Massachusetts Institute of Technology

Joint Program on the Science and Policy of Global Change

GLOBAL CHANGE
SCIENCE POLICY
MIT

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PHONE: **617·253·7492** FAX: **617·253·9845**

E-MAIL: ***globalchange@mit.edu***

WEBSITE: ***http://mit.edu/globalchange/***

POSTAL ADDRESS:
MIT Building E40-428
77 Massachusetts Avenue
Cambridge MA 02139-4307 USA

cgcs@mit.edu
617·253·4902
http://mit.edu/cgcs/
MIT Bldg. 54-1312

ceepr@mit.edu
617·253·3551
http://mit.edu/ceepr/
MIT Bldg. E40-428

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The Massachusetts Institute of Technology's ***Joint Program on the Science and Policy of Global Change*** conducts research and analysis on issues of global environmental change, with a concentration on climate, and communicates the results to the research community, to policymakers, and to the public. Since the Program's inception in 1991, it has focused on the integration of natural and social science aspects of the climate issue, to produce analyses relevant to ongoing national and international policy debates.

The Global Change Joint Program combines the efforts of two complementary research centers at MIT: the *Center for Global Change Science* (CGCS) and the *Center for Energy and Environmental Policy Research* (CEEPR). Resources of the parent centers are strengthened by links to the Ecosystems Center of the Marine Biological Laboratory (in Woods Hole, Massachusetts), the MIT Climate Modeling Initiative, and other MIT environmental programs. Cooperative efforts engage the Program with leading research institutions and nonprofit organizations worldwide. Financial support is provided by an international group of sponsors from government organizations, foundations, and industry.

The MIT Integrated Global System Model (IGSM) of economic and environmental change is the Joint Program's cornerstone. The IGSM is a comprehensive research tool for analyzing potential anthropogenic global climate change and its social and environmental consequences. The IGSM includes consideration of climate science, technological change, and economic and social science, in an interacting set of computer models designed for study of the sensitivities and uncertainties that are crucial to policy evaluation.

The need to inform climate-policy discussions is great. The development, negotiation, and implementation of efficient and effective mitigation measures require access to the best available understanding. Over a decade of effort has established the capability of the MIT Program as a key international source of independent analysis of the climate issue, and of policy studies. Research results are communicated by professional and popular publication. Further contributions to the policy process are achieved through informal contacts and public testimony, and by participation in workshops and conferences by the faculty, staff and students engaged in the work.

MIT Joint Program Co-Directors:
Henry D. Jacoby, *Professor of Management*
Ronald G. Prinn, *TEPCO Professor of Atmospheric Sciences*

The Challenge

For over a decade nations have worked to formulate domestic policies and international agreements in response to the threat of global climate change. Much has been learned over this period, but two aspects stand out. First, we have begun to confront the sheer complexity of global climate as a policy issue: it would be hard to design a greater challenge to scientific research, public understanding, and reasoned political action. Second, the implications of its peculiarly long-term nature are becoming more evident.

There is no short-term solution or single targeted policy that can deal adequately with the issue. Climate change is a century-scale threat requiring a century-long analysis effort and policy attention, plus the design of institutions that can sustain a response over generations. Unfortunately, we appear to be entering a period of severe fragmentation of the international effort.

Obvious difficulties are imposed on the policy process by our inadequate knowledge and incomplete observations of the past and present climate system, our uncertainty regarding the influence of increased levels of anthropogenic greenhouse gases and aerosols on climate, and our limited knowledge of the effects of climate change on ecosystems. Also increasingly evident are the problems created by the complexities and uncertainties of potential efforts to control human influence on the atmosphere.

