cyclone climatology reasonably well. The second integration has been conducted with the increased SST due to global warming and doubled atmospheric C02 concentration. The SST increase (Fig.l) is estimated from the results of transient C02 experiment with MRI-CGCM (Tokioka et al., 1995).

Comparison of the two integrations has revealed significant reduction of the number of tropical cyclones due to global warming (Fig.2) . Most significant reduction (from 219 to 75) has occurred in western North Pacific. In contrast, significant increase (from 74 to 119) has occurred in North Atlantic. No significant change in the intensity of tropical cyclones due to global warming has been found.

To understand reason for the change in tropical cyclone frequency, Gray's Yearly Genesis Parameter (YGP) is computed for the CNTL run and 2xCO2 run. Among the factors that constitute YGP, low level vorticity and relative humidity are found to contribute to the reduction in the frequency of tropical cyclones. However, the change in the YGP due to global warming is generally dominated by SST increase, and the computed YGP shows the overall increase in tropical cyclone frequency. This is in disagreement with the results indicated by the number of simulated tropical cyclones. It may be doubtfiil whether the YGP can be applied to the global warming climate.

Fig. 1 shows that SST is increased almost everywhere, but the magnitude of the SST increase is relatively small over the central Pacific and large over the North Atlantic. This may account for the decrease and increase in the tropical cyclone frequency in these regions. It has been noted that convective activity is increased in the regions where the SST increase due to global warming is large but it is decreased over the regions where the magnitude of SST increase is less even if the SST increase is positive. This suggests that the change in the tropical circulation pattern associated with the pattern of SST increase rather than the local SST change explain the change in the tropical cyclone climatology.

Sirnilar experiment conducted by Bengtsson et al. (1996) has also shown that reduction of tropical cyclone frequency may occur due to global warming. In their experiment, the reduction has occurred more evenly over the globe in contrast to the large regional difference found in our experiment. The difference between the two experiments may be due to the difference in the pattern of SST increase used for the two experiments.

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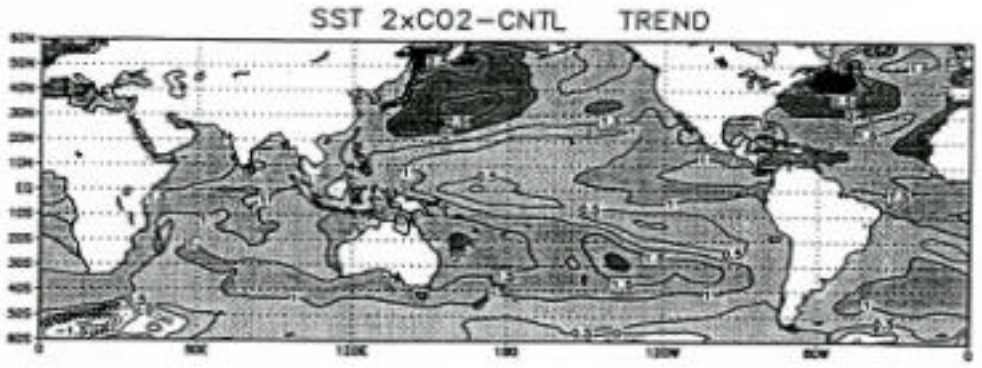

Fig.1 Sea surface temperature increase due to global warming estimated by the linear trend in the transient CO2 experiment with the MRI CGCM.

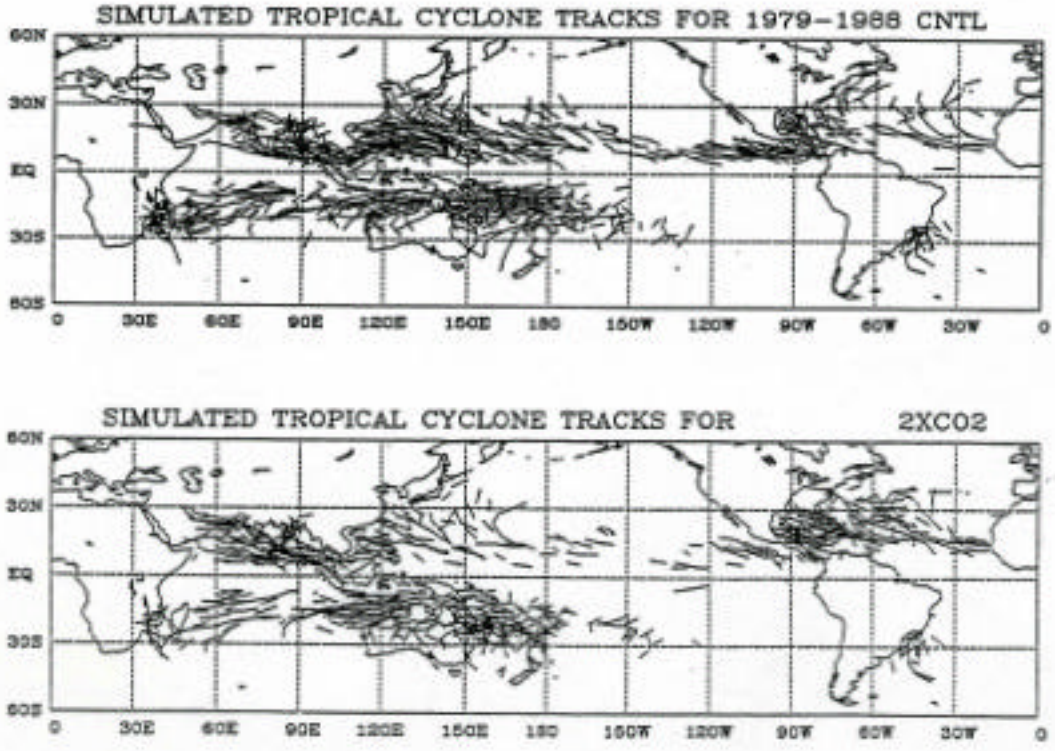

Fig.2 Simulated tropical cyclone tracks for CNTL run (top) and 2XCO2 run (bottom).

WORKING GROUP 2

Incorporating Climate Considerations into the National Forest Policy in Japan

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Abstract. A computer simulation model developed for the Japanese Forest Resource Basic Plan is the basis of the Japanese forest policies. This model will assess mitigation policies under the four scenarios which are: a) stabilizing timber supply at the present level (case 1); b) adopting long rotation (case 2); c) moderately promoting domestic supply (case 3); and d) aggressively promoting domestic supply (case 4). The results indicate the four scenarios contribute to storage carbon into the forest sector in order of case 2, 1, 3 and 4.

Key words, Carbon storage, Growing stock of forests, Wood products, Simulation

1. Introduction

The present forest policy mainly focuses only on the economic side of the forest sector. But another change is the increasing importance of environment protection at the global scale which is now becoming more recognized among the general citizens. In current review work, the policy has considered the environmental side of the forest sector. For example, in the New Forest Basic Plan, a quantity of supply and effects derived from forest roles of non-timber use are to be evaluated, too. Of course, the mitigation effects on the global warming phenomenon, by sequestration of carbon in the atmosphere by the forest ecosystem are important in the Basic Plan. If the forest role of mitigating the global warming is simulated on the Basic Plan, it becomes possible to assess efficiencies of forest policies to reduce the carbon stock in the atmosphere. This report focuses on the role of forest in reducing the global warming phenomenon as incorporated into the Japanese Policy.

2. SCENARIOS FOR ANALYSIS

Three scenarios are set up to show future wood supply derived from domestic forest resources under different options. The case 1 is a policy that the wood supply will be carried out under stable economic conditions which is similar to the present situation. Japan imports 76 % of its total demand for wood, which totaled 83 million cubic meters from overseas in 1994. The amount of domestic supply is only 27 million cubic meters. The case 2 scenario is that a rotation length is almost doubled. An average cutting age of Japanese plantations is 55 years old at present. According to the standard yield table for plantations, growth rates of plantations become pretty smaller over 100 years old. Then, it is not effective to expand the rotation length more than 100 years. Therefore the Case 2 scenario is set to postpone a rotation from 55 to I 00 years. Other various kinds of suppositions in the case 2 are the same as the case 1. Concretely, the average cutting year is prolonged 10 years for every five years. In the case 3, several slightly positive policies are adopted to expand the domestic supply share in the Japanese timber market. These forest policies include the positive investment for logging roads, introducing highly efficient forestry machines, subsidizing forest management and wood industry, tax deductions and so forth. As it turns out, shares of domestic production wood of 24 % at the present stage is magnified positively and realizes its share of 30%. The case 4 scenario adopts a rapid changed policy to promote domestic timber production and realizes the domestic wood share of 32% in the timber market.

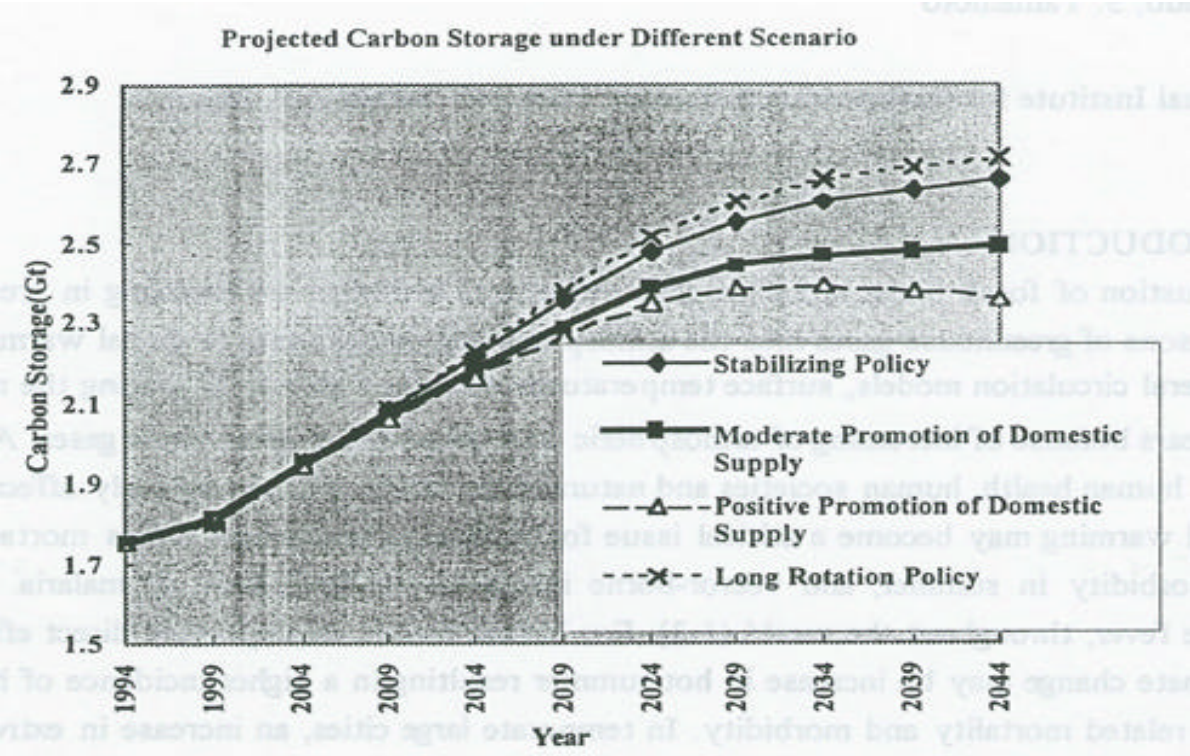
3. Results

The above ground carbon storage of growing stock of plantations is calculated by whole biomass and a wood density. The results in the case 1, 2, 3, and 4 are 2.66Gt, 2.72Gt, 2.46Gt and 2.36Gt respectively 50 years later in Figure. The 90% of harvesting volume from plantation are used for wood products for constructions and these wood products are continuously used for 36.8 years on average before the carbon stored in wood products is released into the atmosphere. The carbon content in wood products is calculated as follows:

Carbon content = Wood volume*density*0.5 (where density of wood yielded from Japanese plantation is 0.4)

4. Conclusion

The total carbon of growing stock of Japanese forests and wood product volume in the next 50 years shows the long rotation scenario is the best among four scenarios. Extension of a rotation itself did not give great influence to increase of growing stock in a country with much import wood like Japan. It is said that 50 million cubic meters is the potential wood supply ability of Japanese plantation forest. Extension of durable years of house realizes to increase growing stock. Especially it is effective for the positive scenario of producing timber to accumulate carbon into a forest sector. Accordingly, this policy will become an effective means letting growing stock increase when production activity of domestic wood will be thrived.



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Direct Impacts of Global Warming on Morbidity in Human Community

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INTORDUCTION

Combustion of fossil fuels, industrial and agricultural activities are resulting in greater emissions of greenhouse gases into the atmosphere and contributing to global warming. In general circulation models, surface temperatures will rise 1 to 3.5 degrees celsius during the next 100 years because of increasing atmospheric concentrations of greenhouse gases. As a result, human health, human societies and natural ecosystems will be adversely affected. Global warming may become a critical issue for increasing severe heat stress mortality and morbidity in summer, and vector-borne infectious diseases such as malaria and dengue fever, throughout the world (1-3). For human health, an important direct effect of climate change may be increase in hot summer resulting in a higher incidence of heat stress related mortality and morbidity. In temperate large cities, an increase in extreme heat stress related morbidity and mortality would be associated with global warming and an enhanced heat island effect. Heat stress related mortality would already show an increase in the elderly as a result of very hot summer temperatures in the cities (4,5). The incidence of heat-related diseases such as heatstroke in the elderly has been shown to increase rapidly as a function of increasing summer temperatures (6,7). Since global warming will increase summer temperature, it is necessary to evaluate the increase of heat-related diseases in some temperate large cities.

METHODS

To evaluate the health effects of heat stress in hot summer, epidemiological studies were carried out for Tokyo, Japan and for Nanjing and Wuhan China. In these cities, the very hot months are July and August with monthly mean temperatures between 27 degrees celsius and 28 degrees celsius and average relative humidities between 70% to 80%. Usually heat stress intensity in summer is different from year to year. In 1993, summer temperatures were moderate, whereas summer temperatures were severe in 1994. Therefore, epidemiological studies have been carried out for the summer seasons during 1993 to 1995.

RESULTS AND DISCUSSION

Since heat stress conditions were moderate in the summer of 1993 in Japan and China, the incidence of heatstroke patients was very low. However, serious heat stress conditions occurred and heatstroke patients increased dramatically in the summer of 1994. In Tokyo, a significant positive correlation was observed between the maximum or mean daily temperature and the daily number of heat stroke patients above a certain threshold temperature. For Nanjing and Wuhan, a significant positive correlation was also observed between temperature and the daily number of heat stroke patients. The incidence of heat stroke was remarkably higher for elderly persons. The regression analysis showed that the number of heat stroke patients increased exponentially when mean daily temperature and maximum daily temperature exceeded threshold temperatures. From the results, it is predicted that the incidence of heat related morbidity, such as heatstoke in Tokyo may increase as a result of global warming. For large cities located in temperate zones, an increase in extreme heat stress related morbidity and mortality would be associated with global warming and an enhanced heat island effect. In particular, heat stress related mortality would show an increase in the elderly as a result of very hot summer temperatures in these cities (4, 5). The incidence of heat-related diseases such as heat stroke in the elderly already has been shown to increase during very hot summer temperatures (2, 4-6). The incidence of heat-related diseases, such as heat stroke in the elderly, has been shown to increase rapidly during prolonged periods of very hot summer temperatures. A significant positive correlation was observed between the maximum or mean daily temperature and the daily number of heatstroke patients above a certain threshold temperature. The regression analysis showed that the number of heat stroke patients increased exponentially when the mean daily temperature and maximum daily temperature exceeded threshold temperatures. Some physiological and biochemical adaptations could occur to protect essential cell functions against increased temperature and permit a rapid recovery from heat stress (7). However, each person has a different sensitivity for sustaining thermal injury according to their age and their capacity to adapt physiologically to prolonged exposures to high temperatures (6). For human health, it is predicted that global warming may increase the frequency and duration of severe heat stress in summer months (1, 2, 5). The incidence of heat related mortality and morbidity, such as heatstoke in the elderly has been shown to increase as a result of exposure to long periods of hot summer temperatures. Therefore, it is necessary to determine to what extent the incidence of heat stress related morbidity and mortality will be affected as a result of global warming.

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The Effects of Mass Media on People' s Knowledge on the Environnent

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KEY WORDS: Media Effect, Knowledge, Perception, National sampling

ABSTRACT

We investigated the effects of Mass Media on the distribution of Knowledge on the Environnent. We asked 12 quiz concerning science and environmental issues for nationwide respondents, who are randomly sampled from 16 years and older, male and female adults. We found the distribution of scores which were derived from the number of correct answers on the quiz, are related significantly to gender, (positive to be male), age (negative to older age), educational level (positive to higher education), and marriage status (positive to married respondents), and also media exposure. Respondents who contact regularly with current issues programs, news, documentarys on TV, health and medical issues, domestic policy issues on Newspaper items, and science magazines have higher knowledge than others, and who contact with sports programs and drama programs on TV have less. Thus we can recognize significant media effects on environment knowledge of people here.

INTRODUCTION

To improve efficiency of fuel consumption or energy-consuming facilities in household sector, people need to be given information about the way to use them efficiently. Also to behave environmentally soundness, we must know what is environmentally soundness, what behavior cause environmental degradation. We can call this knowledge as Environmental Literacy, which is analogy to 'Scientific Literacy by Jon Miller. This literacy would be useful to promote people to act environmentally sound behavior.

ANALYSIS and RESTULTS

This first figure shows that misunderstanding of greenhouse effect and Ozone depletion, though both issues are caused by CFCs. This quiz was based on Kempton's paper (1992). This result was quoted in White Paper on Environment in 1994. To analyze the environmental literacy and media contacts, we did some quiz (Figure2) and tried to explain respondents correct answer rate by demographic characters and media contacts. Our result is showed in Figure 3. According to the multiple regression, gender (positive to male), age (negative to older), education level (positive to higher education), and marital status (positive to male). For newspaper items, positive to the items of 'Health/Medical', 'Domestic politics' and negative to 'Sports and 'Not Read. For TV programs, positive to 'News/Information, 'Current Issues, Documentary and negative to 'Drama'. Reading 'Scientific Magazine' is also positive effect to total correct answer rate.

DISCUSSION and RECOMMENDATION for further research

This result shows that there is a clear effect of media effects on people's environmental knowledge. Tb distribute new discoveries and new technologies among the world, we cannot ignore the role of the media. My result here uses a simple nultiple regression model, but to analyze the effects of the media fully, we have to apply content analysis of TV programs, newspaper and magazines, which Mikami et al. tried.

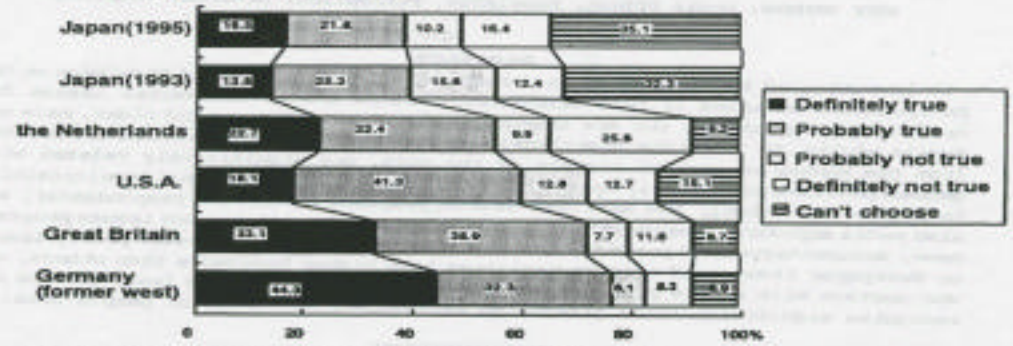

Figure 2 Knowledge Items for Environment and Sciences

T/F	Questionnaire	Correct Answers (%)
F	ALL radioactivity is made by humans	31.5
F	Antibiotics can kill bacteria, but not viruses	22.1
F	Astrology - the study of star signs - has some scientific truth	39.3
T	Human beings developed from earlier species of animals	79.8
F	All man-made chemicals can cause cancer if you eat enough of them	36.1
F	If someone is exposed to any amount of radioactivity, they are certain to die as a result	42.0
T	Some radioactive waste from nuclear power stations will be dangerous for thousands of years	75.8
F	The greenhouse effect is caused by a hole in the earth's atmosphere	26.6
T	Everytime we use coal or oil or gas, we contribute to the greenhouse effect	78.4
F	All pesticides and chemicals used on food crops cause cancer in humans	49.5
T	Human beings are the main cause of plant and animal species dying out	81.6
F	'Cars are not really an important cause of air pollution in Japan	71.0

*) Correct Answers' was calculated from the sum of responses of 'Strongly true' and 'Probably true' in 'True' sentence(indicated T in T/F Column), 'Definitely not true' and 'Probably not true' in 'False' sentence(indicated F in T/F Column)

Figure 3. The Result of Multiple Regression Analysis

	Variables	Model
	Constant	4.85(.394)
Demographic	Gender (Male=1, Female=0)	1.24(.128)
	Age(16~)	-.033(.004)
	Official Educational Level *)	.552(.087)
	Marital Status (Married=1, Other=0)	.403(.139)
Media items	NP; Health/Medical	.358(.138)
	NP; Domestic Policies	.264(.134)
	NP; Sports	-.385(.131)
	TV; News/Information	.573(.139)
	TV; Current Issues	.402(.123)
	TV; Documentary	.302(.130)
	TV; Drama	-.243(.120)
	MG; Scientific Magazine	1.19(.392)
	NP; Not Read	-.707(.301)
		R^2=.21987
		F =31.67395

Figures in every cell are the coefficients of each variable, and figures in parentheses are statistic values. (All t-values are significant at 5% level, F-values are at 0.1% level) a. Educational level (Primary, High School, Universities, Colleges) are all official ones, training schools, culture schools are not included. b. TV indicates Television program items, NP is Newspaper, MG is magazine.

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Current Research on the Integrated Assessment of Global/Climate Change

Research overview prepared for the Fifth Japan-US Joint Workshop on Global Change

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NSF-Funded Research
New Methods for Decision-Focused Integrated Assessment:
Multiple Objectives, Risk Evaluation, and Visualization

Principle Investigators: Hugh Ellis and Ben Hobbs

This work has as its principal objective advancing the state-of-the-art of integrated assessment methodologies through improved analytic techniques. Our focus is on the policy evaluation function of integrated assessment: the display of tradeoffs and risks associated with alternative policies, and the application of value judgements to rank and screen policies. We hope to develop methods that will improve the capability of integrated assessment systems to perform policy relevant modeling and decision evaluation by incorporating:

1. explicit representation of alternative policies;
2. credible physical models and/or the capability to easily modify the system to incorporate alternative model structures and parameters;
3. performance indicators, or *objectives,* that address the concerns of policy makers, characterizations of the uncertainties associated with model o~tputs, and the sources of those uncertainties;
4. a user interface that encourages "play" (sensitivity analysis and exploration), while effectively communicating tradeoffs among objectives and uncertainties; and
5. the ability to quickly show the implications for policy choices of alternative value judgements concerning acceptable risks and tradeoffs among objectives.

These methods are grouped into three research areas: *Computation in support of decision evaluation under multiple objectives and uncertainty; Visualization;* and *System-user dynamics.* The computation issues include: rapid generation of non-dominated alternatives; identification of stochastically non-dominated alternatives when there are multiple objectives; identification of alternatives that perform well on regret-based criteria; and the ability to link (i), a solution in objective space with (ii), the corresponding solution in decision space and (iii), the value judgements implied by choosing that solution. The visualization-related research focuses on effective presentation of information on tradeoffs and risks. System-user dynamics include research activities designed to enhance user's ability to conveniently save and compare results. These areas form the conceptual basis for our work and we plan to implement them in three research thrusts: Multiple Objective Approaches; Alternative Methods for Uncertainty Analysis and Decision Support: Regret and Stochastic Dominance; and Visualization.

Modelers in a workshop will evaluate the methodological developments from this research, that is, the new tools and approaches (involving multiple objectives, uncertainty and visualization). The revised and refined methods will then be used and evaluated by potential users in one additional workshop. The intent here is to produce research results that have broad applicability and generalizability. These workshops will take advantage of a unique opportunity that exists in the form of two existing integrated assessment systems. One is a large-scale integrated model for global climate change developed with support from the National Oceanic and Atmospheric Administration. The other system focuses on adaptation to climate change within a specific region (the Great Lakes), and was supported by NSF and the US Army Corps of Engineers. The

assessment models will provide a realistic context within which our proposed approaches can be developed and evaluated. The workshops in which these models will be applied by the practitioner will further the important goal of fostering interaction between the policy and research communities.

EPA-Funded Research
Integrated Assessment of the Public Health Effects of Climate Change for the United States

Principal Investigators: *Jonathan Patz and Hugh Ellis*

Investigators and Affiliations
Johns Hopkins University: Jonathan Patz, Hugh Ellis, Robert Gilman, Thaddeus Graczyk, Greg Gurri-Glass, Subhash Lele, Marc Parlange, Brad Sack, Jonathan Samet, Clive Shiff, Scott Zeger
University of Maryland: Rita Colwell**,** Anwaral Huq, Estelle Russek-Cohen
Pennsylvania State University: Anne Fisher, Jim Shortle, James Lynch, Ray Najjar, Robert Evans, Egide Nizeyimana
University of Delaware: Laurence Kalkstein
Georgia Institute of Technoloy: Anne Bostrom
Science Communication Studies: Joan Aron
NOAA, National Climatic Data Center: David Easterling, Thomas Karl
NASA, Ctr. Health Applications of Aerospace Related Technologies: Byron Wood
University of South Florida: Joan Rose
US Department of Agriculture: Dana Focks
University of Texas, Houston: Jack Hayes
New Orleans Mosquito Control Board: Edgar Bordes

The objectives of this project are to reduce the uncertainty in risk assessment of the impact of climate change on key public health endpoints, and to characterize and communicate this information to support policy development and analysis. To achieve these objectives we will: 1) Analyze key climate-sensitive diseases that have the potential to expand or contract, intensify, or shift in spatial distribution; 2) Develop an interdisciplinary, integrated approach that addresses the complexity of anticipated disease responses to climate and ecological change; utilize quantitative methods to further improve the risk assessment and, for one case study, illustrate the costs of alternative options for reducing health risk; and 3) Adopt risk communication strategies to insure that our findings can effectively inform policy makers on the public health risks associated with climate change. Attainment of our objectives will result in an expanded knowledge base upon which sound decisions can be made regarding climate change policy.

Our methodological tools include the following: downscaling climate analysis, geographic information systems, remote sensing, hydrologic modeling, disease modeling and spatial statistical analysis. Our approach is multidisciplinary and collaborative, involving participation from twelve academic, government and private organizations. It involves case study analyses and includes climate change simulation analysis, followed by hydrological and ecological modeling, which in combination constitute the driving forces for the public health outcomes. The selected climate-sensitive and region-based case studies include water-borne Crytptosporidiosis and Cholera; vector-borne diseases, specifically Lyme and other tick-borne diseases, Hantavirus, and Dengue and Dengue Hemorrhagic Fever; and heat-related mortality. Risk communication models that will be used as part of our overall effort to insure that our findings will effectively support policy decision making regarding public health risks associated with climate change.

Teaching Initiatives
Global Change and Human Health - spring 1997

An important task in addressing issues of global change and associated effects is to help train students who will become the next generation of scientific and policy leaders. Described below is a course offered for the first time in Spring 1997, in which we are attempting to convey to students

some of the important science of global change and public health, and ways through which that science can be brought to bear on policy relevance.

Course Syllabus
This course will examine the links connecting disease and Earth's environment, and the implications of those links for human health in a changing global environment. Team-taught by faculty from the School of Public Health, Arts and Sciences, Engineering and visitors.

Principal Faculty

- Hugh Ellis, Department of Geography and Environmental Engineering, JHU
  Ames 312, 516-6537, hugh.ellis@jhu.edu
- George Fisher, Department of Earth and Planetary Sciences, JHU
  Olin 327, 516-7237, gfisher@jhu.edu
- Jon Patz. Department of Environmental Health Sciences, JHU SPH
  SPH 7041, 260-5874, jpatz@phnet.sphjhu.edu

Dates	**Lecture Topics, Faculty**
Jan 23	Introduction-- Course design and objectives (Ellis, Fisher, Patz)
Jan24	Hanta Virus -- a case study (Patz)
Jan 30, 31	Integrated assessment and policy relevance (Ellis)
Feb 6,7	Earth system, atmospheric circulation and composition (Fisher)
Feb 13, 14	Hydrology; river, coastal and ocean systems; El Nino (Fisher)
Feb 20,21	Ecology (Katalin Szlavecz, JHU E&PS)
Feb 27, 28	Climate modeling (Haydee Salmun, JHE DOGEE)
Mar 6	Conference on Global Climate Change and Implications for Environmental Health (Ellis, Fisher, Patz)
Mar 7	History of the Chesapeake ecosystem (Grace Brush, JHU DOGEE)
Mar 13	Water resources, urbanization and agriculture (M. Wolman, JHU DOGEE)
Mar 14	MID-TERM
Mar 20, 21	SPRING BREAK
Mar 27	Introduction to environmental epidemiology (Patz)
Mar 28	Direct effects of climate change (Laurence Kalkstein, U. of Delaware, Dept of Geography)
Apr 3	Agricultural development and disease (Alfred Buck, JHU SPH International Health)
Apr 4	Malaria -- a case study (Joan Aron, JHU SPH Population Dynamics)
Apr 10,11	Climate, El Nino and mosquito-borne disease (Patz)
April 11	Cholera, marine environments and water-borne disease (Patz, Anwaral Huq, U of Md Microbiology)
Apr 17	Emerging diseases in the U.S; hanta virus and Lyme disease (Greg Gurri-Glass, JHU SPH Molecular Microbiology and Immunology)
Apr 18	Air pollution: human health and ecological damage (John Balbus, Geo Washington Univ. School of Medicine, Occupation and Environmental Medicine)
Apr 24	Potential health effects of stratospheric ozone depletion (Paul Strickland, JHU SPH Environmental Health)
Apr 25	Refugee health and environmental disasters (Les Roberts, Centers for Disease Control, Atlanta)
May 1, 2	Integrated assessment and policy implications for the future (Ellis, Fisher, Patz)

Fifth U.S.-Japan Workshop on Global Change
Working Group 2: Social Systems

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March 10-12, 1997

Human dimensions of global change involve legal, cultural and political as well as socioeconomic considerations. Integrated models ofien include the latter (e.g., discount rates, risk assessment; see Journal of Economic Prespectives, 1993), but neglect the former, more qualitative considerations.

Humans create and maintain systems of rules and organizations to manage uncertainty. Underlying these systems are sets of deeply held beliefs about the relationships between humankind and nature and the relationships between humans as individuals and in groups. In political science and related social science disciplines there is a vast literature on belief systems (e.g., Sabatier and Jenkins-Smith, 1993) and on institutions for collective action (e.g., Ostrom, 1990). To date, there has been no convergence of these two streams of literature (Schlager and Blomquist, 1996).

Global change, as both an international and a regional issue of concern, presents and opportunity to study the incentives and disincentives for collective response on an international scale (Mintzer and Leonard, 1994; Rowlands, 1995) the beliefs of policy elites at the national level (Wilenius, 1996); and the rise of new non-state institutions, such as the non-governmental organizations that have played such an important role in international conferences on the environment (Hurrell, 1994; Willets, 1996).

More work is needed, however, at the local level, where small changes in average temperatures or sea levels could have devastating effects on the human populations. What local institutional frameworks, nested within national and international governmental arragements, can help to provide the needed flexibility and response systems to mitigate the effects of global change? In the Arctic, for example, in-migration and resource development have led to large, permanent settlements where there were once small, highly mobile societies, resulting in a loss of flexibility to respond to environmental contingencies. In addition, native groups in the north are seeking greater autonomy. How will these aspirations and their realization (e.g., Nunavut) affect the human response to change?

These issues are ripe for investigation, particularly in a comparative framework.

Direct and Indirect Impacts of Climate Change on Human Health: Research Needs

by
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Direct Impacts of Climate Change on Human Health

1) Temperature and Air Pollution

The Intergovernmental Panel on Climate Change (IPCC) has issued a recent report that predicts C02 concentrations in the atmosphere will double in the next 50 to 100 years. As a result of the greenhouse effect, a doubling of atmospheric concentration of C02 could cause surface temperatures to rise 1 to 3 ^{0}C. As a greenhouse gas, C02 absorbs energy that is re-radiated from earth's surfaces at infrared wavelengths. Because of the absorption of infrared energy by C02 and other greenhouse gases, temperatures in the atmosphere near the surface are maintained within a small band of maximum and minimum temperatures throughout the year.

With increasing C02 concentrations, there could also be increased concentrations of air pollutants because the primary source of C02 emissions is combustion of fossil fuels. Therefore, it is important to examine the combined effects of rising temperatures and rising air pollutant concentrations on human health, particularly in urban areas. Urban areas are being emphasized because historically these are the areas where the longest periods of human exposure to high temperatures and air pollutant concentrations have occurred.

An indication of how this analysis can be accomplished and why it is important to examine the combined effects of temperature and air pollution on human health comes from work by Shumway and his collaborators (1988. Environ. Res., 45:224-241). Data on cardiovascular and respiratory mortality as a function of climatic and air pollution variables from 1970 to 1979 for the city of Los Angeles, were analyzed. Regression formulas developed from these data indicated that mortality from cardiovascular and respiratory causes was a quadratic function of temperature and a linear function of air pollutant concentrations. It was shown that mortality increased in a synergistic manner with increasing temperatures and air pollutant concentrations. Age and place of habitation in Los Angeles County stratified mortality data. The elderly age greater than 65 and people who lived in downtown Los Angeles had higher mortality rates as a result of exposure to high temperatures and air pollutant concentrations. Because temperature was a quadratic variable, higher mortality rates were also observed at lower temperatures and air pollutant concentrations.

Analysis of data on morbidity and the development of regression formulas for morbidity as a function of temperature and air pollutant concentrations need to be done for many different urban areas. Analysis of mortality and morbidity data as functions of temperature and air pollutant concentrations also needs to be carried out for many urban areas that are located in different climatic zones in the United States and Japan. These regression formulas make it possible to examine not only the relative risk of mortality and morbidity in different urban areas but also make it possible to evaluate the effectiveness of mitigation technologies to reduce risks of mortality and morbidity that would be achieved by lowering C02 emissions. Most recent studies on direct impacts on human health of climate change have focused only on the health impacts as a result of increasing temperatures. Because high and low temperatures and high and low air pollutant concentrations occur together, analyses need to be expanded to include the combined effects of exposure to both temperature and air pollutants. There may be instances in which mortality and morbidity are functions only of temperature or are functions only of air pollutant concentrations. At the present moment, it is difficult to compare how mortality and morbidity are affected by temperature and air pollutant concentrations from region to region. In addition, the information on morbidity and

mortality needs to be incorporated into the development of methods to evaluate mitigation technology performance at reducing health risks.

2) **Stratospheric Ozone Depletion**

Depletion of stratospheric ozone has resulted in greater exposure to shorter wavelength UV radiation. At the present time, the depletion of stratospheric ozone is most pronounced in the Polar Regions, especially Antarctica but increasing exposures to shorter wavelength UV radiation has been reported in mid- and high latitudes as well. Increased exposure to shorter wavelength may result in a higher incidence of cataracts and skin cancers, both melanoma and non-melanoma skin cancers. At the present time, the incidence of non-melanoma skin cancers appears to be a function of duration of exposure and is highest in light-skinned populations. Melanoma skin cancers, on the other hand, appear to be related only to an initial high intensity exposure to shorter wavelength UV radiation. Many people exhibit photosensitivity when exposed to shorter wavelength UV radiation, especially people who are on long-term medications. A weakening of the immune system as a result of increased exposure to shorter wavelength UV radiation may have an important role in cancer induction of both types of skin cancers and photosensitivity, but this role is unclear. In addition, a weakened immune system may result in increased vulnerability and susceptibility to infectious and non-infectious diseases.

The chlorofluorocarbons (CFCs) have been linked with the complex set of reactions occurring in the stratosphere that causes depletion of stratospheric ozone. The chemicals that have been developed to replace the CFCs are the hydrochlorofluorocarbons (HCFCs) and the hydrofluorocarbons (HFCs). The hydrogen atom in their molecular structures makes these chemicals more chemically and biologically reactive. Not much has been published on the reactivity of the HCFCs and the HFCs in the troposphere and the stratosphere and there are only several reports on the biological reactivity of these chemicals. Data that are available are from Anders and co-workers (Environ. Hlth. Perspect., 96:185-191, 1991; Chem. Res. Toxicol., 4:180-186.1991; Proc. Natl. Acad. Sci., 88:1407-1410,1991; Drug Metabol. Dispos., 21: 634- 639. 1993). These replacement chemicals require much more information about their biological and environmental impacts than is currently available.

Indirect Impacts of Climate Change on Human Health

1) Spread of Infectious Diseases

Many of the biological organisms and processes linked to the spread of infectious diseases are influenced considerably by climatic factors. Increasing temperatures may expand the regions and increase the period of viability and infectiveness for infectious disease vectors such as mosquitoes. Most infectious diseases have their highest incidence rates in tropical regions, but with increasing temperatures, temperate zones could begin to experience higher incidence rates for these diseases. Two major diseases of concern are an increase in the incidence of malaria and dengue fever. In addition the incidence of infections such as schistosomiasis may also rise because of climate-related changes in transmission dynamics and effects on the abundance of snail intermediate hosts. Changing climatic factors can also affect the emergence and resurgence of many other infectious diseases and non-infectious water-borne diseases such as clolera. The role of climatic change in the spread of these diseases needs to be clarified. Preliminary modeling and analysis of the spread of malaria and schistosomiasis as a result of climate change was carried out by Martens and co-workers (Managing Malaria, An Evolutionary Modelling Approach, GLOBO Report Series no.12, RIVM, Bilthoven, The Netherlands; Modelling the Effect of Global Warming on the Prevalence of Schistosomasis, GLOBO Report Series no.10, RIVM, Bilthoven, The Netherlands)

In addition, new strains of these diseases are appearing that are much more resistant to presently available treatments. Research programs are required to develop new treatments for these diseases and to develop methods of vector control that are not only effective but do not leave behind residues that adversely affect environmental health.

2) More Frequent Droughts and Floods, and Their Impacts on Agriculture

Climate change may be characterized by more frequent and longer lasting periods of hot dry weather. More frequent periods of drought and floods could have important implications for agricultural production in areas of the world that have been very productive. The shortages of food that could result may end farming operations in many areas and cause increased migration of rural families to urban centers. Because many of these people may be poor and may be forced to live in very crowded conditions with poor santitation, an increase in diseases that are associated with poor nutrition and santiation could result. In this regard, because of its wide ranging impacts on climate in many parts of the world, the impact of more frequent El Nino-Southern Oscillation (ENSO) events needs to be understood as it relates to causing more frequent and long-lasting droughts and floods in many parts of the world.

Social Systems Response to Global Environmental Change: Institutional Issues Related to Environmental Assessment

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INTRODUCTION

Most all OECD countries have laws requiring environmental assessment of public and private projects. The United States has had twenty-five years experience with formalized environmental impact assessment for federal projects. The passage of the National Environmental Policy Act (NEPA) of 1969, mandated that federal government decision-makers consider the potential environmental impacts of their proposed actions prior to decision making (including more recently impacts to global change). Increasingly there appears to be a harmonization of these approaches across countries. Multilateral lending institutions have adopted similar approaches, as have many development agencies. The changing social, political and technological environment in many of these countries as well as the international marketplace demands that the systems adapt in order to advance. This paper outlines the results of the international environmental effectiveness study I with the hopes that we can learn from our past and map out research areas at an institutional level that may produce greater benefits from assessment approaches to global environmental change.

INSTITUTIONALIZATION OF THE EIA PROCESS IN THE U.S.

Institutions represent the regularized ways in which societies deal with recurring problems. We develop institutions such as the legal institutions to deal with recurring civil disputes, settle disagreements over contracts and distribute justice to those that violate societal norms. Processes, like legal processes, become institutionalized through the establishment of laws and regulations, establishment of courts and jails, establishment of law schools, creation of law firms and so forth. Similarly, the Environmental Impact Assessment (EIA) process has been institutionalized in the United States. The National Environmental Policy Act of 1969 (NEPA) was passed. Following NEPA were Implementing Regulations produced by the U.S. President's Council on Environmental Quality (which emerged after the law was passed). Each Federal government agency then issued its own implementing regulations. Positions were created within agencies to oversee production of EIA's while other positions were created to review and approve EIA's. A body of case laws was developed as interest groups sued federal agencies under NEPA (generally on procedural points). Interest groups became knowledgeable about NEPA as a way of pursuing group goals. Universities developed courses and schools of the environment to teach the NEPA process. New positions were created in universities to teach EIA or existing faculty took on the task. Lawyers began studying and practicing environmental law. Books on environmental law, environmental policy and Environmental analyses were and are published regularly. Consulting firms developed often solely to conduct NEPA analyses, although many branched out to include NEPA with existing staff. Argonne National Laboratory founded the Environmental Impact Statements Division in the early 1970's later to become the Environmental Assessment Division (with a staff of approximately 200). Several professional associations and journals were founded and so forth all based on environmental impact assessments. Different institutional arrangements emerged and exist in each country with environmental assessment legislation and practices. It is by studying these institutional arrangements that I believe we can learn how we might structure global change assessment work in the future. It seems prudent to build off of existing institutional arrangements in order to deal efficiently with social system response to global change.

INTERNATIONAL ENVIRONMENTAL ASSESSMENT EFFECTIVENESS STUDY

The Canadian Federal Environmental Assessment Agency in collaboration with the International Association for Impact Assessment engaged in an international evaluation of assessment practices. This evaluation serves as a good starting point to determine what works and what is needed. In addition I have added additional needs which could be translated into research needs. The findings are summarized below:

1. Institutional foundations of EA both nationally and internationally are in place and in some case being strengthened. Most processes have clear legal mandates, use transparent processes involving the public and generally have an appropriate scope of analysis. Developing countries lack resources and require capacity building to support the EA process.

Needs:
- Better procedural and good practice guidance
· Better on-time performance and clear EA project implementation
- Better resolution of duplication when more than one government is involved
- Better connection between EA processes and decision-making
- Standards for quality performance in EA (international guidelines, principles, and Standards of good practice)

Additional Needs:
- Institutional arrangements appropriate for developing countries (and connection of EA process to decision making)
- Mechanisms for capacity building within developing countries (with associated culture change)

2. EA Processes and Activities are adequate but are in need of upgrading. In general most environmental assessments are adequate, involve the public in consultation and address the issues of concern following acceptable principles. Impact mitigation is often applied and somewhat undervalued. The following however needs work:

Needs:
- Quality control svstems
- Better ways of focussing the assessments (scoping)
- Public involvement focussed on the issues and adapted to the parties involved
- Better frameworks and methods for addressing cumulative impacts and large-scale changes

Additional needs:
- Better understanding of which institutional arrangements for assessment work and why
- Accessible baseline and monitoring data needed for assessments
- Standardized monitoring and mitigation modules easily adapted to host locations and conditions
- Reintegration of humans into the "environment"

3. Strategic Environmental Assessment needs to be included, as a part of Policy Making- Strategic environmental assessments are higher level assessments on programs and policies instead of specific projects. Their use is gaining importance and utility in policy making when used before options are closed. Methods and level of analysis appropriate for project specific approaches may not be appropriate for strategic level assessments. The following needs were identified by the international study:

Needs:
- Flexible approaches to fit varied policy making configurations
- Appropriate methods to the level of decision (don't measure with a micrometer what you intend to cut with a chain saw)
- Inclusion of tradeoffs
- Mechanisms for tracking results of assessments for evaluation purposes

Additional needs:
- Inclusion of values in the assessment (for social groups affected)
- Changes in institutional arrangements to encourage use of strategic environmental assessment higher up the decision-making chain

4. Environmental Analysis should be used as a tool for addressing sustainability. Environmental assessment tools are used for addressing sustainability. There is a 20-plus year history of addressing potential environmental disruption, involving the public and providing

decision-makers with the information they need. Often the issues of sustainability are at a very small geographic scale and treat the environmental system as a closed system. The following were identified as needs by the international study:

Needs:
- Better guidance on the use of sustainability concepts and principles in EA
- Criteria and indicators for screening, significance and checklists
- Ways of specifying carrying capacity, rules of thumb and thresholds
- Mitigation approaches for in-kind compensation
- Practical frameworks for addressing uncertainty, linking ecological functions and social values, avoiding irreversible decisions
- Establish better ways of integrating environmental assessment with decision analysis tools and information technology

Additional Needs:
- Consistent use of similar models to make comparative method possible
- Institutional arrangements for baseline data gathering and monitoring so data are available when needed
- Evaluation methods for determining the validity and reliability of results (and institutional frameworks for evaluation)
- Mechanism to track effectiveness of mitigation measures (and institutional arrangements to assure mitigation is completed)
- Mechanism to share standard approaches to data collection, assessment, monitoring, mitigation

Example Topics for Research
There is an existing institutional framework for dealing with environrnental assessment in much of the world (especially the developed world and among international development and lending institutions). Research is needed to determine how to bring about change in the way environmental assessments are done in order to address global environmental change. Examples of research topics that could be addressed along this line include the following:

Catalog Existing Approaches to Environmental Assessment (especially as these approaches address global change, sustainability and carrying capacity)

Identify institutional arrangements in which assessments are conducted and feed into decision-making (laws, regulations, guidelines, organizations, relationships among organizations, mechanisms for resolving conflict)

Determine the way different government levels connect assessments done for local areas to national policy and national environmental quality

Identify institutional arrangements for establishing, maintaining and sharing baseline and monitoring data (e.g. remote sensing data)

Determine how existing institutional networks could be used for diffusing new assessment approaches

1. Sadler, Barry, International Study of the Effectiveness of Environmental Assessment Final Report - Environmental Assessment in a Changing World: Evaluating Practice to Improve Performance. Canadian Environmental Assessment Agency and the International Association June 1 996.

WORKING GROUP 3

Fifth Japan-US Workshop on Global Change
Honolulu, Hawaii, 10-12 March 1997

Statement for Working Group 3:

Effects of Climate Change on Managed and Unmanaged Systems

Prepared by David R. Maidment
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The effects of climate change on natural systems are manifested through changes in the interaction of the atmosphere with the land surface and in particular with changes in radiation, precipitation, air temperature, wind and humidity. There are also potential impacts on mean sea level if melting of the polar ice caps leads to increases in the volume of ocean waters. Further changes can result from impacts on the global carbon budget of increased carbon dioxide levels in the atmosphere. Of these issues, the ones that I am most familiar with are those dealing with the impact of climate change on water resources, so I'll focus on those in this statement.

The interactions of climatic change and the earth's water resources have existed since the origin of the planet and have been responsible over geologic time for major influences on the evolution of the earth, such as the last ice age when a great ice sheet covered much of North America. In more recent times, cycles of flood and drought have occurred regularly, sometimes with floods in one part of the United States occurring simultaneously with droughts in another, as happened during the great flood of 1993 in the Midwest, which was associated at the same time with a drought in the Southwest of the United States. Because water resource issues are most often addressed at a regional scale, like the Midwest or the Southwest of the United States, rather than at a global scale, it has been difficult to associate predictions of climate change with solid connections to changes in the land surface hydrology of particular regions. Most studies have taken changes in precipitation and temperature regimes (e.g. 5% increase, 10% increase in mean annual levels) typical of those produced under global change scenarios with global climate models, and then used hydrologic models to simulate the effects of such variations on surface and groundwater flows. The problem is that the effects of climate change on regional precipitation and temperature regimes are predicted so differently by one climate change model as compared to another, that it is difficult to know whether the precipitation or temperature really will be raised or lowered in the manner being tested. For the moment, therefore, the effects of global climate change on regional water resources remain essentially unknown. This lack of knowledge is compounded by the fact that current global climate change models do not include a component that tracks the movement of water across the land surface. Therefore, the feed forward effects of climate change on surface and groundwater cannot be simulated along with the climate itself, or in some cases with the climate and ocean.

Historical patterns of drouoht over several centuries have been examined using the thickness of tree rings on trees which are growing on thin soils so that they are vulnerable to climate stresses. Droughts produce thin rings; wet years produce thick ones. These studies have revealed periods of severe and sustained drought in past centuries which are significantly more acute than those experienced in this century when the main body of water resources data has been measured. The profound effects on human life of severe storms and flooding, and of severe droughts, are so apparent as to need no further emphasis. Climatic variations have always been important and will always be important in this field. The addition of a systematic shift in the mean level of these variations through global climate change adds a component to what is already a highly variable picture.

The effects of climate change on ecological systems are associated with the changes in the range of habitation of particular plant and animal species. For example, will the elevation of the tree line in mountains be altered? Will the geographical range of a particular plant species be altered as increased temperatures and drier soils change the local living environment for the species. Historical

evidence shows that plant species once occupied geographic regions that are now barren. The translation of precipitation changes into changes in Soil moisture status is a particularly important connection between hydrologic and ecological systems in the context of climate change.

New opportunities for studying climate change effects are arising by the use of geographic data bases of large scope that combine data from many sources into a consistent spatial framework. I am working on a digital atlas of the world water balance that quantifies on half degree cells for precipitation, temperature, radiation, and soil water capacity, and provides attached models for examining the water balance in the atmosphere, soils, surface water and groundwater. More information on this research can be found on the World Wide Web at:
http://www.ce.utexas.edu/prof/maidment

RESEARCH ACTIVITIES FOR CONSIDERATION AT THE U.S. JAPAN USGCRP WORKSHOP ON GLOBAL CHANGE

L.O. Mearns, National Center for Atmospheric Research

I. Effects of Changes in Climatic Variability on Crop Production

One of our main research interests has focused on determining the sensitivity of various crops (through the application of crop-climate models), to changes in variability on a daily to interannual time scale. The results of this research have been published in three journal articles, Mearns et al., 1992, 1996, and 1997. Our most recent work also included the formation of climate change scenarios that include changes in both the mean and higher order moments of climate. The results are briefly described below.

Our central goal was to determine the importance of including both mean and variability changes in climate change scenarios in an agricultural context. By adapting and applying a stochastic weather generator, we first tested the sensitivity of the CERES-Wheat model to combinations of mean and variability changes of temperature and precipitation for two locations in Kansas. With a 2^0 C increase in temperature with daily (and interannual) variance doubled, yields were further reduced compared to the mean only change. In contrast, the negative effects of the mean temperature increase were greatly ameliorated by variance decreased by one-half. Changes for precipitation are more complex, since change in variability naturally attends change in mean, and constraining the stochastic generator to mean change only is highly artificial. The crop model is sensitive to precipitation variance increases with increased mean and variance decreases with decreased mean. With increased mean precipitation and a further increase in variability, Topeka (where wheat cropping is not very moisture limited) experiences decrease in yield after an initial increase from the "mean change only" case. At Goodland, Kansas, a moisture-limited site where summer fallowing is practiced, yields are decreased with decreased precipitation, but are further decreased when variability is further reduced. The range of mean and variability changes to which the crop model is sensitive are within the range of changes found in regional climate modeling (RegCM) experiments for a $C0_2$ doubling (compared to a control run experiment).

We then formed two types of climate change scenarios based on the changes in climate found in the control and doubled $C0_2$ experiments over the conterminous U.S. of RegCM: 1) one using only mean monthly changes in temperature, precipitation, and solar radiation; and 2) another that included these mean changes plus changes in daily (and interannual) variability. The scenarios were then applied to the CERES-Wheat model at four locations (Goodland, Topeka, Des Moines, and Spokane) in the United States. Contrasting model responses to the two scenarios were found at three of the four sites. At Goodland, and Des Moines mean climate change increased mean yields and decreased yield variability, but the mean plus variance climate change reduced yields to levels closer to their base (unchanged) condition. At Spokane mean climate change increased yields, which were somewhat further increased with climate variability change. Three key aspects that contribute to crop response are identified: the marginality of the current climate for crop growth, the relative size of the mean and variance changes, and timing of these changes. Indices for quantifying uncertainty in the impact assessment were developed based on the nature of the climate scenario formed, and the magnitude of difference between model and observed values of relevant climate variables.

It would be most interesting to apply our techniques using other crop models, to other crops and at other locations, such as for Rice cropping in Japan.

II. The Effect of Spatial Scale of Climate Change on Assessment of Agricultural Impacts

With colleagues at the University of Nebraska, we are working on a project exploring spatial scale aspects of climate change (Easterling et al., 1997). Through a grant with the National Institute for Global Environmental Change (NIGEC) we have performed several climate modeling experiments in the central Great Plains of the U.S. We used the Regional Climate Model RegCM2 driven by

boundary conditions provided by the CSIRO general circulation model (GCM) to produce control and doubled C02 runs. We then investigated the different climate change simulated by the coarse resolution (3.2 deg. lat. by 5.6 deg. long) GCM to the finer resolution (50 km*)* regional model, and then applied the different resolution climate change scenarios to EPIC corn, wheat, and soybean models in the central Great Plains of the U.S. The assessment of change in crop yields for these crops was quite different depending on the scenario used, when the results were aggregated to the GCM resolution. For example, for simulated corn grown in the northeastern GCM grid of our study area, the high-resolution scenario resulted in a yield increase, whereas the coarse resolution climate change resulted in an over all yield decrease. Similar contrasts were found for the other crops. This study indicates that the spatial resolution of climate change is an important uncertainty of climate change assessments (Mearns et al., in preparation).

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Distribution of Primary Production and Current Food Production in the World

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1. Introduction

Population and economical growth in developing countries raises a question whether natural resources and environment can accept further food production. There are many studies on world food supply and demand by economists, however, little has been investigated relating to natural resources and environment. Lack of reliable global data on natural resources and environment was the reason why little had been done on this field. Recently, to get global distribution of surface temperature, precipitation and solar radiation intensity becomes easier by using the GIS system. Though resolution of data is still rough, we can investigate the relationship between potential productivity and actual agricultural production. We compared potential productivity calculated from primary production with current food production in major countries. It will be useful for the decision-making in agricultural policies and environmental protection in the world.

2. Material and methods

(1) Outline of the approach

Food production is closely related to primary production. As solar energy converts to chemical energy by photosynthesis, potential agricultural production can be estimated from primary production. Food production is dependent on intensity of agricultural management as well as primary production. Ratio between actual agricultural production and potential production is significant. In the area where the ratio is low, food production will increase by the intensive management. But little will be increased in the area where the ratio is already high. We discussed the world distribution of potential food production in a previous paper, then we will discuss potential food production in some major countries in this study. Capacity of food production calculated from climate data in major countries was compared with statistical data compiled by FAO.

(2) Identification of agricultural area

Matthews had provided the map of arable land in the world. But the resolution is too rough (1 by 1 degree) and data source is relatively old. There has been no reliable study on the world distribution of arable land since Matthews compiled the map. Then we composed the world cultivated land map based on the Holdledge life zone map. We also used the map of surface temperature and precipitation in the world. Many categories in the Holdledge life zone map are suitable for plant growth. However, we assumed that "Cool Temperate Grassland", "Warm Temperate Chaparral", "Warm Temperate Moist Forest" and "Subtropical Dry Forest" are suitable for the agriculture. The areas of "Rain Forest", "Wet Forest" and "Desert" are not included in this agricultural area.

(3) Calculation of primary production

A lot of studies have been done on primary production in terrestrial ecosystem in order to interpret carbon cycle in the globe. But little has been done on food production. We used the MIAMI model (Leith 1972) for the estimation of primary production. The MIAMI model is simple and can estimate primary production from surface temperature and precipitation.

(4) Estimation of food production in each country

FAO data was used to calculate current agricultural production in each country. Sum of cereal production, dairy products and meat production is considered in this study. These productions were converted into heat energy (kcal). The value can be easily compared with food production potential estimated from primary production.

Countries	Ratio(%)
U.S.A.	7.60
Canada	9.79
France	12.25
Germany	14.89
Italy	10.23
U.K.	15.68
China	17.09
India	24.41
Australia	0.79
New Zealand	1.42
Brazil	5.95
Algentina	1.69

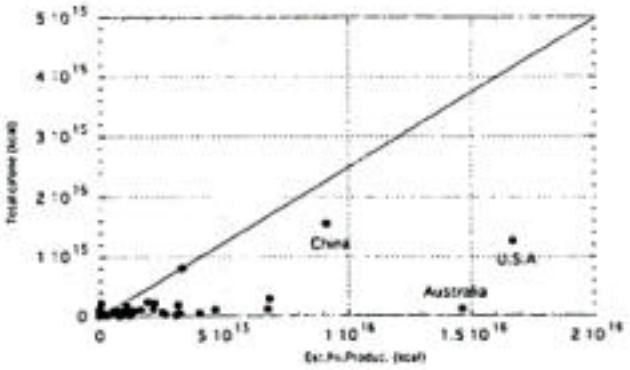

Figure 1. The ratio between current and potential production in major countries

3. Results and discussions

Current food production represented by heat energy and food production potential in each country is summarized in Table 1. Relationship between current food production and food production potential is shown in Figure 1. The ratio between current and potential production in the U.S.A is 7.60%. Same ratio in Canada, France, Germany and Italy are 9.79%, l2.25%, 14.89%, 10.23% receptively. The ratio is relatively low in Oceania and South America. For example, Australia, New Zealand, Brazil and Argentina are 0.79%. 1.42%, 5.95% and 1.69%. To See the Asian countries, China is 17.09% and India is 24.41 %.

Relatively high ratios are calculated in North American and European countries due to the high dairy and meat production. However the population growth rate in these advanced countries is low and they still eat enough food today. It seems easier for these advance countries to provide sufficient food to their people even in the 21st century. High ratios are calculated in China and India, though these countries provide small amount of dairy and meat products to their people. Population will increase rapidly in both countries. The rate of meat protein intake will increase into the next century, accompanying with rapid economic growth. In order to produce meat protein by farming, approximately five to ten times more cereal is in demand. If China and India want to increase food production to meet their demand they would destroy the forest. Then China and India would face both difficulty to provide sufficient food and to protect environment. The ratio is very low in Oceaniana and South American countries. It shows that they can increase their food production easily. The difference between potential and current production does not distribute equally. It seems difficult for Asian countries to increase food production without environmental deterioration.

4. Future investigation

Resolution of data sets used here is 0.144 degrees; it seems coarse for the estimation of agricultural productivity. More high-resolution data is required for more precise investigation. Satellite remote sensing data such **as NOAA/AVHRR, LANDSAT/TM and ERSI/SAR** can provide valuable information about agriculture. It will be significant to compose reliable arable land maps using these data.

APPLYING CRITICAL LEVELS FOR OZONE AND UV-B RADIATION ON RICE PLANTS

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Introduction

Anthropogenic chlorofluorocarbons (CFC's) and other trace gases in the atmosphere may cause the depletion of the stratospheric ozone layer and a subsequent increase ultraviolet-B radiation (UV-B, 280-320 nm) at the earth's surface. Since UV-B radiation can cause lesions in nucleic acids, protein and photosynthetic apparatus, enhanced UV-B would give some deleterious effects on plants and ecosystems. In fact, numerous studies in greenhouses and growth chambers have shown that UV-B radiation can adversely affect plant growth and various physiological and biochemical processes in plants (Runeckles and Krupa, 1994).

Although the stratospheric ozone is decreasing, concentrations of ozone in the troposphere are stable or increasing (Fishman, 1991). Increases in the surface ozone levels in many regions are largely the result of photochemical oxidant pollution, which may reduce the growth and productivity of both agricultural crops and forest trees. Thus, while the beneficial role of stratospheric ozone as an attenuation of UV-B radiation decreases, tropospheric ozone as a widespread phytotoxic air pollutant increases (Lefohn, 1991).

As rice is a primary field crop in Japan and in Asia, the change in ozone levels far aloft and at the surface may pose a threat to food production in this region. Hence, there are many studies of ozone (Nouchi et al., 1991) or photochemical oxidants and UV-B (Teramura et al., 1991; Dai et al., 1992,1994) on rice growth and/or yield. These studies have shown that ozone and UV-B reduce dry matter production and grain yield of rice plants. However, the majority of the information regarding UV-B has been obtained in growth chambers where higher plants tended to be considerably more sensitive to UV-B radiation than in the field. For reliable assessing crop losses caused by air pollutants and enhanced UV-B, exposure experiments are needed to perform in conditions as close as possible to the real-world situation.

We studied the effects of ozone and UV-B on growth and yield of rice plants with field ozone exposure chambers and a field UV-B irradiation system.

Effects of ozone on growth and yield

Several studies have shown reduced growth and yield of rice by ozone and photochemical oxidants. In Japan, however, a doe-response of relationship between ozone levels and the impact on growth and yield and crop loss of rice have never been assessed on a regional scale.

We developed a field chamber system in a paddy field in 1987 (Kobayashi et al., 1994). The system consisted of four ozone generators, five exposure chambers equipped with ventilation fans on both ends, and an ozone measurement and control system. Rice plants were grown in a paddy field and exposed to varying concentrations of ozone throughout most growing seasons from 1987 through 1989. Ozone exposure was performed for 7 h (09:00-16:00) each day, and the ozone concentration in each of five chambers was maintained in a constant proportion to ambient ozone (0.5, 1.0, 1.5, 2.0 or 2.75 times ambient ozone level). Throughout the growing seasons, plant samples were taken for measuring leaf area and dry weight of plant parts. At harvest, samples were taken to determine grain yield and yield components.

The results of the ozone exposures indicated no consistent effect of ozone on leaf area growth, whereas total dry matter decreased with increased ozone concentration (Kobayashi et al., 1995). The effect of ozone on total dry matter '"as particularly evident after heading. Ozone also affected dry matter partitioning. There was increased dry matter distribution to the leaf blades compared with the leaf sheaths, culms, and roots. Dry matter partitioning to panicles at heading slightly increased with increasing ozone. At harvest, the fraction of panicle seemed to have increased with ozone concentration. Rice yield was significantly reduced by ozone. Among the yield components, 1000 grain-weight was significantly reduced by ozone. Harvest index was not affected by the ozone

treatment. The cause of growth and yield reductions by ozone was attributed to a decrease in light-use effl'ciency (LUE), which is defined as the ratio of dry matter production to the cumulative light absorption (Kobayashi and Okada, 1995). Especially, the effect of ozone on the LUE was much greater in the reproductive than in the vegetative phase. The relationship between the seasonal mean ozone concentration (^{0}c) and the yield (Y) was formulated as follows (Kobayashi et al., *1995):*

$$YY_b = \exp (- 0.00235(O_c - O_b))$$

where Y_b is the yield for the background ozone concentration (O_b).

The yield loss by ozone in the Kanto district of Japan, which includes Tokyo and the surrounding six Prefectures, from 1981 to 1985 was assessed by Kobayashi (1992), who developed a growth model which incorporates the effects of ozone and weather variation on crop growth processes. The total production loss in the Kanto district ranged from 16,000 metric tons in 1981 to 78,500 metric tons in 1985, which corresponded to 1.1% (1981) to 4.6% (1985) of the total production in the district.

Effects of enhanced UV-B radiation on growth and yield

To provide a realistic UV-B enhancement, we developed a UV-B irradiation system with modulated lamp output in the field (Nouchi and Kobayashi, 1995). The continuous proportional control system for supplemental UV-B radiation '"as designed to monitor solar UV-B radiation and deliver a desired supplemental UV-B irradiance by controlling the output of fluorescent sunlamps. Enhanced UV-B irradiation experiments to rice plants in a paddy field were carried out for the three years from 1993 through 1995 at Tsukuba. Output of the UV lamps in the field was supplied by a feedback control system throughout the day to provide supplemental levels proportional to ambient solar UV-B. The UV-B enhancement was up to 1.7 times ambient UV-B_{BE} (biologically-effective UV-B) or up to 6.8 kJ m^{-2} d^{-1} for seasonal daily integral UV-B_{BE}. Three rice cultivars (Koshihikari, IR45 and IR74) were irradiated with UV-B in the field. Among the 3 cvs, Koshihikari is the leading Japanese variety of Japonica type, and the other IR cultivars have been reported to be relativelv sensitive to UV-B (Dai et al., 1992). The UV-B irradiation was performed from 8-10 days after the transplanting through the harvest. The mean daily integral in the UV-B plots was 1.7 times (1993), 1.6 times (1994) and 1.4 times (1995) that of the Ambient UV-B_{BE}, and that in the Control plots was 25 % below the Ambient. The difference between the UV-B and Control plots was 95% (1993), 85% (1994), and 65% (1995) of the Ambient.

Despite some changes in antioxidant levels and UV-absorbing pigments, UV-B irradiation had almost no effects on any of the growth traits in either experiment. The only statistical significance of the UV-B impact was found in the leaf area in Koshihikari and IR45 at harvest in the 1993 experiment. As for rice yield, statistically significant changes were found only in the 1994 and 1995 experiments, in which 9 % yield reduction was found. It could therefore be summarized that a 10% increase in UV-B_{BE} will cause approximately a 1% yield reduction. The increase in UV-B_{BE} can be related to ozone depletion with a model of radiative transfer (Bjorn and Murphy, 1985) and the total ozone data at Tsukuba (Japan Meteorological Agency, 1993). The relationship between the total ozone depletion % (x) at Tsukuba in the rice growing season (May 1 - October 31) and the seasonal mean daily integral UV-B_{BE} (y) at the ground surface can be approximated by the equation: $y = 5.20 \exp(0.02\ x)$. Since the predicted ozone depletion is 6-7% at its peak in the future during the summer-autumn season in the northern mid-latitudes (Madronich et al., *1995),* the UV-B_{BE} increase is projected from the above equation to be 15% or less of the current level. The rice yield loss would therefore be 1.5% or less, which is far from devastating damages as opposed to the extrapolation; from the results of chamber/greenhouse studies hitherto.

The discrepancy between the chamber/greenhouse studies and the field studies including this study can be ascribed for some differences between the two types of studies. At least a substantial portion of the discrepancy is simply the result of the difference in the UV-B dosage, which is in general higher in the chamber/greenhouse studies than in the field studies. This is because no UV-B is present in the control plots in chambers/greenhouses, whereas solar UV-B is present in the field control plots. Furthermore, the chamber/greenhouse studies, as compared with field studies, have been conducted under lower UV-A and visible light, which are reported to protect and/or to help

recover from the UV-B damages (Caldwell et al., 1994). Therefore, greenhouse/chamber studies may have overestimated the UV-B impacts.

Conclusion

Our study showed that the growth and yield of rice were substantially reduced by ozone in a possible range of concentration (40-100 nl/l), in Japan, but were not greatly reduced by up to 1.7 times ambient UV-B_{BE} in the field. The cause of the discrepancy between the chamber/greenhouse studies and the field studies of UV-B needs further study. However, the results of this study suggested that the future ozone depletion of up to 7% would have only a minute impact, less than 1.5%, on rice yield. Although our UV-B study showed little effects on rice growth and yield, a reliable prediction of future UV-B impact on agricultural production should be assessed by many field experiments with other cereals and vegetables.

Proposal

The importance of ozone effects on vegetation was first recognized in the U.S. and a lot of experimental data from open-top chambers have been accumulated from the U.S. and European studies. Current concentrations of ozone in Japan, U.S. and Europe have adverse effects on crop yield, tree growth and vitality, and the composition of natural communities. We need to reveal critical levels for ozone, which is defined as the concentration of a air pollutant in the atmosphere above which direct effects may occur on vegetation, based on analysis of experimental and field data.

The depletion of the stratospheric ozone layer and the resultant increase of solar UV-B radiation on the earth's surface are now regarded as major global environmental threats. Many greenhouse/chamber studies have reported adverse effects of increased UV-B on crop growth and yield. However, little is known concerning the responses of agricultural crops and trees to enhanced UV-B in the field. We need to collaborate studies to reveal whether a possible enhanced UV-B affects growth or yield of agriculture crops and forest tree species in the field.

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Prediction of Production Regions of Cereals under Global Climate Change

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KEY WORDS: Suitable Region *I* Potential Region / Major Cereal / Global Climate Change

Abstract

Estimation of suitable regions for major cereal production in the world is significant to predict food supply in the 21st century. Suitable regions for major cereal cultivation in the globe were selected using climate and soil data. Seasonal change pattern of vegetative biomass supports this classification.

The present area of suitable regions for major cereal cultivation is estimated to be 515 Mha (Million ha). The area estimated in this study is similar to the area compiled by FAO. Using the method presented here, we predicted suitable regions for major cereal cultivation in the 21st century. The area of suitable regions will decrease and be 280 Mha, which corresponds to 46% of present one, under conditions of double the current $C0_2$ concentration.

Introduction

The effects of global warming in recent years have been most conspicuous on continents at 40 - 7O^{o} north latitude. It is predicted that this trend will continue (CGER, 1996; IPCC, 1996a). Consequently, there is concern that cereal producing regions will become unsuitable for cultivation (Parry, 1990). IPCC (l996b) and Rosenzweig and Tubiello (1996) report that it is hard to distinguish future advantageous regions for cereal production from each other because the climate change induced by global warming impacts agricultural production in many ways. However, since a map showing exact major cereal production locations does not exist, in order to predict global cereal output, we first identify contemporary major cereal production regions around the world and then determine how these are likely to change. Major cereals in this paper refer to waterfield rice (hereinafter rice), wheat, maize and soybeans.

Data and analysis

Data

We used the following data to estimate the area of suitable regions for major cereal cultivation (SRMC). We used the global vegetation map (Honda, Murai and Katou, 1992; CGER, 1994) constructed using NOAA/GVI data for the biomass change pattern in order to determine candidate agricultural areas.

We used the FAO's world soil map (CGER 1994; FAO, 1995; FAO-UNESCO, 1974) for soil-type data.

The temperature requirement was calculated from the IIASA (International Institute for Applied System Analysis) climatic data, monthly mean temperature (CGER. 1994). The moisture requirement was computed from the IIASA climatic data, monthly mean precipitation (CGER. 1994).

We adopted the model developed by the Geophysical Fluid Dynamics Laboratory (GFDL), and used the map predicting surface air temperature and precipitation changes (Houghton, Jenkins and Ephraums, 1990). According to this model, under conditions of double $C0_2$, temperature at the middle latitudes will rise 2 - 4^{o} C.

Method

All above-mentioned data are processed as raster layer data using equirectangular projection on a WGS84 spheroid and a grid size of 0.144^{o} (1250 rows by 2500 columns).

We referred to the World Food Map found in The Times Atlas (Geelan and Lewis, 1992) and the national agricultural maps of the People's Republic of China (Editorial Committee of the National Map, 1989) to determine typical producing regions of major cereal. Then, we selected 22 locations for which we determined producing regions of major cereal based on the biomass change pattern.

We focused on the crop-producing ability of arable land and the environment in which it exists. We introduced the concept of suitable regions for cultivation, which simply means that each crop requires a suitable environment for maximum growth. A suitable environment is one with appropriate temperature, moisture, and nourishment conditions and a sufficient rooting zone for crops to grow. We developed a method of detection of locations of agricultural land-use from global satellite data, and identification of suitable regions for major cereal cultivation from detected agricultural locations using meteorologic and soil data, and estimated their area. Further, we applied our method in conjunction with expected climate changes to predict the change in location and area of suitable regions for major cereal cultivation as a result of global warming.

Results and discussion

Total area of global SRMC was estimated to be *515* Mha (Million ha) (Table 1). This is 38.4% of the 1342 Mha of total arable land and is almost equal to the total harvested areas of major cereals which is 558 Mha (all statistical data are quoted for 1993 values (FAO, 1995)). We applied our method to predict the change in the area of SRMC as a result of global warming. Under conditions of double $C0_2$, it was estimated that the area of SRMC would be 280 Mha which represents a decrease of 46%.

At present, it is impossible to control global weather (temperature and precipitation). However, it is possible to control some soil properties. Therefore, we identified regions that met all agricultural environmental requirements except for soil requirements. In this paper, we define these as potential regions for major cereal cultivation (hereinafter PRMC). Then, we estimated the present area of PRMC to be 1333 Mha. We predicted that the area of PRMC under conditions of double $C0_2$ would become 1378 Mha which represents an increase of 3%.

Global area of suitable and potential regions for each cereal cultivation was estimated under conditions of contemporary and double $C0_2$ (Table 2). Currently, wheat is produced on soils that are aggregated fertile, such as *chernozems, kastanozems, cambisols, vertisols* and *luvisols*. It is predicted that weather patterns favorable for SRMC will move to the north and to less rich soil types from a pedological viewpoint, such as *podzols* and *podzoluvisols* as a result of global warming. Consequently, it is predicted that the area of suitable regions for wheat cultivation will decrease sharply.

Table 1 Comparison between the estimated area of suitable regions for major cereal cultivation using our method and statistics of total harvested areas. Unit is Mha (Million ha). Statistics are quoted for 1993 values (FAO, 1995).

Continent	SRMC*	Major**	Total Cereals
North America	146.467	100.630	92.777
South America	28.414	46.974	33.176
Africa	78.949	37.549	79.862
Oceania	13.475	9.141	14.459
Eurasia	247.276	363.845	469.138
World Total	514.582	558.139	689.412

* suitable regions for major cereal cultivation
** Total area of major cereals (wheat, rice, soybeans and maize).

Table 2 Area of suitable and potential regions for major cereal cultivation. Unit is Mha (Million ha). Statistics are quoted for 1993 values (FAO, 1995).

Crop	Statistics	SRMC*		PRMC**	
		Present	2xCO_2	Present	2xCO_2
Wheat	222	214	71	856	959
Rice	147	1%	171	625	788
Soybeans	62	15	6	89	124
Maize	127	89	31	285	280

* suitable regions for major cereal cultivation
** potential regions for major cereal cultivation

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[ABSTRACT]

Effects of Climate Change on Plants

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We have studied on effects of climate change on plants in East Asia as a research project of the Global Environment Research Program supported by the Japan Environment Agency. In this project, the modeling and prediction of plant production, vegetation distribution, phenological events, and lake-ecosystems in East Asia were investigated in relation to the probable global climate changes. Results from the project also reveal the importance of analyzing local field data on micro-climate, soil environment, snow patches, and flora and plant growth in mountain vegetation. In addition, the complex effects of increasing concentrations of greenhouse gases and rising temperatures on crop plants such as rice yield and wild plants have been analyzed by experiments using controlled environment facilities called Phytotron.

(1) Probable effects of climatic changes on plant production in monsoon Asia
Using three general circulation models (GCMs) - GISS, GFDL and UKMO -, the climate change scenarios for Monsoon Asia were developed. Using these scenarios, the information was obtained on the possible distribution of annual air temperature, annual precipitation, annual global solar radiation, annual net radiation, and annual average of radiative dryness index on the Monsoon Asia. The Chikugo model based on relationship between climatic factors and dry-matter production was used to calculate net primary productivity (NPP) of natural vegetation.

(2) Climate change and its impacts on the vegetation distribution in East Asia
The potential vegetation distribution shift in Japan and China caused by global climate changes was predicted by the direct transfer function approach. Three types of statistical models, the discriminant analysis model, the fuzzy model, and the multinominal logit model were applied to explain the relationship between actual vegetation classification and actual climatic conditions. The logit model gave a more successful result than other models. Therefore, the effects of global climatic change in China were estimated using the logit model under two climatic change scenarios proposed by Robock et al.

(3) Effects of global warming on the phenological observation in Japan
Phenological events of plants give the important information on reproduction as well as an indicator of global warming. So, it is important to analyze phenological events and environmental changes. Strong correlations were found between meteorological factors and phenological observation such as blooming dates and leaf color-changing dates. On the basis of these correlations, predictive maps of blooming dates and leaf color-changing dates in the Japanese Islands were proposed for each case of 1^{o} C, 2^{o} C and 3^{o} C of monthly mean temperature warming.

(4) Effects of climate change on mountain vegetation in Japan
The effects of climate change on mountain vegetation were investigated from field research data of mountain vegetation in Japan. Especially, the importance of snow in the global warming problem was understood by the study. The analyses of fossil peat soils indicate that "Medieval Warm Period" was prevailed in sub-alpine meadows in Northeast Japan. When the warming exceeded 2 (C, snow patches and alpine meadows shrank considerably and if accompanied with decreasing snowfall and snow accumulation, the shrinkage was accelerated and many meadows disappeared. From the standpoint of ecosystem, it is suggested that the sub-alpine conifers may expand into the alpine regions under the influence of global warming, but that it will hardly succeed to alternate the vegetation zone, where well-developed creeping pine scrub has already occupied. Relationships between the effective accumulated temperature and the phenological stages of Fauna crista-galli are strongly dependent on locations in the slope, which vary mainly with the distance from the snow patch. Similarly, in the difference scale, the distribution area of beech on the Japan Sea side of Honshu will be shifted upwards to the mountain slopes, but it will be affected by snow cover status. So that indirect effect of global warming should be considered for such vegetation dynamics.

(5) Analysis of complex interactions between plant responses and environmental changes using environmental controlled facilities (phytotron).
In order to predict reactions / interactions of plants and their communities to possible future changes not only in normal climate conditions such as temperature and humidity but in other environmental conditions such as C02 concentration and ultraviolet radiation. It is very important to investigate complex relationships between plants and their environments intensively. The environmental controlled facilities are used to reproduce different types of research environments ranging from the arctic to the desert or the tropics. These facilities provide an opportunity to gain increased understanding of the complex interactions between plants and their environment, for example, elevated carbon dioxide concentrations, humidity, temperature change.

In NIES there are many growth cabinets with control functions of air temperature, humidity, C02 concentration, concentrations of air pollutants, intensities and spectra of artificial lights and soil environments, etc. Especially, two plant-environment simulator of wind tunnel type make it possible to control profiles of air temperature, humidity, wind velocity for experiments of plant community.

We continue to study the effects of global warming on plants in development of prediction models, field survey and experimental researches using Phytotron. Especially, we have found the necessity of cooperative studies and networks between Japan and US in experiment researches using Phytotron. We would like to propose "US-Japan Phytotron Network for Global Change Research".

Meta-issues in Global Change Effects Research

James Risbey

My interests in global change are curently focused on developing methods and case study applications for regional integrated assessments. My past work in the impacts area has been more sectorally oriented rather than integrated. This has included work on regional water resource and agricultural assessments. As a possible contribution to the working group discussion I will set out some of the limitations that I think are typical of my own and other past endeavors in sectoral-research, and by implication some of the challenges that I see facing a more integrated approach to effects on natural and managed systems. These comments are informed by collaborative efforts with my colleagues in CMU's Center for Integrated Study of the Human Dimensions of Global Change including Hadi Dowlatabadi, Milind Kadlikar, and Granger Morgan.

Climate change has dominated global change (land use, demography, trade, technology, social and cultural issues etc.) in a consideration of the relevant forces of change in a region or sector. Interactions between climate and other global change processes have often been neglected, as have the temporal evolution of non-climate features of the environmental and socio-economic landscape. This leads to a situation where isolated climate impacts are often compared against fictional stationary baselines.

Models have been used in rigidly quantitative ways that tend to trivialize their output and neglect some of the potentially dynamically rich information content they have to offer. By this I mean that the output of one model is often taken quantitatively verbatim and fed directly into another model. For instance, as when GCM output is used directly to drive hydrological and agricultural models. This misses some of the dynamical nuance that may not be reflected in the raw model fields, but may be discerned upon broader inspection of the model results. The details of the dynamics may often be important in determining local outcomes, and these details may actually be qualitatively captured in a model, if not in precise quantitative form in the correct spatial orientation. Expert elicitations of modellers may provide one technique for mining the dynamical information content of global change models.

Models have been allowed to 'anchor' our views of the possible. Models typically codify our best guesses of the operative mechanisms and parameter values in global change processes. But that does not provide a comprehensive way to span the space of plausible outcomes. When we forget that, we are perhaps overly optimistic in thinking that model outcomes provide a useful way of spanning the potential problem space.

Traditional policy analysis tools and approaches (single decision makers. maximization of utility, cost-benefit analysis. marginal impacts. static values, single polity, discounting, manageable uncertainty, system linearity, etc.) have been developed in specific problem contexts. However, many issues in global change involve temporal, spatial and socio-political scales that are significantly broader than those encountered in most traditional policy analyses. Conventional tools often break down in the broader contexts of global change problems, and we must begin to identify where and why these breakdowns occur as a first step in developing more applicable global change analysis tools.

End to end assessments of effects on systems ofien start the analysis with available tools (global models of natural systems) and use these tools to work down towards local sectoral impacts. That is, the analysis is tools driven rather than problem driven. One can also work in the opposite direction by first characterizing the problem (which impacts might be important and why) and then asking what kinds of information is needed to understand these impacts. Then we can scrutinize our tools to see where they are capable of providing the necessary information and where they require further development. This provides a way to ensure that more robust and useful information is generated, and suggests where to orient research to achieve maximal effect on problem resolution.

The users of global change research and information have not been well integrated into the conception and development of research programs - with some notable exceptions. While this is not always problematic, it is a limitation that will become increasingly salient as the research moves toward practical policy ends.

While much potentially useful information is generated from global change studies, we have not done as well in connecting this information with the appropriate groups and institutions on the 'ground' who could make best use of it. The peculiarities of local custom and tradition, decision making styles, organizational structures, and resource constraints will be among the factors shaping use of information in local contexts. Field studies and research on the use of information are a logical complement to sectoral research. We have attempted some research in this area on farmer adaptation to variability and change, and we are hoping to consider the 'ground' potential for better uses of monsoon and ENSO forecasts.

Human agency is incredibly difficult to incorporate into global change studies, and is frequently omitted. Yet human agency is perhaps the dominant component of global change processes and outcomes. When it is incorporated, human agency is frequently characterized according to standard economic views of humans as rational economic optimizers. Yet all non-economists know that this is not very realistic. At CMU we are attempting to adopt an approach that starts with the following propositions about human agency:

- Humans are the agents of change in the local, regional and global environments. Some of the changes are intentional: others are unintended consequences of actions undertaken for other reasons.
- Humans are detectors of environmental change. Their ability to detect change is bounded by their knowledge, culture, and resources.
- Humans use their limited experience and resources to build models and form heuristics about the world. They use these to form expectations about future outcomes. In doing so, there may be significant deliberation costs entailed in gathering information about novel circumstances.
- Humans identify possible actions and choose among alternative decisions based on these expectations.

We are exploring how these features of human agency combine with various natural and social environmental conditions to create a range of outcomes in global change contexts.

WORKING GROUP 3: EFFECTS OF GLOBAL CHANGE ON NATURAL AND MANAGED SYSTEMS

Comments by Allen M. Solomon, U.S. EPA, CorvalIis OR 97333

There are myriads of effects of global change on natural and managed ecosystems, projected during the next century or so (Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change. Working Group II, Second Assessment Report, Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge UK). All effects are uncertain, in part because the climate changes are of uncertain magnitude and geographic distribution. However, if we attempt to develop a priority listing of terrestrial biospheric uncertainties, we might choose two major criteria. First, we could look at potential problems along a continuum of importance, from that which is a genuine threat to life on earth, to that which pose no obvious threat to anything except the status quo. Second, we could look at potential problems along a continuum of likely occurrences from what is certain to occur under some set of mutually agreed-upon circumstances, (e.g., global warming of 1.5-4.5 C with a specified spatial and seasonal re-distribution of heat and moisture) to those that are unlikely to exceed under any circumstances.

Applying those criteria in sequence, I noted the following three problems which I have investigated in the past, as genuine threats to life on earth. Their identification (and additional problems) could provide a basis for organizing our discussions of research priorities.

I. A positive feedback cycle may occur as warming causes loss of carbon from the terrestrial biosphere, with a resulting increase of atmospheric greenhouse gas concentrations that leads to further warming.

In contrast to the commonly expressed view that the terrestrial biosphere is taking up increasing amounts of carbon because of carbon fertilization of photosynthesis, many ecologists suggest that the terrestrial biota is releasing increasing amounts of C02 and that this may account for the increased amplitude in the seasonal C02 oscillation. Several processes could account for increased carbon release (Solomon and Cramer, 1993). For example, about half of the carbon which was stored in terrestrial ecosystems before the industrial age has recently reentered the atmosphere following fires, logging and other land clearance actions by humans. Crutzen and Andreae (1990) point out that the tropical deforestation which generates a large terrestrial source is indeed increasing.

A supporting idea can be derived from the record of temperature and C02 in air bubbles in the polar ice caps (e.g., Barnola, Raynaud, Korotkevich and Lorius 1987). Throughout the past 160,000 years, the variations in C02 match those in the record of temperature. Low temperatures have been accompanied by low atmospheric C02 and high temperatures match high atmospheric C02. Recently, the data have indicated that temperature change preceded changes in C02, indicating that temperature changes reflected in the ice cores of the past 160,000 years could have forced the prehistoric C02 changes (Houghton and Woodwell, 1989). This hypothesis requires that, as temperature increases, the rate of respiration would increase more than that of photosynthesis, generating a net release of C02. Soil respiration may be essentially decoupled from the above-ground photosynthesis-respiration carbon cycling and could increase exponentially with increasing temperature while operating on organic substrates stored in soils over hundreds and thousands of years (e.g. Billings, Lukens, Mortensen and Peterson 1982). If this is true, then greater warmth predicted to occur from increasing atmospheric C02 could be part of a positive feedback system whereby greater temperature leads to greater release of C02, in turn enhancing temperature. The close and direct relationship between C02 and temperature over 160 000 years makes it difficult to justify the view that increasing C02 will not increase release of carbon to the atmosphere, as the "carbon fertilization" hypothesis requires.

The logical extension of a positive feedback system in global carbon cycling has been examined as having the potential to generate a 'runaway greenhouse' (complete evaporation of the oceans). Kasting and Ackerman (1986) conclude that the dynamics of the water vapor-C02 system are immune to this effect (i.e. form a negative feedback system), even at atmospheric C02 concentrations two orders of magnitude greater than those contemplated from burning all the fossil

carbon on earth over several hundred years (e.g. Sundquist 1986). Because the model was aimed at the early life-free earth, they did not examine the concentration of atmospheric C02 in the modern world at which biospheric inputs might become unimportant. However, it is clear that although an upper limit to any biota-driven positive feedback system must exist, there is no certainty that it exists within the narrow range of temperatures required by animal and plant life on earth. Even a tiny possibility of this process taking hold deserves the close attention of research into the processes that generate global greenhouse gas dynamics.

2. Disruption of life cycles of long-lived species by rapid climate change may lead to loss of genetic variation, and finally, to extinction of varieties and species of those long-lived species (trees).
A potential difficulty arising from the rapid rate of the expected climate change is the intrinsic timing of tree life cycles. The most rapidly maturing trees require a minimum of 5 - 10 years to reach reproductive maturity with longer periods needed in the closed-canopy forests which store the majority of the earth's terrestrial carbon. Slow-growing species such as temperate hardwoods require 50 years to reach maturity in closed canopy forests and some may take 450 years to reach reproductive maturity afier seeds germinate.

The question of concern here is whether the life cycle of individual trees can be completed before changing climate at their growth sites eliminates the conditions required for successful growth in one or more life stages (Solomon et al., 1993). The climate associated with a doubling of C02, possible within 50-100 years, could kill trees before they reach reproductive maturity. Even if reproductive maturity is reached, the seeds the trees produce may be unsuitable for the new climate conditions. Trees whose seedlings can survive today may belong to mature trees which changing climate prohibits from growing there in 50-100 years. Mature trees that can grow there in 50 to 100 years may be derived from seedlings that cannot survive climatic conditions that prevail today.

The effect of this problem is to eliminate much of the clinal genetic variability inherent in uncultivated species, and ecotypes, varieties and other interbreeding genetic units with narrow ecological amplitudes simply have no place to grow where climate is continuously suitable. At its worst, the process could cause extinction of whole populations. Unlike many other impacts extinction of genetic resources permits no recovery even in thousands of years. The possibility of the process occuring is directly proportional to the rate of environmental change. Its intensity requires considerable research on life-stage vulnerabilities and acclimatization mechanisms.

3. Geographic redistribution of agricultural crop productivity could result from increasing frequency of infrequent but devastating weather conditions which cannot be reliably forecasted, but can reduce global food supplies just when population gains are beginning to outrun productivity gains.

Model analyses by Leemans and Solomon (1993) demonstrated differences between arable land that is gained and that lost due to warming. The burgeoning global population requires a constant and chronically increasing food supply, uninterrupted by the successive crop failures which are required to convince local farmers to switch to less familiar crops. Overall, the projections indicated a relatively major loss of farmed land, even as the area where farming can potentially invade simultaneously undergoes great increases. Indeed, this is a serious concern in the future because the world's major food crops, rice and spring and winter wheat which constitute about 40% of the present global crop productivity (FAO, 1986), lost about 8% of their currently simulated croplands. Although they eventually gained about 28% more land in areas where they are currently absent, the immediate losses of available food could be considerable. None of these analyses considered the variability of weather (droughtiness, wind and hailstorms, early and late freezes) within which planting choices must be made annually.

It may be important that after warming about twice the area of ricegrowing land becomes less productive, than becomes more productive. Contrast this loss and gain projection with the losses and gains projected for the non-food crop varieties discussed immediately above. There, the loss is only about 1% of current distributions, although the gain is also considerably less than among the food grains. For example, about 12% more area can potentially support the non-food crop varieties after warming than before difference between area of agricultural yield from agriculture under future warmed climate of the distributions projected under certain climate scenarios increased in

land cover between current and doubled C02 climates. Yet, when several crop yields on a unit area basis decreased (temperate maize, winter and spring wheat, pulses), suggesting that warming may be associated with a systematic decline in productivity, or an increase in effort required to produce crops. The crops that decline in unit area productivity are those with temperate zone distributions and with the greatest increases in areal cover after warming (23% increase in area total, compared with 13% by the other crops simulated). These productivity-declining varieties also coincide with the distribution of mechanized agriculture, suggesting that available technological responses may be capable of neutralizing the lost unit area production.

Crop varieties which increase in productivity per unit area included cassava (4.4% more tons/ha), sugar cane (3.4% greater tons/ha) and tropical maize *(2.5%* more tons/ha). All of these are grown substantially or entirely for non-human ingestion. Cassava and tropical maize are primarily used as animal foods, while sugar cane in many places provides the basis for alcohol used with fossil fuels to power vehicles and other machinery. Future demands for these products in a technology-dominated, animal consuming world, are likely to increase at least as much as their production is simulated to do, increasing competition between future demands for technological and for food products from the finite supply of the world's arable land.

These related considerations suggest that the threat to global food supplies by climate change is very likely and hence, needs to be seriously evaluated.

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Carbon budgets of forest ecosystems in Monsoon Asia and each country from mesh data analysis of potential net primary productivity

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Estimation of carbon budgets on whole ecosystem level is most important because of uncertainty in the role of terrestrial ecosystems on global carbon cycling. Difficulty of the estimation will originate from the uncertain estimates of total carbon loss by respiration from all living organisms in an ecosystem. However, it is urgently necessary for estimating terrestrial carbon cycling to clarify the balance of carbon in each country even though there are uncertainty of total carbon loss from whole ecosystems.

Calculating Processes

We preliminary estimate the carbon budgets of forest ecosystems in Monsoon Asia and each country from mesh data of potential net primary productivity (NPP: t dry matter/ha/y, Ohta *et al.* 1993) by terrestrial vegetation calculated from meteorological data. Calculating processes (Uchijima and Seino 1985) are as follows:

$$NPP = [0.29 \exp(-0.216\ RDI^2))\ R_n \quad (1)$$

Rn: annual net radiation (kcal/cm^2)
RDI: annual radiative dryness index (R_n/lr)
l: latent heat of water evaporation (kca1/gH_2O)
r: annual precipitation (cm)

Annual mean net primary productivity of each country (*m*NPP: t dry matter/ha/y) was calculated using the gridded NPP data. Annual mean gross productivity (mGPP: tC/ha/y) was estimated as

$$mGPP = a\ (mNPP) \quad (2)$$

where *a* was the ratio of GPP to NPP. We use the mean value of 3.5 from Tadaki and Hatiya (1968).

When forest net carbon sink, gross production by vegetation minus respiration *(R)* by living organisms, is predicted, there are few information of respiration rate in whole ecosystems. So, we calculate forest carbon sink as follows:

$$NFCsink = b\ c\ (mGPP)\ A \quad (3)$$

NFCsink: net carbon sink of whole forest ecosystems in a country (MtC/y)
A: Forest area of a country (ha)
b: conversion constant to carbon from dry matter, 0.45
c: conversion constant to net sink from gross gain, calculated as (GPP-R)/GPP and equals to 0.0212 from IPCC *(1995)*

The carbon emission of terrestrial ecosystem in each country is mainly caused by anthoropogenic changes in land-use, such as forest area to cropland or urban area. Carbon emission from these areas *(NFCsource:* MtC/y) is not certain and we assume that the carbon emission continues in deforested areas as a same level of respiration rate when it was forest. The estimated value will be minimal because the deforested area is accompanied with burning of organic matter and the carbon emission rate will be much higher than decomposition rate.

$$NFCsource = b\ d\ (mGPP)\ D \quad (4)$$

d: respiration rate to gross production, R/GPP, 0.979 from IPCC (1995)
D: deforestation area (ha)

Final balance of carbon in forest and lande-use change areas in each country *(NFCbalance:* MtC/y) was calculated as follows:

$$NFCbalance = NFCsink - NFCsource \quad (5)$$

Results and Discussion

Net carbon sink in Monsoon Asia (land area is 1,761 million ha and to be 13.4% to the whole land, forest area in these regions is 469 million ha and to be 11.5% to the world forest area) was 0.26GtC/y and was 18.4% to the world. From the rate of the land or forest area, Monsoon Asia functioned as higher carbon sink in comparison with the other areas. However, *NFCsource*, carbon emission from deforested area, was 0.08GtC/y (66.7% to the world) and the result surpassed our expectations. Carbon balance, *NFCbalance* was sink of 0.l8GtC/y (14% to the world). Forest and deforested areas of Monsoon Asia were currently not the carbon source to the atmosphere however.

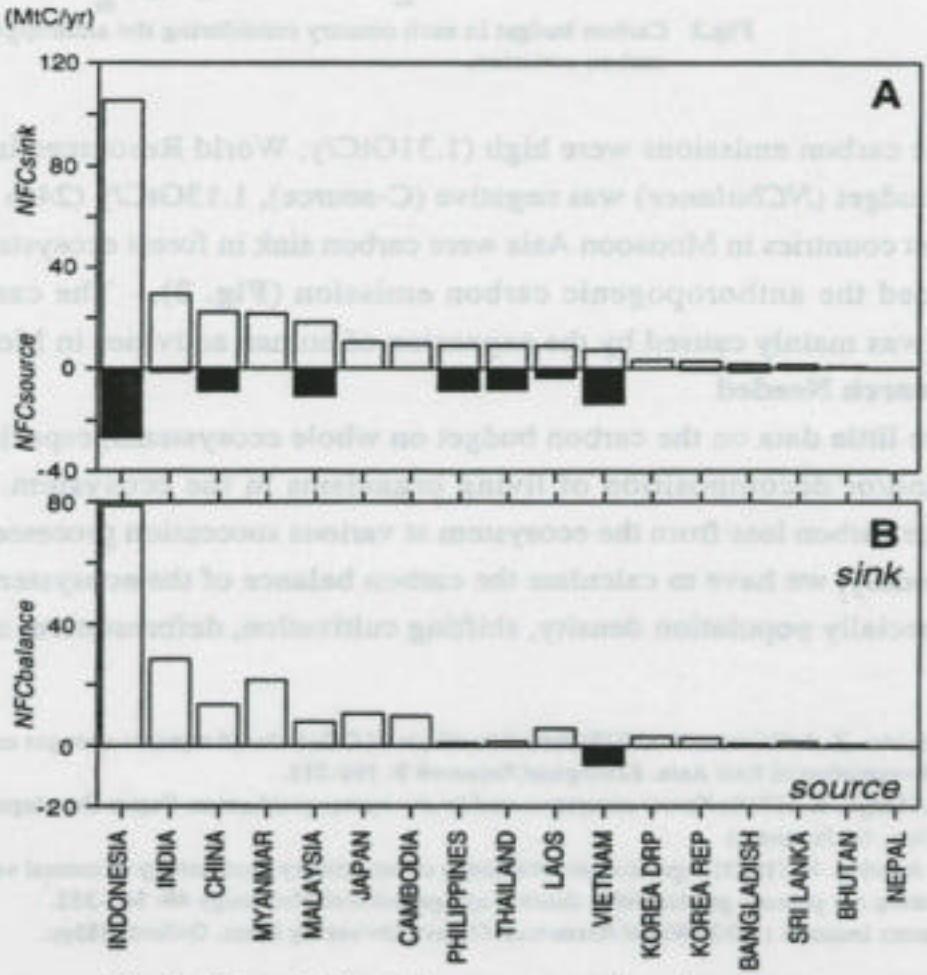

Fig. 1 Carbon budget of forest ecosystem in each country.

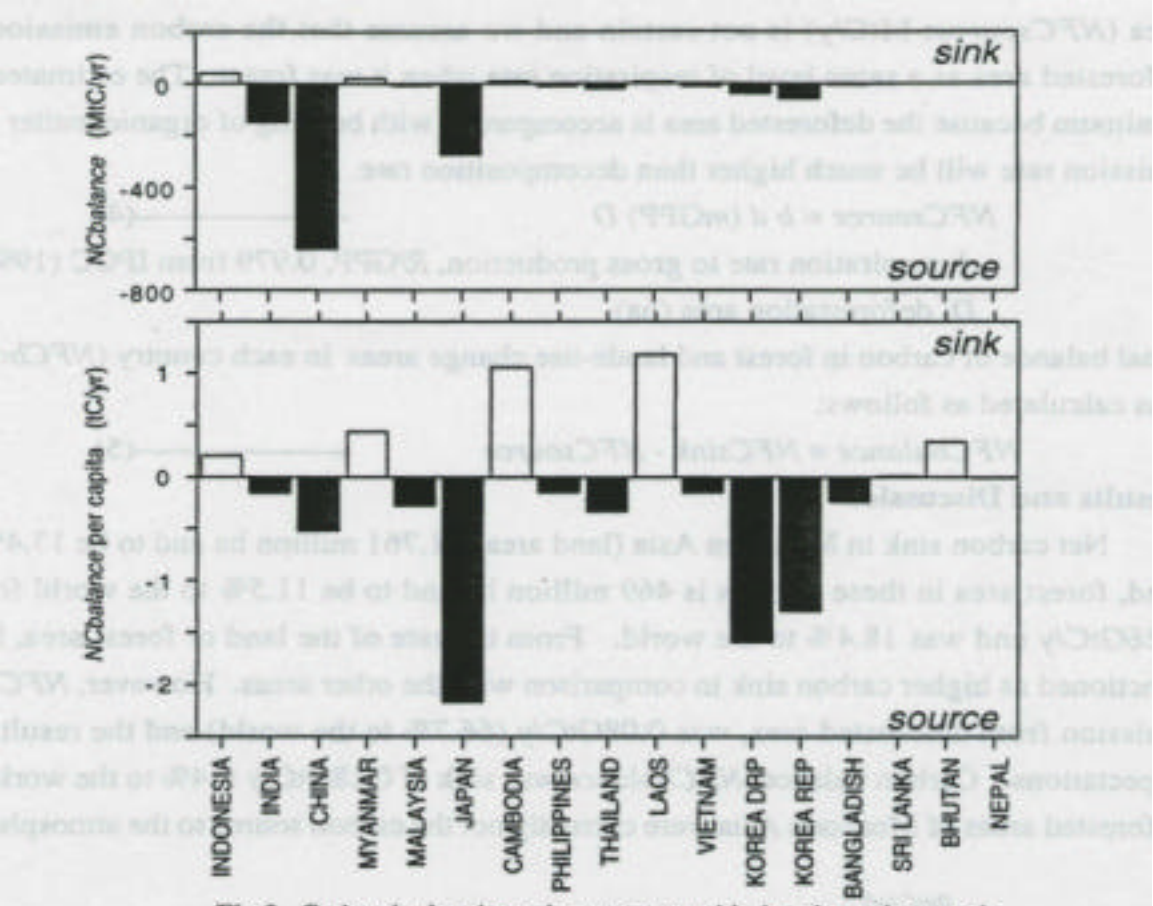

Fig.2 Carbon budget in each country considering the anthropgenic carbon emission.

anthropogenic carbon emissions were high (1.31GtC/y, World Resources Institute 1992) and the final carbon budget *(NCbalance)* was negative (C-source), 1.1 3GtC/y (24% to the world).

The most countries in Monsoon Asia were carbon sink in forest ecosystem **(Fig. 1)**, but source when we added the anthoropogenic carbon emission **(Fig**. **2).** The carbon emission to the atomosphere was mainly caused by the expansion of human activities in Monsoon Asia.

Further Research Needed

We have little data on the carbon budget on whole ecosystems, especially in carbon loss by respiration and/or decomposition of living organisms in the ecosystem. Firstly, we have to accumulate the carbon loss from the ecosystem at various succession processes in the many climate regions. Secondly, we have to calculate the carbon balance of the ecosystem, considering human activities, especially population density, shifting cultivation, deforestation, and silviculture.

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WORKING GROUP 4

Development of Global Map as Global Spatial Data Framework

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1. Background

Recently the concept of a spatial data framework is getting popular especially in the mapping community. This is why geographic data is recognized as important contents which supports information and network society and the framework is core dataset to integrate various geographic contents.

Ministry of Construction of Japan and its affiliated organization, Geographical Survey Institute, have been advocating Global Mapping concept as a contribution of surveying and mapping to support the implementation of Agenda 21 since 1992, and established the International Steering Committee on Global Mapping since 1996. Global Map is a group of geographic datasets which are designed to be useful for making agreements of measures for environmental conservation and the mitigation of natural disasters globally. More specifically, Global Map covers the whole land area of the global at a scale of 1:1,000,000 or ground resolution of 1km, and is updated regularly.

It could be said that Global Map is a framework that supports global environmental issues.

2. Contents and Functions of Global Geospatial Data Framework

A global spatial data framework (GSDF) is an aggregation of core datasets for georeference and different applications. The framework contents are topography, land use/land cover, coastal line, drainage system, transpiration networks, administrative boundaries and geographic names. As shown figure 1-5, the framework converts non-geocoded dataset such as statistic data, in site observation data, remote sensing data, etc. into geospatial dataset and integrates them. The each framework dataset, itself, is also a useful dataset for multi-purposes.

Though GSDF is not useful for researchers on local specific area because of coarse resolution but the framework is indispensable for global analysis.

3. Implementation of GSDF

For the implementation of GSDF, (1) user requirements, (2) development, (3) evaluation, (4) refinement/update, (5) harmonization and (6) distribution are compenents.

GSDF has already been developed under international collaborations (see Table 1). Some of them do not have consistent accuracy or are developed from old data sources. The relation of dataset development is shown in Fig-6. Even framework datasets are complex related to each other. Errors in a framework affect other global datasets based on the framework. This propagation of error is a significant problem.

For example, Digital Chart of the World (DCW) is one of the most fundamental dataset and is used for multi-purposes in the community of global change. Formal documents say that DCW datum is based on World Geodetic System 84 (WGS-84). But according to our verification, DCW is not based on WGS-84 but local geodetic system at least Japan. So far information of other countries on datum are unknown.

The other framework datasets have errors or inconsistency. We are developing evaluation procedures and evaluating some datasets and the effects. In order to evaluate the datasets in a wide area, institutional framework is indispensable. Moreover for the other components, it's also indispensable.

Table-1 Existing Global Framework Datasets

Theme	**Project / Dataset Name (Organizer)**
Topography	GTOPO30 (USGS-EDC),GLOBE(NOAA-NGDC), DTED0(NIMA)
Land Use / Land Cover	IGBP-DISCOVER(EDC),CORINE(EEA), AFRICOVER(FAO)
Coastal line, Drainage System, Transpiration Networks	DCW (NIMA)
Administrative Boundaries	(CIESIN), (ACASIAN)
Others	City Lights(NOAA-NGDC), Demography(NCGIA) Vegetation Index(USGS-EDC)

RESTORING GLOBAL ENVIRONMENT WITH AEROSOLS

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KEY WORDS: Global Environment / Restoring Technology / Effects of Atmospheric Aerolsols / Global Warming / Ozone Depletion / Particle Technology

ABSTRACT

Aerosol particles play important roles on global changes, i.e. ozone depletion, global warming, acid rain and so on, by converting, concentrating and transporting materials in the atmosphere and by relating to a division of solar energy. In this paper it will be discussed that a possibility of approaches to restrain the global changes by removing particles from or injecting them to the atmosphere or by controlling formation, reaction or movement of particles in the atmosphere.

CONTENTS

REQUIRED RESEARCHES & DEVELOPMENT

1. Researches for evaluating a plan
    - 1-1 Assessment of all the effects on the whole global change
        - Modeling of the whole global change
        - Laboratory studies for reliable model
    - 1-2 Assessment of energy cost
    - 1-3 Estimation of economical cost
2. Development of technologies, equipment and means for realizing a plan
    - 1-1 Splaying aerosols
    - 1-2 Ionization of aerosols
    - 1-3 Collection of aerosols

CONCLUSION

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Methodological Issues Associated with the Evaluation of GHG Mitigation Options

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Although it is convenient to think that the development of a new technology, or the incremental improvement of an existing technology, holds the key to the reduction of GHG emissions, the availability of a technology does not necessarily mean that it can be successfully utilized. It is often factors other than just the cost or performance of a given technology that will determine its ultimate success or failure in the real world. This is particularly true with the newly industrializing countries of Asia, which are expected to produce a large portion of future GHG emissions.

Technologies for the reduction of GHG emissions generally fall into the following four categories: fuel substitution (using a lower carbon content fuel); use of renewable energy options; increased energy efficiency (either production or end use); or the use of nuclear energy. With the increased interest in the utilization of the renewable energy option, it is important to understand the differences between renewable energy systems and those of conventional fossil energy bases systems. These occur at each of the basic in levels of project development including resource assessment, project evaluation, and project implementation. Although the discussion below uses renewables as an example, similar arguments could be applied to the other GHG mitigation options.

Probably one of the largest differences between renewable and fossil-based systems comes in the resource assessment phase. Few, if any, of the newly industrialized countries have carried out comprehensive renewable energy resource assessment activities. Such assessments are both critical and necessary first steps in project development since, unlike fossil energy, if domestic resources are not sufficient to support the project, the necessary resources cannot be imported. This is further complicated by two factors. First, the renewable resource base tends to be very site specific, so it is difficult to utilize a general country assessment for project siting purposes, even if one is available. Second, one or more years of data collection are usually needed to have a high enough level of confidence in the resource base to obtain project financing. Such a time frame is often outside the range of government programs disiring to show short-term results.

In the technology evaluation phase of the project at least three areas deserve mention. First, it is very difficult to obtain country specific technology performance and costs characteristics. Performance characteristics are often closely related to resource assessments, which often are not available, and costs do not include important transport and in-country support charges. A second area has to do with the need for an agreed upon method of treating both the dispersed and non-dispatchable nature of renewables. In a recent draft country study response strategy, all renewable energy systems were evaluated based upon the addition of a backup system of coal fired power plants at 100% the size of the renewable energy technology. Obviously, none of the renewable energy systems evaluated were cost effective. A final area is associated with the need for analytical modeling tools that properly link the renewable energy systems with both conventional fossil alternatives as well as demand-side based options. Without such tools, it is difficult to understand the impacts of the many linkages that exist between a country's supply and demand systems.

In the final phase of technology development, or technology implementation, one of the most important factors is having the in-country skills necessary to both properly install and maintain new technologies that have no history of use in the country. It is relatively easy and not all that expensive to order and have shipped a new technology half way around the world, but it is much more difficult to identify and obtain proper installation or maintenance support when the initial contact may even be difficult due to communication barriers. Successful implementation and utilization of new technologies, worldwide required a balance between the efforts spent on all the development phases.

Statement on Research and Development for Adaptation and Mitigation of Global Climate Change

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For the

5th Japan-US Workshop on Global Change

Research activities in my unit are part of the research programs of the Department of Agricultural and Resource Economics and the Center for Resourec and Environmental Economics and Management (CREEM). The focus on developing economic models of climate change both on a global scale as well as disaggregated especially for the Asia-Pacific region - the main source of future emissions in the world.

Along with other faculty at the University of Hawaii and several graduate students, we have developed a model that takes into account the supply cost of fossil fuel resources and the sectoral energy demands in an economy, and derives the time path of emissions. This model which is available on the microcomputer, has been used to simulate the future change in emissions and temperature, under alternative assumptions on the availability of renewable energy technologies as well as efficiency improvements in energy appliances.

The results we have obtained for the extent of global warming are quite dramatic. Temperature estimates are much lower than the predictions of the Intergovernmental Panel on Climate Change (IPCC), and more importantly, we show that given the historic reduction in the cost of renewables, such as photovoltaic energy systems, and with the increasing scarcity of fossil fuels, their prices will increase, thus making renewables cost effective. The simulations predict that solar energy may become economical sometime in the middle of the 21st century, the precise time depending on the rate of research and development in renewables.

Further simulations have been done to examine the effect of carbon taxes on warming paths as well as on inter-fuel substitution. Results suggest that carbon taxes even of the order of $15-20/ton will raise substantial tax revenues - of the order of hundreds of billions of dollars in the OECD countries. Even if a miniscule portion of it is plugged into solar energy research, the payoff in terms of reduced warming may be significant.

Current research focuses on energy assessment and climate change mitigation policies in the major Asia-Pacific countries beginning with India. We are organizing a conference in India in early 1998 to get interested researchers and policy makers together and develop a research agenda for climate change adaptation and mitigation. This work is being done with the University of California at Berkeley, the World Resources Institute and several Indian institutions.

Darryl D. DesMarteau

1. Research Interests Related to Environment and Global Change

A. Alternative Working Fluids for Refrigeration, Air Conditioning and Heat Pumps

For the past 10 years we have carries out syntheses and critical property measurements on potential environmentally acceptable alternatives for presently used CFCs, HCFCs, HFCs and FCs. The goal of our work has been to look at third generation alternatives and to identify and characterize as many as possible alternatives which might have potential as working fluids. This work has focused primarily on compounds and mixtures with good potential as alternatives for HCFC-22, CFCs-11, 12 & 114 and for current second generate alternatives for these compounds. A number of promising HFC propanes were identified for the CFCs and several azeotropic mixtures have been found with properties close to HCFC-22.

B. Hydrogen-Based Energy Sources

Fuel cells offer potential as high efficiency, clean power sources. Of the various types of fuel cell technologies under active development, solid polymer electrolyte (SPE) fuel cells offer outstanding potential for vehicular power systems. Our research in this area dating from 1984 began with fluorinated electrolytes for phospoic acid-based fuel cells and evolved into fluorinated polymer electrolytes for SPEs using proton exchange membranes (PEMs). The goals of this work are high conductivity at higher operating temperatures (>100^{o}C) and improved catalyst/membrane interfaces. A number of new fluorinated ionomer polymers are being prepared utilizing sulfonimide, sulfone, and phosponic acid functions as improved alternative to the commercial materials relying on the sulfonic acid functions.

Due to the variety of materials being developed, we are also working in collaboration with others towards developing a molecular-based structural model for materials of this type. Such a model could greatly aid in the design and application of new materials with improved properties for fuel cells and other applications.

2. Some Recent Abstracts

a. 48th Southeastern Regional Meeting of the American Chemical Society, Greenville, SC, Nov. 10-13, 1996.
Poster 249

STRUCTURAL CHARACTERIZATION OF PERFLUORINATED IONOMER MEMBRANES. Rosa D. Bailey, Darryl D. DesMarteau, Jin-Tau Liu, Jing-Ji Ma, Charles W. Martin, William T. Pennington and Ming-Hu Tu, Department of Chemistry, Clemson University, Clemson, SC 19634

Traditional fluorinated polymer electrolytes for use in PEM Fuel cells are ion clustering polymers, such as DuPont's Nafion. These polymers in membrane form are cation selective and exhibit good proton conductivities at low temperatures (<80^{o}C), but are deficient in their ability to conduct a higher temperature without pressurization to maintain sufficient water concentration. They also have undesirably high permeability to alternative fuels, such as methanol. To address these problems, we are currently developing new polymers containing sulfonimide functions in place of the sulfonic acid function in Nafion and related materials. Novel difunctional crosslinking monomers are also being developed for improved mechanical properties. As part of a general project to probe the structure-property-performances relationships of these new materials, they have been structrually characterized by wide-angle X-ray diffraction. The results of these studies, as a function of equivalent weight, temperature, membrane form and processing history will be reported.

Paper 460

PERFLUORINATED IONOMERS CONTAINING SUPERACID SULFONIMIDE FUNCTIONS. Darryl D. DesMarteau, Jin-Tao Liu, Ming-Ju Tu, Charles W. Martin, William T. Pennington, Stephen Creager, Ya-Ping Sun, Chris Bunker, James Sumner, Greg Shafer and James McClellan, Clemson, University, Chemistry Department, Box 341905, Clemson, SC 29634-1905.

Perflurinated ionomers countering sulfonic acid functions are under active consideration as proton exchange membranes (PEMs) for use in hydrogen-oxygen fuel cells. These materials originally developed as membrane separators for the chloralkali industry have many desirable properties as PEMs in fuel cells but they also have many limitations. In an ongoing effort to develop superior PEMs, a new class of perfluorinated ionomers containing the -CF2SO2N(H)SO2CF3 acid function in place of -CF2SO3H have been developed. Current research on these novel materials will be reviewed.

b. ACD 13th Winter Fluorine Conference, St. Petersburg, FL, Jan. 19-24, 1997. Poster16

SYNTHESIS AND PHYSICAL PROPERTIES OF POTENTIAL NEW ALTERNATIVES FOR CURRENT HCFCS AND HFCS. Ismail Kul, Gang Zhao, Yuan Xie, A.L. Beyerlein and D.D. DesMarteau, Department of Chemistry, Clemson University, Box 341905, Clemson, SC 29634-1905

The international Montreal Protocol signed in 1990 requires a total phase out of CFC production and consumption by the year 2000 and for HCFCs by 2030. In order to evaluate the performance of possible alternatives to the full as halogenated chloroflurocarbons (CFCs) or partially halogenated hydrofluorocarbons (HCFCs) as working fluids in refrigeration or heat pump applications, knowledge of the physical properties is required (e.g. vapor pressure, below the boiling point and above the boiling point, critical temperature, critical pressure, critical density, heat of vaporization, etc.). In this research, we concentrated on finding potential alternatives for R-11 and R-22. Fluorinated ethers and S compounds (i.e. CF3OCF2CF3, CF3OCH2CF2, CF3SF5 and CF2SCF3) and their mixtures with HFCs are being evaluated as HCFC-22 alternatives and R-338 mccq (CF3CF2CF2CFH2/isopentane mixtures as R0-11 alternatives. Herein the synthesis and evaluation of physical properties of these pure compounds and their mixtures will be discussed.

c. Physical properties of fluorinated Propane and Butane Derivatives and the Vapor Pressure of R-245ca/338 mccq Mixtures as R011 Alternatives, A.L. Beyerlein, D.D. DesMarteau, K. Naik and Y. Xie, *ASHRAE Transactions* 1996, 102(1), 3968.

Two new fluorinated propane derivatives, six new fluorinated butane derivatives and the R-245ca (HCF3CF2CH3F)/338 mccq (F3CF2CF2CH2F) mixtures are investigated as R011 alternatives. The investigations on the pure chemicals included measurements of the melting point, boiling point, vapor pressure below the boiling point, heat of vaporization at the boiling point, saturated liquid density, and critical properties (temperature and density). Four of the butane derivatives - R-338mcfc, R-356mffm, R-356mecs, and R-356mms - have boiling points comparable to that of R-11 and have potential as far-term R-11 alternatives. The vapor pressures of the R-245ca/338mccq mixtures were measured over the entire concentration range for temperatures ranging from 25^{o}C (77^{o}F) to 135^{o}C (275F). The mixtures form an azeotrope at 0.64 R-245ca mole fraction with a normal boiling point of 22.6^{o}C (72.7^{o}C).

3. Future Research Directions

- Adaptation and mitigation of global change through improved energy efficiency in existing technology.
- Adaptation and mitigation of global change through new, more energy efficient technology.
- Adaptation and mitigation of global change through more "green" technology.

EVALUATION OF CO2 PAYBACK TIME OF POWER PLANTS BY LCA

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DATA FOR POWER PLANTS

In this study, CO2 payback times were calculated for typical future renewable energy electric power plants (small scale hydroelectric, OTEC, and photovoltaic) compared to commercial fossil fuel-fired electric power plants (coal, oil, and LNG) in order to estimate CO2 reduction potential of renewable energy electric power plants comparing to commercial fossil fuel-fired electric power plants. CO2 emissions resulting from plant construction and the production of plant construction materials were calculated for each plant. The amounts of materials and input energy for construction of each power plant were taken from previous papers (Uchiyama et al., 1991, Resource Council, 1983, Tahara et al., 1993, Inaba et al., 1995b). The resulting LCI (Life Cycle Inventory) was calculated by "NIRE-LCA (Life Cycle Assessment) software developed at the National Institute for Resources and Environment using a bottom-up approach (Kobayashi et al., 1994, Kobayashi et al., 1995).

METHODOLOGY TO CALCULATE CO2 EMISSIONS

The CO2 emissions from production of materials were calculated by "NIRE-LCA". Most of data LCI (Life Cycle Inventory) were taken from our previous paper (Inaba et al., 1995a).

CO2 emissions not only from combustion of fossil fuels, but also from the production of fossil fuels, electricity and other materials were calculated using the life-cycle assessment emissions inventory methodology. The system boundary for imported materials in this study was set at the ports of the producing countries, meaning that the CO2 emissions in those foreign countries were excluded from this calculation while those from the transportation were included. The data for mining of raw materials including fossil fuels in the exporting countries were also excluded from this calculation. Japan now imports about 100% of aluminum ingots and about 65% of the naphtha used as industrial materials, whose production data were excluded. CO2 emissions from liquefaction of natural gas in the producing countries was regarded as part of transportation and was taken into account as emissions for transport was included. The transportation from the Japanese port to production facilities was also ignored. CO2 emissions from the production of materials are shown in Table 1.

Table 1. CO2 emissions from materials and energy.

Items	NIRE (kg-CO2/kg)
iron and steel	1.180
aluminum	2.035
concrete	0.099
cement	0.719
stainless steel	3.325
silicon steel	1.563
copper	1.304
paper	1.685
PE	1.262
PVC	1.497
titanium steel	10.062
CFC	2.498
FRP	1.660
chrome steel	7.785
ammonia	1.107
silicone	86.241
glass	1.928
electricity (kWh)	0.438
coal	2.383
heavy oil	3.216

RESULTS AND DISCUSSION

CO2 Emissions from Power Plant Construction

The calculated total CO2 emissions from the construction of each power plant were divided by the annual net generated electricity because the power plant generating capacity of each plant differed. These results are shown in Table 2. Oil- and LNG-fired power plants have the same input energy and materials but CO2 emitted per annual net generated electricity of the LNG-fired power plant smaller than the oil-fired power plant because of the higher efficiency of the LNG-fired power plant. CO2 emitted per annual net generated electricity of PV(I) is smaller than PV(J), as PV(I) has a larger annual net electricity generation.

Table 2. Power plant CO2 emissions from construction and per kWh generated

	CO2 emissions [kg-CO2/(kWh/year)]	CO2 emissions [kg-CO2/kWh]	Per kWh [kg-C/kWh]
Coal	0.0221	0.9159	0.2498
Oil	0.0164	0.7557	0.2061
LNG	0.0160	0.5630	0.1536
Hydro	0.3954	0.0171	0.0047
OTEC(2.5MW)	2.2305	0.1190	0.0324
OTEC(100MW)	0.2554	0.0136	0.0037
PV U	3.5400	0.1534	0.0418
PV I	3.4143	0.1480	0.0404
PV J	4.3070	0.1866	0.0509

CO2 Emissions for Power Plant Operation

Fossil fuel-fired power plants emit CO2 from fossil fuel combustion for electricity production (coal : 5.57 X 10^9, oil : 4.66 X 10^9, LNG : 3.57 X 10^9 kg-CO2/year). CO2 emissions from operation of renewable energy electric power plants were assumed to be 1%/year for hydroelectric and PV, and 2%/year for OTEC, respectively, of the CO2 emissions from their construction. CO2 emissions from fossil fuel-fired power plants during operation from sources other than fossil fuel combustion were not taken into account, as they are thought to be insignificant compared to that from fossil fuel combustion (Uchiyama et al., 1991).

CO2 Payback Time

CO2 payback time was calculated from estimates of CO2 emissions from construction and during operation in a large scale of fossil fuel combustion during operation. For example, the definition of CO2 payback time, T for hydroelectric vs. coal-fired power plant is defined as follows:

$$T=(Chydro / Ehydro-Ccoal / Ecoal) / (Ocoal / Ecoal-Ohydro / Ehydro) \quad (1)$$

$$y=Ccoal + Ocoal \bullet \mathbf{T} \quad (2)$$

$$Y=y / Ecoal = Ccoal / Ecoal + Ocoal / Ecoal \bullet \mathbf{T} \quad (3)$$

The result of equations similar to Eq.2 for each combination of renewable energy and conventional power plants are represented by the intersection of the respective lines for CO2 emissions shown in Fig. 1. CO2 payback times of renewable energy electric power plants based on coal power plants were about 60% of those based on LNG power plants, which is mainly caused by the difference in carbon content / calorific value. CO2 payback times of hydroelectric and OTEC (100MW) were very short, which was mainly smaller CO2 emissions from construction compared to PV power plants. It was suggested that if the operating lifetime of the renewable energy power plant was

longer than the CO2 payback time, the plant was better with respect to the mitigation of global warming.

CONCLUSION

The LCA methodology using a bottom-up approach to calculate CO2 emissions from construction of each power plant was shown in this paper. The system boundary for imported materials in this study was set at the ports of the producing countries, meaning that the CO2 emisssions in those foreign countries were excluded from this calculation. The data for mining of raw materials including fossil fuels in the exporting countries were also excluded from this calculation. The international cooperation is required to calculate CO2 emissions from the production of materials.

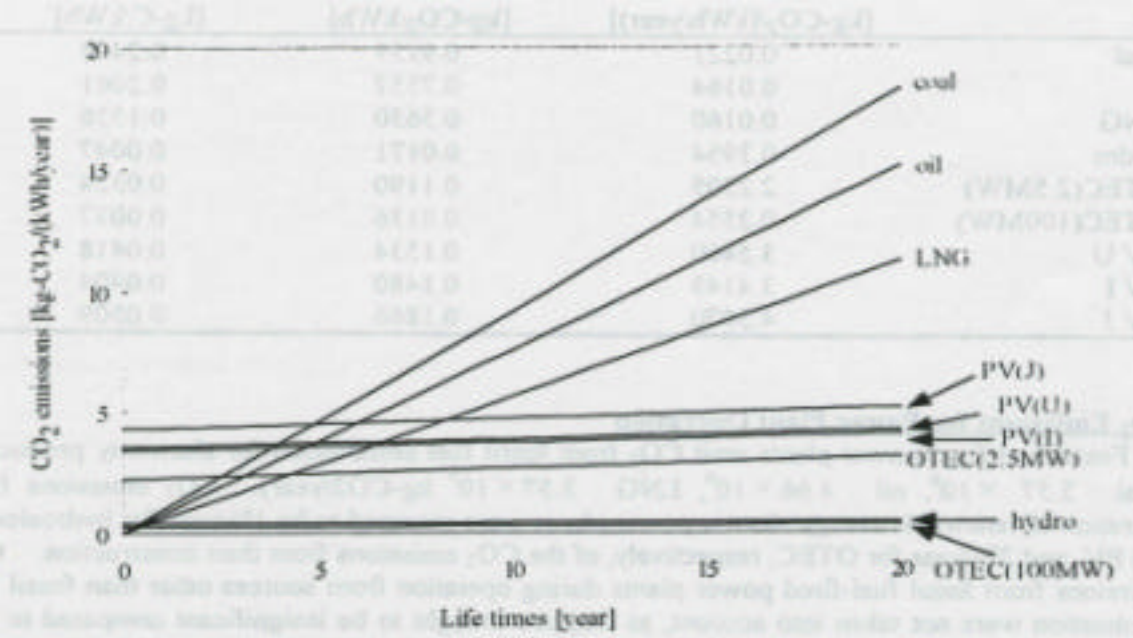

Fig. 1. CO_2 emissions of each power plant.

NOMENCLATURE
O=CO2 emissions from generating plant [kg-CO2/year]
E=Electricity generated annually [kWh/year]
C=CO2 emissions from material product and construction [kg-CO2]
T=CO2 payback time [year]
y=Cumulative CO2 emissions [kg-CO2]
Y=Annual CO2 emissions per electricity generated [kg-CO2/(kWh/year)]
Em=CO2 emissions per kWh [kg-CO2/kWh]
Te=Lifetime [year]

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Environmental Acceptability for New Chemical Substances

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Environmental acceptability of new chemical substances should be studied from many aspects. There are some groups working for these projects in our institute. In our Division, atmospheric chemical reactions are investigated: (1) heterogeneous processes and (2) pathway of homogeneous gas-phase reaction.

(1) Heterogeneous Processes

The experimental approach is now in progress to estimate heterogeneous processes, while that of homogeneous reactions is established. We study both gas-liquid and gas-solid interface processes.

Dissolution into clouds, rain and sea water
Uptake coefficient and overall mass transfer coefficient are required to estimate this removal process. We measure these physical parameters by using a bubller reactor proposed by Dr. Worsnop and a two-phase (gas and liquid) flow reactor, respectively. New alternatives to chlorofluorocarbons and their atmospheric degradation products such as carbonyl fluoride are the major compounds. It is ready to measure their hydrolysis rate constant by a stopped flow method. We also try to identify the degradation products in liquid phase with a gas or a liquid chromatograph mass spectrometer.

Photodegradation on particulate matters and aerosols
We investigate heterogeneous reactions on solid particles with a closed circulation reactor and a flow reactor. Chlorofluorocarbons, their substitutes, hydrocarbons and Noy have been examined. Soils, clays, metal oxides, sodium chloride, and sulfuric acid are tested as model compounds of environmental particles or aerosols. We study kinetics and degradation products of typical heterogeneous reactions among them.

(2) Pathway of Homogeneous Gas-phase Reaction

We have been conducting product analysis of gas-phase reactions with Cl or OH radicals to estimate atmospheric degradation products, using an FTIR equipped with a multireflectance long path cell surrounded by some fluorescent lamps. Halocarbons and alternative chlorofluorocarbons are mainly examined.

An environmental chamber is recently set up which is made of stainless steal with inner wall coated by Teflon, and is equipped with a mulireflected mirror and a high resolution FTIR (Bomen DA8). A UV-VIS detector will also be installed. The temperature and pressure of the chamber can be controlled at 233 to 423 K and 10^{-5} to 760 Torr, respectively. Photoillumination can be performed with a light wave-length region of 190 to 800nm (by two 1kW xenon short arc lamps) and 172 nm (by a 200 W xenon excimer lamp).

The experimental apparatus will make it possible to simulate chemical reactions at low temperature and pressure which is very important reactions in both polar regions and stratosphere. The chamber is also designed to study heterogeneous reactions. We will estimate the contribution of heterogeneous processes to the atmospheric lifetime of chemical substances.

Development of alternative chlorofluorocarbons and environmental acceptability study on chemical substances can proceed in cooperation with the United States.

Consideration of CO2 Fixation and New Energies in a Re-Coded Conventional Energy Model

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ABSTRACT

The authors constructed a global energy model by linear programming based on the Edmonds and Reilly's model. In the model, the world is geo-politically divided into 13 regions and the primary energy supply, energy conversion, energy transportation, secondary energy consumption, CO2 fixation, etc. are considered. It is capable of assessing CO2 release over a period of up to 100 years by unit of 10 years. The outline of the model and the examples of the assessment is introduced, though we are still evaluating and revising this model.

STRUCTURE of THE MODEL

The concept of the model is transferred from Edmonds and Reilly's long-term global energy-economic model. Though their program is coded by FORTRAN language, the newly constructed model is re-coded by linear programming method. In the model, the solver tries to find the cost minimum condition within all regions considering energy transportation between another regions and CO2 fixation technology as well as energy supply, conversion and the demand of each region.

For primary energy supply, solids, oil, gases, nuclear energy, hydraulic energy, solar energy are listed and they are converted to secondary energy such as solids, liquids, gases and electricity to be supplied to the region. Hydrogen and methanol are produced by the generators and these fuels are stored and used for power generation for the purpose of the reduction of CO2 release.

Hourly variation of energy demand and solar power potential of each region in one day can be counted in this model. A day is put into 4 time zones i.e. 0-6, 6-12, 12-18, 18-24.

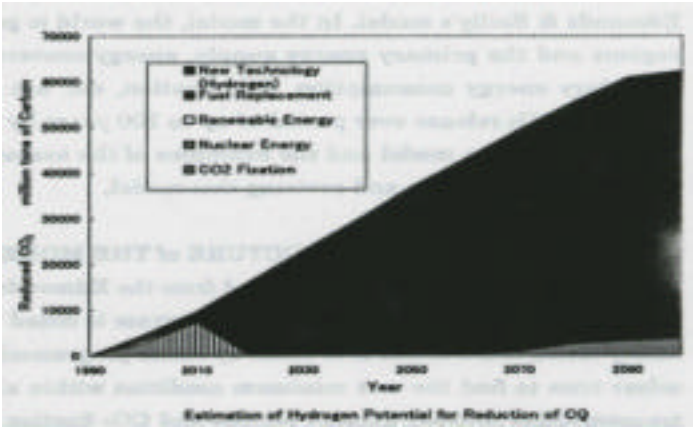
As for the power conversion, it is composed by (1) the facilities to convert solid, oil, gas fuels to each products and (2) power generators by solid fuel, liquid fuel, gas fuel, nuclear energy, hydraulic energy, solar energy, hydrogen methanol. The CO2 generation by these facilities are regarded as amount of CO2 generation in the region. The transportation of energies between each regions counted in this model is the transportation of the primary energies, hydrogen through pipe lines, and methanol by tankers. CO2 release from each region is calculated from the produced CO2, reduced CO2 by afforestation and fixed CO2 into gas or oil wells, or deep sea.

INPUT DATA

Referring to the input data of Edmunds and Reilly's model, the input data for this model is decided. The data for newly added functions are investigated from interanationally recognized journals.

RESULTS & CONCLUSIONS

The example of the results of a test calculation is shown in a figure. In this case, the limit for facilities of hydrogen energy conversion is set to be mostly cleared away. These results show the input data and the assumption have important roles as well as hydrogen can be a key technology for CO2 reduction. This model is still on the stage for debugging, discussing the estimation algorithm and revising the input data. We would like to continue to establish this model as authorized one and open it to evaluate and find our research projects.



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Development of a New Fluorinated Ether as Alternatives to CFCs

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Since it was found that chloroflurocarbons (CFCs) destroy the ozone layer in the stratosphere, it was decided to abolish them totally by the beginning of 1996. HCFCs which are called second generation alternatives to CFCs will be phased out because of having the effect to deplete the ozone layer. Consequently, the CFCs and HCFCs alternatives that are environmentally low effective are necessary to develop.

HFCs, and hetero-compounds are the possible fluorinated alternatives to CFCs. We were especially interested in researching HFCs and fluorinated hetero-compounds. Now, new HFC as solvent is developing as joint research programs between NIMC and Nippon Zeon Co., Ltd. Fluorinated ether compounds are also developing in national projects "Development of New Refrigerants, Blowing Agents and Cleaning Solvents for Effective Use of Energy" as joint research between National Institute for Resoures and Environment (NIRE), National Industrial Research Institute of Nagoya (NIRIS), and Research Institute of Innovative Technology for the Earth (RITE). Both research are carrying out under the commission of the New Energy and Industry Technology Development Organization (NEDO).

In this report, we wish to describe the possibility of some fluorinated alternatives to CFCs. One is cyclic HFC as solvent and another is ether compounds as the candidate of refrigerant.

The selected alternative compounds and their properties were listed in the Table.

We think these candidates have the potential to replace some ODSs. Because the candidates having the good properties such as short lifetime, low GWP, good thermal stability, nonflammable, and low toxicity.

We are continuing to develop fluorinated compounds as CFC alternatives in these projects to find out the most safest compound to the environment.

Table Properties of Developed Alternatives to CFCs

	$CH_3OCF_2CF_3$	$CH_3OCF_2CF_2CF_3$	$CH_3OCF(CF_3)_2$	c-$C_5F_8H_2$
Boiling Point [℃]	5.59	34.18	29.35	79
Molecular weight	150.1	200.1	200.1	214
Density (liq、23℃) [kg/m³]	1280	1409	1420	1680
Surface tension (23℃) [mN/m]	10.63	12.39	11.86	20.7
Critical Temp. [K]	406.80	437.70	433.30	-
Critical Pressure [MPa]	2.887	2.481	2.553	-
Latent Heat of Vaporization (B.P) [kJ/kg]	169.7	142.3	139.3	165
Thermal Conductivity (liq.、23℃) [W/m•K]	0.0872	0.0753	0.0780	-
Viscosity (liq.、23℃) [mPa•s]	0.288	0.471	0.463	1.67
Flash Point	non	non	non	non
Thermal Stability 120℃×3day	stable	stable	stable	-
Lifetime [years]	6.5	6.4	4.9	4.7[1]
GWP (ITH = 100 years)	622	485	368	-
Sub-Acute Inhalation Toxicity (rat)	6h×28day NOEL>20.0g/m³	6h×7day NOEL>7.0g/m³	6h×7day NOEL>2.0g/m³	-
Replacement	CFC-114	CFC-11	CFC-11	CFC-113 PFC Trichloroethane

1) Calcd

POTENTIAL LAND AREA FOR REFORESTATION AND CARBON DIOXIDE MITIGATION EFFECT THROUGH BIOMASS ENERGY CONVERSION

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POTENTIAL LAND AREA FOR REFORESTATION

Reforestation has a great potential to fix carbon dioxide (CO2) in the atmosphere through photosynthesis of biomass and biomass energy conversion. A total amount of the CO2 fixation by planted trees highly depends on the practical planting areas, and it is no exaggeration to say that the evaluation of the biological CO2 fixation is controlled by the estimation of this value of area. In this report, the potential land area in 2050 was estimated using FAO and World Bank data for yearly growth of crop productivity and population etc. The land area of other wooded land is supposed to be used for bioenergy plantation of fast growing trees. This area is converted to arrable land due to the increase of food supply by population growth and improvement of nourishment. At the same time, the improvement of productivity of crop should be considered, and the annual increase of productivity is assumed to be 1.4% per year. Taking all these factors into account, the potential land area is 69 Mha in Latin America, 23 Mha in South East Asia, and 34 Mha in Africa, totaling 126 Mha.

THE GENERATION OF ELECTRICITY BY BIOMASS COMBUSTION

The mitigation of CO2 is estimated here when electricity is generated by combustion of biomass such as fast growing trees, for example, *Eucalyptus*, it is important to note that the net accumulation of CO2 in the atmosphere can be maintained if the amount of biomass which is used for energy combustion is balanced with that of biomass planted. If forests are managed and utilized for energy in a sustainable manner, CO2 emission from combustion of fossil fuels can be avoided. Two cases are discussed for the electricity generation from biomass combustion.

Case 1: *Eucalyptus* plantation of 20km in diameter, with a 6-year rotation and 5230 ha/y harvested

Parameters:

Net production of *Eucalyptus*	10.5 dry ton/ha
Harvested area	5230 ha
Calorific value *Eucalyptus*	20 GJ/dry ton
Effeciency of power generation	0.22 (biomass combustion)
Effeciency of power generation	0.33 (coal combustion)
Carbon emission from coal combustion	0.027 t-C/GJ

The net production of Eucalyptus (10.5 dry ton/ha/y) seems reasonable because that of Eucalyptus has been reported to be more than 40 wet ton/ha/y in Brazil. In this case, the carbon content in wood is about 45-50%. The calorific value of Eucalyptus is 20GJ/ dry weight (about 4800 kcal) and the effeciency of direct combustion is 22%, because a small scale power generation plant is adopted in this case. At this time, no consideration is given to energy consumption for the construction of the power plant.

The mitigation of CO2 is calculated as follows:
10.5 (dry ton/ha/y) x 31400 (ha) x 20 (GJ/ dry ton) x 0.22/0.33 x 0.0247 (t-C/GJ) = 108.6 kt-C/y

As for the energy used in cultivation of Eucalyptus, energy is necessary for the preparation of land, planting, fertilization, management and thinning. Furthermore, the energy needed for cutting and transportation must be considered when harvesting. These are based on the value reported by Turhollow et al.:

Energy needed for tree growth	11.94 GJ/ha/y
Energy needed for tree harvesting	4.1 GJ/ha/y
Carbon emission from gasoline	0.0208 t-C/GJ

Taking into consideration the energy needed for the growth and harvest of trees, it is calculated to be 3.5kt-C/y. The above-mentioned value is based on the data reported by Larson (1995). The energy input of fossil fuel for tree growth and harvest is converted to the energy of gasoline. Thus, the true CO2 mitigation effect becomes 108.6 -3.5 = 105.1 kt-C/y. In other words, 105,100 t of carbon can be reduced on this area each year.

Case 2: Eucalyptus plantation of 1 Mha, with a 6-year rotation and 0.167 Mha/y harvested

Parameters:

Net production of Eucalyptus	10.5 dry ton/ha
Harvested area	0.167 Mha
Calorific value of Eucalyptus	20 GJ/dry ton
Effeciency of power generation	0.27 (biomass combustion)
Effeciency of power generation	0.33 (coal combustion)
Carbon emission from coal combustion	0.027 t-C/GJ

In this case, the effeciency of power generation with biomass is raised to 0.27 from 0.22 due to the scale effect of power plants.

The mitigation of CO2 is calculated as follows:
10.5(dry ton/ha/y) x 1.0 (Mha) x 20 (GJ/dry ton) x 0.27/0.33 x 0.0247 (t-C/GJ) = 4.24 Mt-C/y

Energy needed for cultivation and harvest is as follows:

Energy needed for tree growth	4.1 GJ/ha/y
Energy needed for tree harvesting	13.76 GJ/ha/y
Carbon emission from gasoline	0.0208 t-C/GJ

In this case, the energy for harvesting is larger than for Case 1 due to the longer distance for tree transportation. The true CO2 mitigation effect for 1 Mha becomes 4.24-0.12=4.12 Mt-C/y. Therefore, the net CO2 mitigation effect is 0.5 billion t-C on 126 Mha.

SUMMARY

Biomass energy is understood as a key technology against global warming. According to the Intergovernmental Panel on Climate Change (IPCC), the land for biomass plantation is evaluated about 600 Mha or more. However, it is considered that the available land area is smaller than expected in the scenario if looking at the real situation of the developing countries in the tropical region where forest has been cut down due to urbanization, industrializion, and conversion to farming. In this article, the available land is estimated to be about 126 Mha. As for the individual species of wood and energy conversion technology biomass, fast growing Eucalyptus is chosen and the generation of electricity by direct combustion of biomass is considered. In this analysis, about 4 million tons of carbon can be reduced on 1Mha (100km x 100km) land. Thus, 0.5 billion tons of carbon can be reduced on 126 Mha if sustainable management of biomass energy plantation is carried out for power generation from biomass.

REFERENCES

Larson, E.D., C.I. Marrison and R.H. Williams (1995). CO2 mitigation potential of biomass energy plantations in developing regions. Private communications.

Turhollow, A.F. and R.D. Perlack (1991), Emission of CO2 from energy crop production, Biomass and Bioenergy, 1(3), 129-135.

PROPOSALS

5th U.S.-Japan Workshop on Global Change
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Working Group 1

AREA: Role of gas hydrates in global change

TOPIC: Identification of conditions under which global warming can lead to a significant release of methane from gas hydrate decomposition.

PROJECT: Form a Japan-U.S. team to identify critical sites which can serve as test cases for the impact of global warming and carry out a well-defined scientific experiment on the conditions necessary to cause change at those sites.

OBJECTIVE:
To provide an accurate assessment of the impact of temperature change on the flux of methane from critical sites of gas hydrate exposure in the ocean.

SCIENTIFIC RATIONALE:
Gas hydrates represent an enormous resevoir of fossil fuel methane in the Earth. Much of this is locked deep in the ocean sediments, but at few sites, large amounts of gas hydrate are exposed on the sea floor. Critical locations include the Arctic shelves, off the coast of Japan, the Western U.S., and the Gulf of Mexico. A warming of 1 degree Celsius, penetrating to a depth of about 600m, could cause significant releases. This is well within the range of prediction of current models of global warming.

PROPOSAL:
Devise and conduct joint Japan-U.S. experiments on the sensitivity of key hydrate exposure sites by using submersible and ROV technologies to sample the sites, geochemical/geophysical model experiments and models to identify the stability characteristics, and climate models to predict the temperature change and timing under different greenhouse gas scenarios.

SCHEDULE:
Identify key collaborators in 1997-1998; prepare a coordinated proposal in 1998-1999; execute field experiments in 1999-2000.

PARTICIPANTS:
Japan: H. Kobayashi; T. Sato (NIRE); T. Gamo; Ishibasi (Univ. Tokyo)
U.S.: P. Brewer (MBARI); K. Kvenvolden (USGS); I. MacDonald (Texas A&M Univ.); P. Vogt (NRL)

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Working Group I

AREA: Improve predictive capability of global climate change

TOPIC: Development and use of improved, higher-resolution coupled atmosphere, land surface, ocean, and sea-ice climate models

PROJECT: Hold a workshop on the status, use, and future development of climate models

OBJECTIVE:
To improve communication and possibly increase the collaboration among the global climate change modeling groups of the U.S. and Japan.

SCIENTIFIC RATIONALE:
Several groups in the U.S. and in Japan have developed, or are developing, and are using coupled models for prediction of global climate change experiments. Improved parameterizations are being developed and tested. New physical processes are being included. Models with increased resolution, and thus with the capability for resolving more important features of the climate system, are being developed. These groups are doing this work largely independently. Better scientific communication, especially among the groups in the U.S. and Japan, will speed the process of model development and perhaps generate interaction and coordination among these groups.

PROPOSAL:
To hold a workshop that will include scientists from all major-coupled modeling research groups in the U.S. and Japan in order to increase the communication and collaboration among these groups. We propose that the workshop include discussions on the present state of climate modeling, plans for further model development, and results from recent experiments using present models.

SCHEDULE:
The workshop should be held in the spring of 1998, in the U.S., perhaps in Hawaii or Colorado.

PARTICIPANTS:
Representatives from all interested major modeling groups in the U.S. and Japan, perhaps 20-30 from each country.

CONTACTS:
Japan: Masato Sugi (MRI)
U.S.: Maurice L. Blackmnon (NCAR)

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Working Group 1

AREA: Advanced ocean chemical instrumentation for global change detection and prediction

TOPIC: The creation of the next generation of ocean sampling and sensing technologies for the detection of the biogeochemical signature of global change.

PROJECT: Form a Japan - U.S. team to identify and solve critical sampling and measurement problems that now limit progress.

OBJECTIVE:
To design, build, test, and successfully deploy new sampling and measurement capabilities which offer significant improvements in cost, size, and detection capability.

SCIENTIFIC RATIONALE:
The detection of the signature of global change in the ocean requires a large number of expensive and difficult measurements. We need to devise ways to make smaller, better, less expensive instruments, and to find cost-effective ways to deploy them if we are to make advances in scientific understanding, and provide the data necessary to test models of global change.

PROPOSAL:
1) To hold a workshop as soon as possible to bring together key researchers from institutions, agencies, and universities: for example MBARI, WHOI, and NOAA-PMEL in the U.S.; and NIES, NIRE, and Hokkaido University in Japan.

2) To achieve agreement on key strategies for instrumentation development so those instruments from all groups are compatible and achieve the desired standards of measurement and reliability.

3) To bring together the separate components of coordinated experiments and observing platforms, such as ships, buoys, floats, and drifters so that a coherent set of observations is obtained.

4) To test the instrumentation and the data returned, against real oceanic deployments and models, and devise protocols for presenting and interpreting the data.

SCHEDULE:
To be determined.

PARTICIPANTS:
To be determined.

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Working Group 1

AREA: Prediction of global change

TOPIC: Improvement in ocean monitoring of properties critical to understanding global change

PROJECT: A Northwest Pacific Ocean, high-latitude, time-series station

OBJECTIVE: To improve our understanding of the ocean's role in the global carbon cycle, specifically regarding mechanisms controlling the "biological pump" and $C0_2$ exchange at the air-water interface.

SCIENTIFIC RATIONALE: Organic carbon production and transfer out of the upper ocean is one of the main factors regulating the concentration of $C0_2$ in the atmosphere. Mechanisms that control this process must be understood to predict future changes in the concentration of radiatively important gases. One of the most powerful ways of determining rates and mechanisms is to make time-dependent measurements at critical locations in the surface ocean. The reason for Japan-U.S. collaboration on this program is that the Japanese are presently developing a strategy for an ocean sampling program in the framework of the Joint Global Ocean Flux Study (JGOFS). The project includes establishing a time-series station much like the ones that have been operated by the U.S. JGOFS program for the past ten years. Japanese oceanographers will coordinate the sampling program and platform while U.S. scientists with experience in some of the critical measurements will collaborate.

PROPOSAL: We propose a time-series station for the purpose of measuring critical biogeochemical properties in the high-latitude, northwest Pacific Ocean. The station will be occupied 6-8 times per year using various Japanese vessels including the R.V. MIRAJ (JAMSTEC) for the critical wintertime stations. To enhance the measurements made on cruises, we.propose additional data gathering by a surface mooring capable of continuously monitoring important biogeochemical properties. This type of new technical development is critical to advance the methods used to accomplish labor-intensive experimental programs. Collaboration with investigators using the ocean color and temperature sensors on the Japanese satellite ADEOS is anticipated to help interpret measurements of ocean physical and biogeochemical properties. Japan-U.S. collaboration on the time-series study could create the foundation for future cooperation within the planned International Pacific Research Center.

SCHEDULE: Preliminary cruises in the Japanese JGOFS time-series program are planned for the spring or summer of 1997, and test cruises of the R.V. MIRAI are scheduled for Nov. 1997-Oct. 1998. Time-series to begin in the summer of 1998.

PARTICIPANTS: Japan: Yukihiro Nojiri (National Institute for Environmental Studies); Toshiro Saino (Nagoya Univ.); lsao Koike (Univ. Tokyo); Masashi Kusakabe (JAMSTEC); N. Handa (Aichi Prefectrrral Univ.); Shizuo Tsunogai (Hokkaido Univ.); Katuyuki Sasaki (Central Fisheiy Research Institute); Koh Harada (National Institute for Resources and Environment)
U.S.: Steven Emerson (Univ. of Washington); Paul Quay (Univ. of Washington); David Karl (Univ. of Hawaii); Richard Feeley (NOAA, PMEL); Peter Brewer (MBARI)

CONTACTS:
Japan: Yukihiro Nojiri, ~IES, EA); Tsukuba, Japan; (nojiri@nies.go.jp)
U.S.: Steven Emerson (Univ. of Washington) Seattle, WA, U.S.A. (emerson@u.washington.edu)

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Working Group I

AREA: Global change prediction

TOPIC: High-resolution ocean modeling in climate studies

PROJECT: To hold a U.S.-Japan workshop to facilitate extensive ocean modeling collaborations and progress in high-resolution studies

OBJECTIVE:
The proposed workshop will emphasize the treatment of the ocean from Pacific to global extent with boundary currents (e.g., Kursoshio) and eddies included, along with biogeochemical and atmospheric connections.

SCIENTIFIC RATIONALE:
The ocean has small space scales and long time scales of importance to changing climate, to productivity of fisheries, and to potential changes in sea level. Uses of advanced numerical models, high-performance computers, and satellite and in-situ datasets are required; and two nations dedicated to this effort can make much faster progress than either by itself.

PROPOSAL:
The purpose of the workshop will be to emphasize ocean model improvements and uses. However, connections to atmospheric modeling are so important that this should be part of a larger (proposed) workshop on climate modeling. Numerical and physical improvements in ocean models, high-performance computing applications and their scientific results, and evaluation of model output with respect to observations (sea-surface height, surface temperature, oceanic transports, and hydrographic sections) would all be discussed.

SCHEDULE:
To be held in late 1998 at a site convenient to both Japan and U.S. participants. Funding to be obtained in the interim from agencies in the two countries.

PARTICIPANTS:
Original organizers to include Semtner and Motoi, along with Blackmon and Sugi on the climate connections. Wide participation from U.S. and Japanese institutions involved with or interested in high-resolution ocean modeling for climate study.

CONTACTS:
Japan: Tatsuo Motoi (Meteorological Research Institute; motoi@mri-jma.go.jp)
U.S.: Albert Semtner (Naval Postgraduate School; sbert@ucar.edu)

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Working Group 2

AREA: Social dimensions of global change

TOPIC: Integrated assessment, valuation

PROJECT: Incorporating human/social factors into quantitative integrated assessments of global change.

OBJECTIVE:
Explore new, non-traditional methods of 'valuation without money' and incorporate them into an integrated assessment framework.

SCIENTIFIC RATIONALE:
Economic valuation is important, necessary, and insufficient. We need new creative ways for making human/social factors and impacts integral components of global change integrated assessments.

PROPOSAL:
Convene a workshop of integrated assessment practitioners and social scientists from Japan and the U.S.; map out the state of the art; identify research opportunities.

SCHEDULE:
1998.

PARTICIPANTS:
Japan: Masahino Amano (Forestry and Forestry Products Research Institute)
U.S.: Gary Williams (Argonne National Laboratory); Ellis, Hobbs (Johns Hopkins Univ.)

CONTACTS:
Japan: Amano
U.S.: Ellis

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Working Group 2

AREA: Social response

TOPIC: The effect of Information on public perception, attitudes, knowledge and behavior

PROJECT: Use of ethnographic survey methods to analyze information sources, depth of knowledge and changing perceptions, and attitudes and behavior of lay persons.

OBJECTIVE:
To obtain needed information about social system responses to global warming, including use and interpretation of information about global environmental changes.

SCIENTIFIC RATIONALE:
To date, there have not been in depth analyses of information sources, the depth of knowledge and its relationship, the relationship of knowledge and perception, attitudes and behavior.

PROPOSAL:
To conduct ethnographic interviews on specific demographic variables in regions of both the U.S. and Japan for analysis and comparison.

SCHEDULE:
Interviews will be conducted between late 1998 to 1999.

PARTICIPANTS:
Japan: Midori Aoyagi-Usui (NIES)
U.S.: To be determined

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AREA: Institutional analysis

TOPIC: Institutional analysis of environmental assessment

PROJECT: Comparative analysis of institutional arrangements for environmental assessment

OBJECTIVE:
Identify institutional arrangements for environmental assessment in countries that produce information at regional levels for potential contribution to global change research. ldentify models for institutional arrangements (e.g., for data collection, monitoring, mitigation) which may be useful for integrated assessment.

SCIENTIFIC RATIONALE:
There is a 25-year history of environmental assessment in the world. Most OECD countries have systems for environmental assessment. Institutions have emerged and evolved in each of these countries to deal with recurring assessment problems such as data collection, monitoring, mitigation, and communication of results. A comparative approach is suggested that allows researchers to identify different arrangements which may be able to complement global change assessment.

PROPOSAL:
Research institutional bases for considering the human-environment response with special focus on how these institutional arrangements could be linked or modified to more effectively meet the needs of countries in the global change arena. This would include examination and evaluation of systems for producing, analyzing, monitoring and communicating information on human health effects, population changes, community change and other factors related to government and private activities. For instance, Japan currently conducts environmental assessments for public and private projects at a provincial level while the United States conducts assessments only for projects involving major federal decisions at the national level and for private and government projects at a state level. Neither country has a mechanism for compiling monitoring data across projects or regions or for tracking the effectiveness of mitigation, though related data exists for individual projects.

SCHEDULE:
An 18-month schedule is proposed

PARTICIPANTS:
Japan: Environmental Agency, Japan
U.S.: Gary Williams, (Argonne National Laboratory); President's Council on Environmental Quality, (CEQ)

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AREA: Impacts of climate change on human health

TOPIC: Direct impacts on morbidity and mortality in urban areas as a result of the combined exposure to increasing temperatures and air pollutant concentrations

PROJECT: Investigate and determine relationships for heat stress, cardiovascular and respiratory morbidity, and mortality as a function of temperature and air pollutants for urban areas in Japan and the U.S.

OBJECTIVE:
Develop regression formulas from morbidity data from Tokyo for the months of July and August, 1980-1994 as functions of temperature, relative humidity, and concentrations of primary and secondary air pollutants. Disease categories to be analyzed include heat stress, endocrine diseases, cardiovascular diseases, cerebral vascular diseases and respiratory diseases. The data will be stratified by age and gender to determine what effect these two variables has on incidence rates for these five disease categories.

SCIENTIFIC RATIONALE:
If atmospheric concentrations of $C0_2$ double in the next 50 to 100 years, average surface temperatures are projected to rise 10 to 30 C. In addition, because a primary source of $C0_2$ emissions is the combustion of fossil fliels, increasing $C0_2$ concentrations in the atmosphere and increasing temperatures could be accompanied by increasing atmospheric concentrations of air pollutants, especially in urban areas. Because greater temperatures and greater air pollutant concentrations will occur together, it is important to determine what the effects are on morbidity as a result of combined exposures to these climatic and environmental factors.

PROPOSAL:
From regression analysis of these two factors, determine the relative risks of morbidity in these five disease categories as a result of increasing exposure to higher temperatures and air pollutant concentrations. By stratifying the morbidity data by age and gender, determine the populations that are the most vulnerable to increased exposure to climatic and atmospheric pollution factors. By analyzing morbidity data from several large urban areas in Japan and the U.S., those climatic and environmental factors that affect morbidity in the five disease categories of this study will be more clearly defined.

SCHEDULE:
From 1997 to 1998, carry out these analyses for cities in Japan and the U.S. and include yearlong morbidity data. From 1998 to 2000, extend analyses to include heat stress, cardiovascular and respiratory mortality and extend studies to include cities in other cooperating countries.

PARTICIPANTS:
Japan: Mitsuru Ando (NlES) Tsukuba, Ibaraki
U.S.: Warren Piver (NIEHS) Research Triangle Park, NC

CONTACTS:
Japan: Mitsuru Ando (N1ES), Tsukuba, Ibaraki; Environment Agency
U.S.: Warren Piver (NIEHS) Research Triangle Park, NC; USEPA; NOAA; NASA; Robert Shumway (UC-Davis)

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AREA: Impacts of climate change on human health

TOPIC: Direct impacts on human health as a result of greater exposure to shorter wavelength UV solar radiation caused by depletion of stratospheric ozone by chlorofluorocarbons (CFCs).

PROJECT: Monitor changes in intensities of ground-level exposures to shorter wavelength UV solar radiation in mid to upper latitudes. For each latitude, ground-level exposures to shorter wavelength Uv radiation needs to be collected for all elevations from sea-level to higher mountainous elevations. Investigations will then be conducted to evaluate the relationship between changing exposure and related health effects.

OBJECTIVE:
Determine the relationships at different latitudes between increased exposure to shorter wavelength UV solar radiation and the incidence of non-melanoma and melanoma skin cancers and eye disorders such as cataracts. Investigate the role of greater exposure to shorter wavelength UV solar radiation to dysfunction of both the cutaneous and systemic immune systems and the role of immune system dysfunction in cancer induction, photosensitivity, and phototoxicity.

SCIENTIFIC RATIONALE:
Exposure to shorter wavelength UV solar radiation has been linked to a higher incidence of non-melanoma skin cancers, especially for lightly-pigmented populations. The role of exposure to shorter wavelength UV radiation, effects on immune system function and the induction of non-melanoma and melanoma skin cancers is unclear. In addition, persons on chronic medications have experienced greater photosensitivity and phototoxicity as a result of increased exposure to shorter wavelength UV radiation. It is not clear what the role of greater exposure to shorter wavelength UV radiation is in causing enhanced photosensitivity and phototoxicity. Both photosensivity and phototoxicity are vastly understudied health problems that could potentially affect large human populations.

PROPOSAL:
Investigate the roles of greater exposure to shorter wavelength UV solar radiation and immune system function in the induction of non-melanoma and melanoma skin cancers and photosensitivity. Monitor incidence rates of skin cancers, eye disorders and photosensivity and phototoxicity reactions as functions of ground-level exposures of shorter wavelength UV solar radiation at different latitudes and elevations above sea-level.

SCHEDULE:
Studies to determine the role of immune system function in skin cancer induction need to be extended through
1997 to 1999

PARTICIPANTS:
Japan: To be determined
U.S.: NOAA, NASA, NIH

CONTACTS:
Japan: To be determined
U.S.: Margaret Kripke (Univ. of Houston)

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AREA: Impacts of climate change on human health

TOPIC: An increase in morbidity and mortality may occur because of the spread of infectious diseases that require a host and/or a vector for transmission and infectious non-vector-borne diseases from tropical latitudes at low and high altitudes, to mid latitudes at low and high altitudes, as a result of increasing surface and ocean temperatures.

PROJECT: Monitor the spread of vector-borne and non-vector-borne infectious diseases into more northern and southern latitudes and higher altitudes as a result of increasing land surface temperatures and ocean temperatures. Vector-borne diseases include malaria and dengue fever and non-vector-borne diseases include cholera.

OBJECTIVE:
Develop remote sensing capabilities to monitor movement of infectious disease vectors (mosquitoes and other insect pest populations) and aquatic biota that carry water-borne infectious diseases into more northern and southern latitudes. Develop simulation models to describe the movement of infectious disease vectors as a result of climate change. Develop new pest management strategies and methods to control pest populations and evaluate their environmental health impacts. Develop new treatments because many strains of the vector-borne diseases are resistant to current treatments.

SCIENTIFIC RATIONALE:
Warmer temperatures and higher humidities favor the growth of pest populations that transmit malaria, dengue fever and schistosomiasis. In addition, higher temperatures and humidities increase the time period and the elevations at which these insect vectors are more active in transmitting these diseases. Warmer water temperatures favor the spread of cholera and other water-borne infectious diseases into more northern and southern latitudes.

PROPOSAL:
Monitor the spread and incidence rates of vector-borne and water-borne infectious diseases into more northern and southern latitudes and at higher elevations. Monitor the effectiveness of presently available vaccines for controlling these diseases. The widespread use of pesticides has produced populations of disease vectors that are resistant to presently available vector control methods and new methods need to be developed and evaluated for their environmental health impacts. Present strains of these diseases are resistant to available medications. New treatments need to be developed.

SCHEDULE:
Efforts to monitor the spread of infectious disease vectors, to control the spread of disease vectors, and to develop new medications need to begin immediately. The schedule for the development of new treatments and pest control methods requires a long-term commitment of resources and is difficult to specify.

PARTICIPANTS:
Japan: To be determined
U.S.: NIH, USEPA, DOD, USDA, NOAA, NASA

CONTACTS:
Japan: To be determined
U.S.: Paul Epstein (Harvard Medical School); W.J.M. Martens,(RIVM) Bilthoven, The Netherlands, for simulation models for malaria and schistosomiasis spread.

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AREA: Technologies to mitigate climate change and impacts on human health.

TOPIC: Evaluation of the human health impacts of replacement chemicals for the chlorofluorocarbons (CFCs).

PROJECT: Investigate and determine the environmental health impacts of the hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), which are the replacement chemicals for the CFCs.

OBJECTIVE:
Determine the toxicities of these replacement chemicals. Determine the effects of these replacement chemicals and their breakdown products on tropospheric chemistry and air pollution. Determine the stratospheric ozone depletion characteristics of the HCFCs and HFCs.

SCIENTIFIC RATIONALE:
CFCs are very effective greenhouse gases and have been linked with depletion of stratospheric ozone, particularly over the polar regions. The HCFCs and HFCs are replacement chemicals for the CFCs which contain hydrogen in their molecular structures. The presence of hydrogen atoms makes these chemicals not only chemically more reactive but also biologically more reactive. Metabolism of some of the HFCs and HCFCs have produced metabolites that are hepatotoxic. In addition, the molecular structures of several of the HCFCs and HFCs resemble halothane, an anesthetic with toxicity to the central nervous system, cardiovascular system, kidney, and liver. The HCFCs and HFCs can react with hydroxyl radicals in the troposphere and produce acid chlorides which are toxic and very irritating to skin, eyes, and mucous membranes.

PROPOSAL:
Investigate the toxic properties of these chemicals and determine their impacts on atmospheric chemistry, including their lifetimes in the troposphere and their photoreactivity in the stratosphere.

SCHEDULE:
It is urgent to begin these studies as soon as possible because the HCFCs and HFCs are already in commercial use.

PARTICIPANTS:
Japan: Environment Agency
U.S.: NIH, USEPA

CONTACTS:
Japan: To be determined
U.S.: Marion Anders (Univ. of Rochester) on metabolism of HCFCs and HFCs

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AREA: Social dimensions of global change - communication

TOPIC: Use of modeling information for planning

PROJECT: Assess model uncertainty and planning information needs

OBJECTIVE:
(1) Identify information needs of end-users for global change researchers; and
(2) Evaluate uncertainty analyses from end-users' viewpoints.

SCIENTIFIC RATIONALE:
Social systems adapt in anticipation of climate change. Information from predictive models is one source of information for local, regional, and national planning systems. Understanding the relationships between model outputs, uncertainty, information channels and the types of information needed by planners at different government levels are critical for adaptation of human systems.

PROPOSAL:
Models for global change will be identified and work on model sensitivity and uncertainty in the models will be summarized for each major output. At the same time, potential end-users of this information (e.g., planners at the local, regional, and national levels) will be surveyed to determine types of information that are most useful, relevant time frames, and most useful information channels and the appropriate frequency of information provided.

SCHEDULE:
Mid 1998.

PARTICIPANTS:
Japan: Masahino Amano (Forestry and Forestry Products Research Institute)
U.S.: Argonne National Laboratory, Johns Hopkins Univ.

CONTACTS:
Japan: Amano
U.S.: Williams, Ellis

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Working Group 2

AREA: Policy aspects of global change

TOPIC: Policy support and information networking

PROJECT: Creation of an electronic discussion and exchange network of international (particularly U.S. and Japan) researchers in policy and social sciences to provide cooperation and collaboration with Working Group 3 of the Asia-Pacific Network for Global Change Research. Working Group 3 is concerned with policy support issues necessary to improve the flow of information to decision makers in government, business, and other key sectors of society.

OBJECTIVE:
To establish a policy network for exchange of information on decision-making, institutional frameworks and other policy issues.

SCIENTIFIC RATIONALE:
Human responses to global change depend on information flow and this varies across national and cultural boundaries. There is a need to understand and systematize in a comparative fashion the diffusion of information to decision-makers, the private sector, and other key sectors of society. Policy and social science networks exist, but are not necessarily organized around the global change agenda. This network is needed to bring together the best methodologies, models, and data for the policy support issues involved in integrated assessment.

PROPOSAL:
Develop a virtual work group and interactive web site for exchange of data, methodologies, and models, as well as providing links to existing global change networks. Use this network to organize collaborative research and organize the policy support issue sessions for future International Human Dimensions Program (IHDP) workshops.

SCHEDULE:
The virtual work group would be created in conjunction with the human dimensions open meeting in Austria in June 1997.

PARTICIPANTS:
Japan: Midori Aoyagi-Usui (NIES, JEA); Shuzo Nishioka (NIES, JEA)
U.S.: Fae Korsmo (Univ. of Alaska - Fairbanks); Janet Stocks (Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon Univ.); Richard Rockwell (I SR, Univ. of Michigan)

CONTACTS:
Japan: Midori Aoyagi-Usui (NlES)
U.S.: Fae Korsmo (UAF)

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AREA: Human dimensions of regional impacts assessment

TOPIC: The effects of public participation in regional impacts assessment processes

PROJECT: Comparative study of participation in regional impacts assessments in the U.S. and Japan.

OBJECTIVE:
To understand the influence of local communities, interest groups, and other public participants on assessment processes and conclusions.

SCIENTIFIC RATIONALE:
There has been very little evaluation of public involvement in assessment processes, even as there has been increased demand for public involvement.

PROPOSAL:
This study will use ethnographic methods, including interviews and participant observation of ongoing regional impacts studies; such as the Bering Sea Impacts Study, with a focus on the communication between different stakeholders; the influence of different stakeholders on the process of assessment; and the inclusion of participant output into the assessment results.

SCHEDULE:
Three years

PARTICIPANTS:
Japan: Midori Aoyai-Usui (NlES)
U.S.: Fae Korsmo (Univ. of Alaska-Fairbanks); Janet Stocks (Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon Univ.)

CONTACTS:
Japan: Midori Aoyai-Usui (NIES)
U.S.: Fae Korsmo (Univ. of Alaska-Fairbanks)

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Working Group 3

AREA: Impacts of global change on natural and managed ecosystems

TOPIC: Modeling carbon budgets in whole ecosystem soils.

PROJECT: Carbon storage and carbon fluxes from rhizosphere (humus and root layer of substrate)

OBJECTIVE:
To evaluate the role of human activities on soil carbon status based on available measurements used to develop models that describe whole ecosystems. Specifically, we wish to estimate how changing land use, atmospheric chemistry, and climate can directly and indirectly affect the fluxes and storage of carbon in the upper soil layers, especially in the tropics.

SCIENTIFIC RATIONALE:
Terrestrial carbon cycling is strongly affected by human activities. Shifting cultivation, abandonment of agriculture, forest burning, and silviculture, each affect the stored carbon differently, and change the rates of carbon storage and release from soils. In addition, changing atmospheric chemistry (acid rain $C0_2$ NOx SOx) induces soil carbon storage changes by shifting carbon allocation into plant roots and as exudates from roots, and by dissolution of soil compounds. Finally, climate changes (warmth, moisture) affect soil carbon storage by shifting rates of soil respiration, humus decomposition and nitrogen cycle processes. Even though approximately 2/3 of the global terrestrial carbon is stored in soils, there is little qualitative or quantitative information available with which to evaluate effects of these interacting processes on soil carbon. The development and interrogation of whole ecosystem models (including above ground parts needed to examine below ground processes) from available concepts and data will serve as a starting point to resolve this great uncertainty. The rapid turnover and magnitude of the carbon cycle in tropical soils is particularly important in determining global carbon cycle dynamics and is especially poorly known, providing the most appropriate focus for this research.

PROPOSAL:
To organize a comprehensive scientific meeting on this topic, which will be preceded by a series of planning seminars and followed by strategy seminars to define and inaugurate the cooperative research projects defined by the meeting. The planning seminars will ensure that the scientific meeting is carefully planned and implemented. The strategy seminars will ensure that its products are effectively employed. The products will be used in the seminars to define cooperative Japanese-U.S. research on carbon storage and fluxes in tropical regions. The Japanese work will focus on monsoonal Asia, while the U.S. effort will concentrate on South America and Africa.

SCHEDULE:
The workshop will take place in the autumn of 1997. A project steering committee will be organized immediately.

PARTICIPANTS:
Japan: Seuchi Ohata and Ken Sugimura [Forestry and Forest Products Research Institute (FFPRI)); Shunji Ohata and Yasushi Morikawa (Waseda Univ.)
U.S.: Sandra Brown and Allen Solomon (U.S. EPA); Robert Luxmoore and W. Mac Post (Oak Ridge National Laboratory); Peter Vitousek (Stanford Univ.); William Schlesinger (Duke Univ.)

CONTACTS:
Japan: Seuchi Ohata, (FFPRI)
U.S.: Sandra Brown (U.S. EPA) Corvallis, OR

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AREA: Effects of global change on managed and unmanaged systems

TOPIC: Plant response to atmospheric gases (Ozone and $C0_2$) and radiation (UV-B)

PROJECT: Joint U.S.-Japan Phytotron and field experiment networks

OBJECTIVE:
To establish critical levels for atmospheric gases (Ozone and $C0_2$) and enhanced UV-B caused by stratospheric ozone depletion on agricultural crops and forest trees.

SCIENTIFIC RATIONALE:
Currently, a great deal of information on physiological and growth responses of plants to global changes in climate, radiation and phytotoxic ozone, is required to understand future changes to agricultural crops and forest trees due to global change. This information is being produced in both Japan and the U.S., in various phytotron or field experiments (greenhouses, phytotron, open-top chambers, mesocosms and FACE). There have already been many studies of $C0_2$, ozone and UV-B on reduction or increase of plant growth in greenhouses, growth chambers, open-top chambers or field radiation systems. For example, the growth and yield of rice were substantially reduced by ozone in a possible range of concentration (40-60 ppb), in Japan. On the other hand, the growth and yield of rice were not greatly reduced by up to 1.7 times ambient UV-BBE in the field.

PROPOSAL:
Current concentrations of ozone in Japan, the U.S., and Europe have adverse effects on crop yield, tree growth and vitality, and the composition of natural communities. We need to reveal critical levels for ozone, which is defined as the concentration of an air pollutant in the atmosphere above which direct effects may occur on vegetation, based on analysis of experimental and field data. Moreover, various stresses such as water stress and increase of $C0_2$ affect plant responses. Many greenhouse/chamber studies have reported adverse effects of increased UV-B on crop growth and yield. However, little is known concerning the responses of agricultural crops and trees to enhanced UV-B in the field. We need to collaborate studies to reveal whether a possible enhanced UV-B affects growth or yield of agriculture crops and forest tree species in the field under combinations of various stresses. We propose a joint study in phytotron and field experiment networks and workshop regarding their scientific data.

SCHEDULE:
A large workshop of scientists from both countries, who work in phytotron and field experiment networks for global change research, will be planned after completion of ongoing experiments.

PARTICIPANTS:
Japan: Noriaki Kondo (Univ. Tokyo); Takeshi Izuta (Tokyo Univ. Agric. & Tech.); Yoshihisa Kohno (CRIEPI); Kazuhiko Kobayashi and Noriko Oura (NlAES);, Tadashi Kumagal (Tohoku Univ.); Kenji Omasa (NIES); Genji Ohara (Chuugoku National Exp Station)
U.S.: David Tingey, David Olszyk, William Hogsett (U.S.. EPA. Corvallis); Richard Norby (Oak Ridge Nat'l Lab); Reynord, Boyd Strain (Duke Univ.); Joseph Miller, All Heagle, F. L. Booker (North Carolina Univ./USDA)

CONTACTS:
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U.S.: Allen M. Solomon (US EPA Corvallis)

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AREA: Climate change and managed and unmanaged ecosystems

TOPIC: Crop response to climate variability

PROJECT: Response of rice crop models to changes in climate variability

OBJECTIVE:
1) Test, validate, and compare two different rice models at several locations in Japan.
2) Determine crop model response to changes in high frequency climate variability.
3) From results of 1) and 2), deduce effect of variability change on actual rice crop in Japan.

SCIENTIFIC RATIONALE:
Most studies of crop response to changes in climate concern only mean changes in climate variables such as temperature and precipitation, on a monthly time scale. However, it is likely that the variance of these variables will also change. Few studies consider the effect of changes of higher order variability on crops.

PROPOSAL:
We propose to examine the response of two different rice crop models to variations in climate variability. The CERES-rice model developed in the U.S. and the rice model of Kazuhio Kobayashi at NIAES will be used.

We will test and validate the models at several locations in Japan, particularly focusing on how well the crop models account for the effects of extreme events such as extreme maximum and minimum temperatures.

We will then generate time series of the climate variables (using a stochastic weather generator) needed for the crop models, with changes in daily and interannual variability, both increases and decreases (but keeping the mean values the same). We will investigate the crop model responses to these changes.

SCHEDULE:
To be determined

PARTICIPANTS:
Japan: NIAES
U.S.: NCAR

CONTACTS:
Japan: I. Nouchi
U.S.: L. Mearns

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AREA: Effects of global change on natural systems

TOPIC: Data sets for climate, soils, land use/cover, and watersheds

PROJECT: Japan-U.S. workshop on uses of gridded environmental data in East Asia

OBJECTIVE:
To examine the uses to which gridded data can be applied in assessing environmental change in East Asia.

SCIENTIFIC RATIONALE:
Spatially distributed data on a grid mesh are used to describe precipitation, temperature, net radiation, soil properties, land use and land cover, and watersheds. Such data are then applied to estimate the effects of environmental changes such as climate change and changes in land use and land cover. The available annual and mean monthly climate data grids for East Asia are at a resolution of 0.5 to 2.5 degrees (50 km to 250 km cell size) while in other regions of the world, precipitation and temperature are available at 2.50 (5km) cell size. The Science and Technology Agency of Japan announced a goal of having a meteorological grid with a resolution of 1km, as part of its program for global change assessment. A 300 (1 km) digital elevation model (GTOPO3O) is available for the whole earth and can be used as a framework for preparing more detailed datasets of other quantities, including gridded river and watershed networks. Validation and improvement of the spatial resolution of gridded environmental data sets is needed in East Asia.

PROPOSAL:
It is necessary to gather the relevant experts from Japan, the U.S., and possibly other countries in East Asia and elsewhere. Involvement of relevant officials from UN agencies is also needed. We propose to hold a one-week workshop in Tsukuba, Japan, possibly in Autumn 1997, to catalog and review the existing data, to examine the uses to which it can be put, to identify where additional data and methods are needed, and to propose a program of work for providing these data and methods.

SCHEDULE:
Form a steering committee to plan the workshop during spring 1997, apply for funding summer 1997, hold workshop in autumn 1997 or later.

PARTICIPANTS:
Japan: NIES, MRI, GSI, FFPRI, NIAES, NIED
U.S.: EPA, USDA, Univ. of Delaware, Univ. of Texas, NCAR, NOAA, USGS, DOE

CONTACTS:
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U.S.: David Maidment (Univ. of Texas)

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AREA: Effects of global change on managed and unmanaged systems

TOPIC: Detection of arable land and gradation of marginal areas

PROJECT: Japan - U.S. joint research on the development of a distribution map of arable land and marginal areas

OBJECTIVE:
To provide key materials in order to predict maximum food supply.

SCIENTIFIC RATIONALE:
To predict food supply and demand in the near future, agricultural productivity and current agricultural outputs have to be evaluated precisely. In order to understand effects of the carbon cycle, many methods have focused on estimation of terrestrial primary production. However, there are no reliable data sets on world agricultural distribution. This is due, in part, to the fact that actual agricultural output is strongly dependent on local characteristics, such as management methods, crop type, and socio-economic factors. Recent improvements to GIS systems and satellite monitoring make it feasible to monitor current agricultural distributions. In particular, multi-temporal satellite data (ex. NOAA/AVHRR, ADEOS/AVNIR, ADEOS2/GLI, etc.) provide great contributions to estimate various agricultural parameters, and are widely used for understanding terrestrial ecosystems.

PROPOSAL:
The development of improved methods to detect arable lands and marginal areas requires a collaborative effort among the relevant natural science, social science, and economic disciplines. A prerequisite for success will be to provide sufficient time for interaction and interchange among the various research communities. Most studies of agricultural land and productivity do not consider whether the land is currently used for agricultural purposes or if there is only the potential for farming on the land. We propose a joint research effort consisting of development of methods to 1) detect arable land based on GIS (includes meteorological, soil, topographical) data and remotely sensed data (includes spectral reflectance) and 2) classify marginal areas into 'potential' or 'impossible' agricultural categories based on scientific and socio-economic conditions.

SCHEDULE:
To be determined.

PARTICIPANTS:
Japan: K. Okamoto (NIAES); N. Mino (NlAES); H. Kawashima (NIAES)
U.S.: A. M. Solomon (EPA); C. Rosenzweig (NASA)

CONTACTS:
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Working Group 4

AREA: Evaluating technologies for mitigation of global change

TOPIC: Applications of life-cycle methodology

PROJECT: Organize an international workshop on applications of life-cycle analysis

OBJECTIVE:
Exchange information between the U.S. and Japan that leads to the understanding of life-cycle methodology and its application in the evaluation of energy technologies, and to the harmonization of approaches.

SCIENTIFIC RATIONALE:
Understanding the life-cycle approach to technology evaluation is critical for the proper accounting of embodied GHG emissions. This is especially important as technologies are imported and exported as part of global change mitigation strategies.

PROPOSAL:
Hold a three-day workshop in Japan where researchers meet to discuss the various stages of life-cycle analysis.

SCHEDULE:
Autumn 1998

PARTICIPANTS:
Japan: NIRE, MEL
U.S.: Argonne National Laboratory, Univ. of Hawaii

CONTACTS:
Japan: Inaba, Sagisaka (NIRE), Aya (MEL)
U.S.: Bloyd, Chakravorty

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AREA: Assessment and modeling of technological options for the mitigation of global change

TOPIC: Modeling global change by including detailed costs and estimates of non-renewable and renewable energy technologies.

PROJECT: Develop an energy model with alternative technological options

OBJECTIVE:
Analysis of energy use and emissions scenarios for the Asia-Pacific region.

SCIENTIFIC RATIONALE:
Although there are numerous energy models available, most are either global in nature (too aggregated), or they do not have sufficient detail in modeling alternative energy production technologies necessary for GHG reduction.

PROPOSAL:
The proposed work will consist of two phases. In the first phase, we will conduct a detailed assessment of supply and demand characteristics of the major energy consumers in the region (e.g., Japan, U.S., People's Republic of China). This will include evaluation of supply costs and potential of alternative energy technologies using a life-cycle approach and forecasts of energy demand. The second phase will involve utilizing the information collected in the first phase to develop an energy supply model including technological options to mitigate effects of emissions due to economic growth. Finally, the model will be run to generate alternative energy use and emissions scenarios.

SCHEDULE:
To be determined

PARTICIPANTS:
Japan: NIRE, MEL
U.S.: Argonne National Laboratory, Univ. of Hawaii

CONTACTS:
Japan: Inaba, Sagisaka (NIRE), Aya (MEL)
U.S: Bloyd, Chakravorty

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AREA: Mitigation of global change

TOPIC: Future alternatives for current HCFCs and FFCs

PROJECT: Development of alternatives for HCFCs and FFCs

OBJECTIVE:
Develop new environmentally acceptable alternatives through synthesis, characterization, and evaluation of potential HCFC and FFC alternatives.

SCIENTIFIC RATIONALE:
Several presently used HCFCs and FFCs have environmentally deleterious consequences when emitted into the environment. Alternatives might prove advantageous from environmental, economic, and industrial perspectives.

PROPOSAL:
Synthesize, characterize, and evaluate future alternatives for suitability in applications and for their environmental acceptability. Relevant properties of new compounds will be determined and new standard experimental techniques developed to facilitate evaluation of environmental acceptability.

SCHEDULE:
Over a 5-year period, a substantial number of new compounds and mixtures will be evaluated. New experimental techniques related to environmental issues will be characterized.

PARTICIPANTS:
Japan: NIMC, NIRE
U.S.: Clemson Univ.

CONTACTS:
Japan: Akira Sekiya (NIMC), Shuzo Kutsuna (NIRE)
U.S.: Darryl DesMarteau

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AREA: Mitigation technologies

TOPIC: Biomass

PROJECT: Biomass conversion technology for energy and chemicals

OBJECTIVE: To mitigate $C0_2$ by replacing fossil resources with biomass

SCIENTIFIC RATIONALE:
Biomass is carbon neutral when used in a sustainable manner. Through biomass conversion, energy and chemicals can be produced in an environmentally friendly way with no net increase in the carbon loading in the atmosphere.

PROPOSAL:
Biomass conversion technology for the mitigation of $C0_2$

Collaborate on research on biomass conversion for the production of electricity, hydrogen, methane, alcohols, oil, and charcoal. Evaluate the $C0_2$ mitigation effects of an optimized system.

SCHEDULE:
5-year effort

PARTICIPANTS:
Japan: NIRE, GIRIK
U.S.: HNEI

CONTACTS:
Japan: S. Yokoyama
U.S.: M. J. Antal

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AREA: Mitigation of global change

TOPIC: Fuel cells for vehicular power

PROJECT: Develop new proton exchange membranes (PEMs) for use in solid polymer electrolyte (SPE) fuel cells.

OBJECTIVE:
Improve conductivity and mechanical properties at operating temperatures above 100^0C.

SCIENTIFIC RATIONALE:
Fuel cells have high potential as clean energy sources with high efficiency. Current membrane materials impose severe restrictions on design and manufacture of fuel cells for vehicular power.

PROPOSAL:
Develop new fluorinated polymeric materials with improved mechanical properties and high conductivity at elevated temperatures. This can be accomplished using new acid functions, novel cross-linking methods, and improved membrane electrode assemblies.

SCHEDULE:
Over a 5-year period, promising new polymer systems can be developed.

PARTICIPANTS:
Japan: To be determined
U.S.: Clemson Univ.

CONTACTS:
Japan: Akira Sekiya
U.S.: Darryl D. DesMarteau

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AREA: Research and technology for mitigation of global change

TOPIC: Prediction of plant and ecosystem response to elevated $C0_2$ and climate change

PROJECT: Establishment of Phytotron research network

OBJECTIVE:
To address major concerns and needs of the use of controlled environment facilities in global change research

SCIENTIFIC RATIONALE:
There is an ever-increasing demand for state-of-the-art controlled environment (CE) facilities and technologies for studies of the effects of global change on plants and ecosystems. Controlled environment facilities, which include modern computer-controlled growth chambers, image instrumentation and bioengineering (biotechnology), and advanced computer visualization, are used to reproduce different types of research environments -- ranging from the Arctic to the desert to the tropics. These research tools permit researchers to have precise control over environmental conditions, e.g., air temperature, irradiance, carbon dioxide, relative humidity, atmospheric pressure, nutrient concentrations, etc. Thus, they provide an opportunity to gain increased understanding of the complex interactions between plants and changing environments, for example, elevated carbon dioxide concentrations, temperature change, UV effects, acid rain, and air pollution.

PROPOSAL:
To establish the Phytotron Research Network. Our goals are to coordinate efforts in a controlled environment (CE) research between Japan and the U.S., including 1) approaches for upgrading and expanding current facilities and establishing new facilities and research alignments; 2) developing new CE technologies; 3) establishing an international CE inventory; 4) improving student and postdoctoral training in, and access to, controlled environment technologies; and 5) the assessment of use of data and models based on CE studies for use in extrapolation to issues of global change. Our approach is to bring together Japanese and U.S. researchers, with expertise in controlled environment research ranging from molecular biology to ecosystem ecology, to exchange ideas and techniques; form collaborative efforts; identify problem areas; and communicate ideas and products to an international audience. This project will provide international leadership to address major concerns and needs in a controlled environment, including sharing of resources; standardization of controlled environment research protocols; coordination of research efforts that link different levels of biological organization (cellular to ecosystems) and controlled environment studies with field studies; and emphasis on communication, student training, technology development, and coordination of controlled environment research for global change.

SCHEDULE:
During the summer of 1997, a project steering committee will meet at Biosphere II (Arizona) to refine project goals, identify key participants, and to formulate the agenda. Nov.1997 - follow up coordination meeting in Tsukuba, Japan; design of formal proposals for workshops in 1998 and 1999.

PARTICIPANTS:
To be determined

CONTACTS:
Japan: Kenji Omasa (Head of Environmental Plant Science, National Institute for Environmental Studies, Tsukuba)
U.S.: James F. Reynolds (Director, Phytotron, Duke Univ., Durham, NC)

APPENDIX A: AGENDA

AGENDA
5th Japan-U.S. Workshop on Global Change
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East-West Center Honolulu, Hawaii

Sunday, March 9

5:00 pm Meeting of Workshop Co-Chairs(ELWOOD and KITABAYASHI)
5:30 pm Meeting of Workshop Co-Chairs and Working Group Chairs
6:30 pm Welcome reception for all participants
All will be held in the Harbor View Suite of the Ilikai Hotel

Monday, March 10

9:00am Welcome by Co-Chairs
9:15am Welcome by Dr.Lee-Jay CHO, Executive VP, E-W Center
9:30 am Keynote lectures: Dr. Fred MACKENZIE. Univ of Hawaii
10:00am IPCC Report: Dr. Allen SOLOMON, US EPA
10:15 am Break
10:45 am Summary of global change research activities in Japan and the U.S.

Japan: Dr. Koji KITABAYASHI Director-General of National Institute for Resources and Environment, AIST, MITI

U.S.: Dr. Jerry ELWOOD
Office of Health and Enviroimiental

Research
U.S. Department of Energy

12:00 pm Lunch at the East-West Center
12:30 pm Lunch speaker: Dr. Takashi UEHIRO
Intl. Coordination Researcher
National Institute for Environmental Studies

1:30pm Charge to Working Groups, Co-Chairs
1:45pm Working Group Sessions:

(1) **Prediction of Global Change**
Co-Chairs: BLACKMON and SUGI
Rapporteurs: SEMThER and CHIBA

(2) **Social System Response to Global Change**
Co-Chairs: KORSMO and AMANO
Rapporteurs: PIVER and ANDO

(3) **Effect of Global Change on Managed and Unmanaged Systems**
Co-Chairs: MAIDMENT and UEHIRO
Rapporteurs: RISBEY and NOUCHI

(4) **Research and Development for Adaptation and Mitigation**
Co-Chairs: DESMARTEAU and YOKOYAMA
Rapporteurs: BLOYD and SEKIYA

3:15 pm Break
3:30 pm Continue Working Group Sessions

5:00 pm	Plenary session: Five minute progress reports from each of the four working groups presented by Co-Chairs and Rapporteurs.
5:30 pm	Adjourn
7:00 pm	Workshop dinner hosted by U.S. Nicholas Nickolas Restaurant, Ala Moana Hotel

Tuesday, March 11

9:00 am	Plenary Session: "Toward the Realization of Global Change Prediction" Speaker: Mr. Yukata MAEDA Deputy Director of Ocean and Earth Division Japan Science and Technology Agency
9:30am	Working Groups reconvene
10:30 am	Break
10:45 am	Working Groups Reconvene
12:15 pm	Lunch at East-West Center
Lunch Speaker:	Dr. Seiji F. NAYA Director, Department of Business, Economic Development, and Tourism State of Hawaii
1:30 pm	Return to Working Group Sessions
2:30 pm	Short Break, preparation of working group summaries
2:45 pm	Plenary Session, Reports from Working Group Chairs and General Discussion
4:00pm	Meetings as necessary, discussion of possible collaborative research topics, initial preparation of Joint Cornmunique'
6:00pm	Adjourn, Hand in brief working group surnmaries to conference organizers for inclusion in Joint Conununique'
7:00pm	Workshop Dinner hosted by Japan

Wednesday, March 12

7:30 am	Informal Breakfast meeting of Co-Chairs and Working Group Chairs at hotel Canoes Restaurant
8:30 am	Final deadline for working group summaries
8:45 am	Leave for excursion
12:00pm	InformaI lunch elsewhere as part of excursion
1:30pm	Reconvene at E-W center Working Groups reconvene, prepare proposals for collaborative research
3:00 pm	Break
3:15 pm	Signing of Joint Communique, closing ceremony
3:30 pm	Adjourn

APPENDIX B: PARTICIPANTS

5th Japan-U.S. Workshop on Global Change
10-12 March1997, The East West Center, Honolulu, HI
Participants

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BIOGRAPHICAL STATEMENTS

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Nucleation and Growth of Particles,
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Masaru CHIBA
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Takashi IBUSUKI (49 years old)
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PROFESSIONAL EXPERIENCES
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Researcher of 2nd Department of Pollution Control, National Research Institute for Pollution and
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I have been involved in researches on measurement technology of trace air pollutants and reaction mechanisms of air pollutants related to photochemical pollution.

Senior Researcher of 2nd Department of Pollution Control of NRIPR in 1979
Post Doctoral Fellow of University of North Carolina (Chapel Hill), worked in US EPA Laboratory at Research Triangle Park, from March 1980 to December 1981
I have studied chemical reactions in aqueous solutions and on solid particles to understand the mechanisms of acid rain formation and the fate of CFCs.
Head of 1st Division of 2nd Department of Pollution Control in 1986
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Since 1986, in addition to the above researches I have initiated studies on chemical utilization of solar light, such as photoreduction of carbon dioxide (artificial photosynthesis) and treatment of pollutants using photocatalysts.

Chief Senior Researcher of NIRE in 1994
I was the Director of Atmospheric Environment Protection Department, NIRE in 1996. In 1994 I was nominated as General Secretary of the Conference for Advancement of Environmental Technology Research (CAETR), CAETR is organized by AIST, MITI to promote information exchange and cooperation among ca. 500 environmental technology researchers belonged to 15 AIST institutes. Since 1993, CAETR is going to construct ETERNET-APR (Environmental Technology Research Network in Asia-Pacific region) which will promote international cooperation concerning R & D of environmental technology minimizing the adverse effects of industrial activities in Asia-Pacific region. I coordinate such activities of CAETR.

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Cary BLOYD
Dr. Cary Bloyd is an Energy & Environmental Policy Scientist with the Environmental Assessment and Information Sciences Division of Argonne National Laboratory (ANL). He has worked for over 20 years in the general area of technical, economic and policy analysis of energy production systems. For the past 6 years he has been on a site transfer from Chicago to Honolulu, Hawaii where he is working on energy and environmental issues in the Asia-Pacific. He is currently the Director of the Asia-Pacific Sustainable Development Center (APSDC) which is located at the East West Center and operated for the US Department of Energy by Argonne National Laboratory. The APSDC has been established in Hawaii to support the United States Department of Energy in implementing its Asia-Pacific Economic cooperation (APEC) program by assisting countries in understanding the role of energy efficiency and renewable energy technologies in providing least cost energy services while increasing the quality of life and furthering economic growth. His work

at the East West Center has also concentrated on climate change issues in the Asia-Pacific and he recently participated as an energy technology expert in an Asian Development Bank study on the development of a climate change response strategy for the Peoples Republic of China. Dr. Bloyd also directed ANL's research effort for the U.S. Department of Energy's multi-laboratory Congressional Greenhouse Gas Study. This study examined the greenhouse gas reduction potential and reduction costs for the utility, industrial, and transportation sectors of the United States. Dr. Bloyd holds a Ph.D. in Engineering and Public Policy and a M.E. in Mechanical Engineering from Carnegie Mellon University, and a B.S. in Mechanical Engineering from the University of Oklahoma.

Peter G. BREWER

Dr. Brewer is an ocean chemist, and Senior Scientist, at the Monterey Bay Aquarium Research Institute (MBARI). Prior to joining MBARI in 1991 he spent 24 years as a researcher at the Woods Hole Oceanographic Institution, rising to the rank of Senior Scientist. He served as Program Manager for Ocean Chemistry at the National Science Foundation 1981-1983, receiving the NSF Sustained Superior Performance Award. He has taken part in more than 30 deep-sea cruises, and has served as Chief Scientist on major expeditions. He is a Fellow of the American Geophysical Union, and of the Amen can Association for the Advancement of Science. Internationally he has served as a member of SCOR and as Vice-Chair of JGOFS. He has served as a member of the Vice-President 92s Environmental Task Force, and is a member of MEDEA. He served as President of the Ocean Sciences Section of AGU from 1994-1996. At MBARI he served as President and Chief Executive Officer from 1991 - 1996, completing major laboratory and SWATH ship construction programs and doubling the size of the Institution, before returning to full time research. His research interests are broad, and include the ocean geochemistry of the greenhouse gases. He has devised novel techniques both for measurement, and for extracting the oceanic signatures of global change.

At MBARI his current interests include the geochemistry of gas hydrates, and the evolution of the oceanic fossil fliel C02 signal. He is author, or co-author, of more than 80 scientific papers. Dr. Brewer and his wife Hilary were both born in England and are naturalized US citizens. They make their home in Carmel, California.

Ujjayant CHAKRAVORTY

Dr. Ujjayant Chakravorty is an Associate Professor of Resource and Environmental Economics at the University of Hawaii. He has a Ph.D. in Agricultural and Resource Economics from the University of Hawaii and a Bachelor's degree in Civil Engineering from the Indian Institute of Technology. His research interests include the economics of energy use and climate change, water resource management, deforestation and gender issues, and fisheries regulation. His current projects include modeling global warming, technological change in renewable energy and fossil fuel use with special emphasis on the Asia-Pacific region, developing economic models of fisheries regulation for Pacific Ocean pelagic fish stocks, economic analysis of water sharing between Israel and the Palestinian territories, and examining deforestation and biodiversity issues in Sri Lanka and Sub-Saharan Africa. His projects have been funded by NSF, NOAA, the Japanese Foreign Ministry and other sources. He has consulted with various United Nations agencies, the World Bank, major oil companies and has been Visiting Professor at several universities including UC Berkeley, University of Maryland, Hebrew University, Jerusalem, and Jadavpur University, Calcutta. He is an Adjunct Research Fellow with the East-West Center Energy Program. Before coming to academia, he was a journalist and wrote extensively on international environment and development issues.

Dr. Chakravorty has published in leading economics journals including the Journal of Political Economy, Econonietrica and the Journal of Environmental Economics and Management. He is currently in the process of founding a new Center for Resource and Environmental Economics and Management (CREEM) at the University of Hawaii. The Center is already engaged in several research projects in the Asia-Pacific region.

Darryl D. DESMARTEAU
Darryl D. DesMarteau was born in Kansas in 1940 and moved to Washington in 1951. He received his B.S. in chemistry from Washington State University in 1963 and his Ph.D. in 1966 from the University of Washington specializing in fluorine chemistry. He was a visiting assistant professor at the University of Washington 1966-67, Assistant Professor at Northeastern University 1967-71 and Kansas State University 1971-73. He was an Associate Professor 73-78 and professor 78-87 at Kansas State University before moving to Clemson University as Professor & Head of Chemistry 1982-89. In 1989 he "'as named the Tobey-Beaudrot Professor of Chemistry at Clemson. D. DesMarteau has received several awards for his research in fluorine chemistry including the ACS Award for Creative work in Fluorine Chemistry 1983, The Clemson University Alumni Award for Outstanding Research 1985, The Governor's Award for Contributions to Science in South Carolina 1988, the Humboldt Prize 1988, The ACS Charles H. Stone Award 1993, and an Alumni Achievement Award from Washington State University, 1995. He has 180 publications and 20 patents all dealing with the synthesis and properties of fluorinated compounds and materials. For the past 10 years he has been active in research and as a consultant on stratospheric ozone and global warming issues related to CFCs, HCFCs, HFCs and FCcs as working fluids in refrigeration, air conditioning and heat pumps. Present research deals with alternatives for HCFC-22 funded by EPRI. He is also active in alternative energy sources with a major research program in fluorinated polymer electrolytes for fuel cells and batteries.

J. Hugh ELLIS
Hugh Ellis received his B.A.Sc. (1979), M.A.Sc. (1981) and Ph.D. (1984) degrees in Civil Engineering (water resources) from the University of Waterloo. Professor Ellis joined the faculty of the Department of Geography and Environmental Engineering in 1984 as an Assistant Professor became Associate Professor in 1990, received a secondary appointment in Civil Engineering in 1993, was appointed Professor in 1994 and Chairman in 1995. He teaches courses in mathematical programming, stochastic programming, air pollution and water and air resources management. His work in acid rain control has led to collaborations with the Maryland Department of Natural Resources, the US Environmental Protection Agency and the National Acid Precipitation Assessment Program. Recently completed work supported by the National Oceanic and Atmospheric Administration involved the development of a large-scale integrated assessment model for global climate change. Another recent study analyzed alternative tropospheric ozone control strategies for Maryland. Current sponsored research includes an NSF-funded project (New Methods for Decision-Focused Integrated Assessment: Multiple Objectives, Risk Evaluation, and Visualization) and an EPA-funded project (Integrated Assessment of the Public Health Effects of Climate Change for the United States)

Dr. Ellis' research interests involve the development of multiobjective and stochastic programming models for environmental management, and include the optimization of air and groundwater monitoring networks acid rain control, integrated assessment of global/climate change, regret -based approaches for decision-making under uncertainty,,assessment of the value of information in environmental management problems optimization of infrastructure inspection and maintenance policies and system identification for vibrating structures.

Jerry W. ELWOOD
Dr. Jerry Elwood is a Research Program Manager in the Department of Energy's (DOE) Office of Health and Environmental Research (OHER) in Germantown, Maryland. He serves on OHER's Task Force on Global Change Research, and as DOE's representative on interagency subcommittees and working groups dealing with ecological research and monitoring and biodiversity. He is also the DOE representative on the Executive Committee of the U.S. Man and the Biosphere Program. His programmatic responsibilities include managing two of DOE's programs that are part of the U.S. Global Change Research Program. One of these, the Program on Ecosystem Research (PER), is designed to improve the scientific basis for predicting and assessing the probable response of major ecological systems to natural and human-induced changes in atmospheric composition and climate, including the ability of these systems to adapt to such changes. The second program, the National Institute for Global Environmental Change (NIGEC) is intended to improve the scientific basis for assessing the ecological, economic, and societal

consequences of climate change at regional and national scales, with emphasis on regions in the continental U.S. Dr. Elwood has a Ph.D. in ecology, and previously served as a senior research staff member in the Environmental Sciences Division at DOE's Oak Ridge National Laboratory in Oak Ridge, Tennessee. His research interests are in the ecology of streams and rivers, nutrient cycling, the effects of acidic deposition, and the environmental fate of radionuclides and heavy metals. Dr. Elwood is a Fellow of the American Association for the Advancement of Science and a member of several professional scientific societies.

Steven R. EMERSON

Education

B.S., 1969	(Cum Laude) College of Wooster, Wooster, Ohio
Ph.D., 1974	Columbia University, New York (Geochemistry, Oceanography, Environmental Sciences)

Dissertation: "Radium-226 and radon-222 as limnological tracers, the carbon dioxide gas exchange rate"

Employment:

1974-76	Post-doctoral Fellowship, Swiss Federal Inst. of Tech., Zurich
1976-79	Research Assistant Professor, School of Oceanography, UW
1980-82	Assistant Professor, School of Oceanography, U~J
1982-1986	Associate Professor, School of Oceanography, UW
1986-present	Professor, School of Oceanography, UW

Research Interests:

Cycling of metabolic gases and isotopes in the ocean surface waters; air-water $C0_2$ transfer in aquatic systems; organic carbon dynamics at the deep sea sediment water interface; calcium carbonate preservation in the sea; the effect of anoxic conditions on solubility of metals in seawater; tracers of past changes in the redox state of the ocean.

Five Relevant Publications:

Schudlich R., and S. Emerson (1996) Gas saturation in the surface ocean: the role of heat *flux,* gas exchange and bubbles. Deep-Sea Res. 43, 569-590.

Emerson, S., P. Quay, C. Stump, D. Wilbur, and R. Schudlich *(1995)* Chemical tracers of productivity and respiration in the subtropical Pacific ocean. J. Geophys. Res., 100, 15,73-15,887.

Emerson, S, and T. Hayward *(1995)* Chemical tracers of biological processes in shallow waters of the North Pacific: Preformed nitrate distributions. J. Mar. Res., 53, *499-513.*

Emerson, 5. (1996) Enhanced transport of carbon dioxide during gas exchange in nature. In: Proceedings of the 3rd International Symposium on Air-Water Gas Transfer, Heidelberg, Germany, 1995 Jahnke and Monahan, editors, AEON Verlag. Hanau. Germany.

Quay, P., 5. Emerson, D. Wilbur, and C. Stump (1993) the **8180** of dissolved 02 in the surface waters of the subarctic pacific: a tracer of biological productivity. J. Geophys. Res., 98, *8,447-8,458.*

Fae L. KORSMO

Ph.D. University of New Mexico, 1992, Political Science; M.A., International Relations, George Washington University, 1984; B.A. University of Washington, 1980. Studied politics of ethnic ity interest group behavior political mobilization of indigenous societies. politics of science and technology. Member. International Arctic Research Center Advisory Committee. University of Alaska Fairbanks; Serving as Social Sciences Coordinator for Bering Sea Impact Study Workshop Series.

My past research has focused on the political awakening and participation native societies in the circumpolar north, the reception of these new interests by national governments, and the resulting policy changes. Presently I am looking at the participation of scientists in national and international

policy arenas, particularly on the subject of global change. I am also helping to organize the human dimensions contribution to a regional impact study. I will bring copies of impact study materials to the workshop.

David R. MAIDMENT

David Maidment is Professor of Civil Engineering at the University of Texas at Austin, where he has been on the faculty since 1981. He is a specialist in hydrology and water resources. He received his BE degree in Agricultural Engineering from the University of Canterbury in Christchurch, New Zealand, and his MS and Ph.D. in Civil Engineering from the University of Illinois at Urbana-Champaign. He is Editor in Chief of the Handbook of Hydrology (McGraw-Hill, 1993), a 1400-page compendium of knowledge in all fields of hydrology, and co-author of the text Applied Hydrology (McGraw-Hill, 1988), which is widely used for hydrology courses in the US and overseas. He was Editor of the Journal of Hydrology from 1992-1995, and is presently Associate Editor of that Journal and of the Journal of Hydrologic Engineering. He is cooperating with the United Nations agencies, particularly FAO and UNESCO, on a water balance of Africa, and is preparing a digital atlas of the world water balance to quantify the movement of water through all phases of the hydrologic cycle on a global basis. Dr. Maidment's research is focused on the use of geographical information systems in water resources so digital maps can be integrated with models simulating the motion of water through the landscape. He has conducted many projects with this theme including analyses of the atmospheric water balance, soil water balance, surface water balance and groundwater balance of Texas, and various other regions.

Linda MEARNS

Linda O. Mearns is a Scientist III in the Environmental and Societal Impacts Group at the National Center for Atmospheric Research, Boulder, Colorado. She holds a Ph.D. in Geography/Climatology from UCLA. She has performed research and published in the areas of crop-climate interactions, climate change scenario formation, climate change impacts on the agro-ecosystems, and analysis of climate variability and extreme climate events in both observajions and climate models. She has most recently published a series of articles on the effects of changes in climate variability (in contrast to changes in mean climate) on simulated cr6p yields. She has contributed to the IPCC Climate Change 1992 and 1995 Reports on the subject of climate variability in general circulation models, the climatology of mountainous regions, and impacts of climate change on agriculture. She is a member of the IPCC Task Group on Scenarios for Climate Impact Assessment. She currently leads a project funded by the EPA, NASA, and USDA, on the effects of changes in climate variability on crop production in the Southeastern U.S

Warren T. PIVER

Dr. Piver received his bachelor's degree in chemistry from Duke University in 1963 and his master's and Ph.D. degrees in chemical engineering in 1970 and 1972 respectively from North Carolina State University. Since 1 972, Dr. Piver has been with the National Institute of Environmental Health Sciences and is with the Laboratory of Computational Biology and Risk Analysis. He is also an Adjunct Professor in the Department of Civil and Environmental Engineering at Duke University.

His research interests include the development and use of mathematical models that describe the transport and transformation of contaminants in the subsurface, and the development of regression formulas that relate morbidity and mortality to changes in temperature and air pollutant concentrations. In the area of contaminant transport in the subsurface, the models are used to predict exposure concentrations that are required for risk assessment and the remediation of contaminated aquifers. The regression formulas for morbidity and mortality make it possible to estimate reductions in morbidity and mortality risk as a result of reductions in temperatures and pollutant concentrations. Dr. Piver has been assisting the World Health Organization in establishing and using data from global groundwater quality monitoring networks to assess impacts of contaminants on human health and to develop remediation technologies that are both cost effective and minimize health risks.

In 1996, a Fellowship from the Research Development Corporation of Japan made it possible for Dr. Piver to begin an analysis of the impacts of temperature and air pollution on morbidity in Tokyo. These studies are being carried out with Dr. Mitsuru Ando National Institute for Environmental Studies, *305* Ibaraki, Tsukuba, Japan. Data for July and August from 1980 to 1994 are being analyzed. Five disease categories are being examined. They include: Heat Stress; Endocrine Diseases - thyroid, diabetes, and gout; Cardiovascular Diseases - hypertension, myocardial infarction, cardiac insufficiency, and arteriosclerosis; Cerebral Vascular Diseases - cerebral hemorrhage, cerebral infarction, and cerebral ischemia; Respiratory Diseases - common cold, acute bronchitis, chronic paranasal sinusitis, allergic rhinitis, influenza, chronic bronchitis, pneumonia, and asthma. The data have been stratified by age and gender. The age groups are: 0-14; 15-29; 30-44; 45-64; 65+.

James RISBEY
Risbey received his Ph.D. in climatology from the Massachusetts Institute of Technology. He also received a Master's degree in Technology and Policy from MIT. He is currently a research fellow in the Center for Integrated Study of the Human Dimensions of Global Change at Carnegie Mellon University. Risbey coordinates the impacts assessment activities of this Center.

Risbey has focused his research on climate and environmental issues. His thesis research was a case study on the use of climate models in assessing the impacts of regional climate change on water resources. He is currently involved in a range of collaborative projects related to integrated impact assessment of global change issues. These include: development of techniques for generating regional climate scenarios, assessment of the use and implications of flux adjustments in coupled ocean-atmosphere climate models, developing decision-analytic models of agricultural adaptation to climate change, assessment of tools and development of approaches for regional integrated assessments, and using simple ocean models to study the the rmohaline circulation in coupled GCMs. His regional work includes assessment projects on North America, Australia, and South Asia.

Albert J. (Bert) SEMTNER
Albert Semtner received a B.S. in mathematics from Caltech in 1963. He earned a Ph.D. in Geophysical Fluid Dynamics from Princeton in 1973, alter having been an applied mathematician at the Jet Propulsion Laboratory and an oceanographic officer in the NOAA Commissioned Corps. He was Adjunct Assistant Professor in Meteorology at UCLA (1973-76) and Research Scientist in climate at the National Center for Atmospheric Research (1976-86) until becoming a Professor of Oceanography at the Naval Postgraduate School. His main research interests are the development and use of advanced ocean and climate models, in order to understand and predict ocean variability and climate change at high resolution on decade to century time scales. He is a Fellow of the American Meteorological Society and a recipient of a 1993 Smithsonian Leadership Award in Breakthrough Computational Science. He serves on various scientific advisory committees related to global and Arctic Ocean modeling, climate prediction, and high-performance computing.

Allen M. SOLOMON
Solomon received his Ph.D. in Botany (focus: Plant Ecology) from Rutgers University, New Jersey, USA, in 1970. He has been involved in global change research for the past 20 years. After serving as Assistant Professor in the Geoscience Department of University of Arizona from 1970 to 1976, he moved to Oak Ridge National Laboratory, Oak Ridge, TN 37831, where he was a staff scientist in the Environmental Sciences Division from 1976 to 1987. There lie assembled and participated in research teams to explore aspects of global carbon cycle issues, developed research initiatives involving global ecological issues, and performed research on responses of forests to changing climate and C02.

At the International Institute for Applied Systems Analysis, A-236 1, Laxenburg Austria, he served as Leader of the Biosphere Dynamics Project from 1987 to 1990. His duties were to provide administrative and scientific leadership for a group of *7-25* IIASA research scholars, and 50-100

international cooperations analyzing long-term (centuries) and large-scale (continental) environmental change and its anthropogenic sources. He returned to the U.S. as Professor of Forest Ecology (tenured), School of Forestry and Wood Products, and Co-Director, Lake Superior Ecosystems Research Center, Michigan Technological University, Houghton, MI 49931 from 1989 to 1992. There, he organized and initiated a program of ecosystem studies in the Lake Superior Basin, interacted with other faculty in Forestry to generate externally-funded research prqiects in global change, and taught Forest Geography and seminars in Global Ecological Change.
Since 1992, he has been with the U.S. Environmental Protection Agency, Western Ecology Division, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon, 97333 as Senior Global Ecologist. There he plans, directs, evaluates and carries out research on global ecological change; leads group of in-house staff and external cooperator scientists in developing models of biospheric response to global change, and provides expertise on the terrestrial carbon cycle questions to EPA and other agencies.

Solomon has authored 70+ research papers and reports, including the editing of two books. Among these are approximately 40 papers that dealt with modeling the relationships between climate and vegetation from the local to the global scale.

Gary WILLIAMS
Argonne National Laboratory
Enviromental Management and Policy Group
Ph.D. Colorado State University, Sociology, 1981. M.Ed. and B.A. University of Georgia, Sociology, 1973, 1971. Peace Corps Volunteer in Venezuela and Malaysia, 1973-1975. Taught at the University of Wyoming (Department of Sociology) and studied the social effects of energy development in the Western United States. Assistant environmental scientist and social scientist at the University of Chicago's Argonne National Laboratory 1984 to present. Established the Social and Natural Resource Section at Argonne National Laboratory. Scientific responsibilities include environmental assessment, environmental justice analyses, socioeconomic impact assessment, evaluation research, demographic analysis, data base design and development, public involvement and design of Internet applications. Served as Executive Secretary and current Board Member of the International Association for Technology Assessment and Forecasting Institutions and former Board Member of the International Association for Impact Assessment.