For example, measures to limit greenhouse gas emissions are intertwined with major segments of both the modern industrial economy and more traditional agriculture and forestry. Climate policy cannot be separated from issues of tax structure, international trade regimes, agricultural policy, energy security and conservation initiatives, and other environmental concerns such as urban air pollution and the appropriate role of nuclear power. Moreover, any long-term emissions control agreement inevitably raises questions of international equity,

A Response: *The MIT Global Change Joint Program*

The MIT ***Joint Program on the Science and Policy of Global Change*** is a response to the research, analysis and communication needs of the climate change issue. Founded in 1991, the Program builds on an MIT tradition of bringing multiple disciplines to bear on issues of national and international importance. The Program combines the capabilities of two pre-existing MIT research centers: the *Center for Global Change Science* (CGCS) and the *Center for Energy and Environmental Policy Research* (CEEPR).

With a foundation of more than a half-century of work on weather and climate at MIT, the CGCS is a shared activity of the School of Science and School of Engineering. It is devoted to research on long-standing scientific problems that impede the ability to make accurate prediction of changes in the global environment. A key CGCS component, with which the Joint Program closely cooperates, is its Climate Modeling Initiative. It is applying fundamental research on climate processes, and global model construction, to studies of the science of climate prediction and its limits.

The CEEPR conducts policy research on energy, natural resources, and environmental issues. Created in the 1970s, it is a shared effort of the Sloan School of Management, the Economics Department and the Laboratory for Energy and the Environment.

In addition, the Program collaborates with other groups at the Institute who are working in related areas, such as problems of water resources, mobility, and international affairs. The Program brings together these experts in the natural and social sciences, energy

most importantly between the current industrial economies and developing nations.

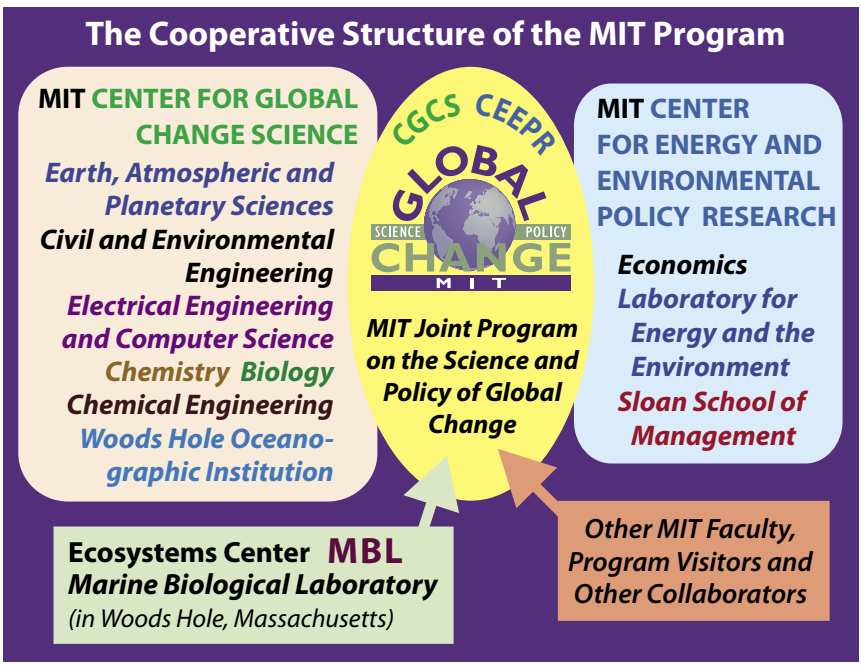
This tangle of environmental threats, uncertainties, and intersecting policy concerns poses not only a political and economic challenge but also an intellectual one. Means need to be provided to develop and communicate an understanding of the climate issue in all its parts. It is all too easy for policy studies to move into their own orbit, disconnected from the natural science that motivates concern in the first place. Or for scientific research to proceed down its own path, with insufficient concern for decreasing the key uncertainties and communicating new discoveries that are crucial for policy discussion.

Integrating these diverse components of the issue is not an easy task and, like climate policy itself, the needed research and policy guidance is not a one-time task. Knowledge of fundamental climate processes and of detection and attribution of change is continuously evolving. It is not sufficient to assess this knowledge once for policy purposes, or even every four or five years. Effective long-term climate action will only emerge from a sequence of decisions over decades. Thus the process will need to be informed by a continuing flow of policy research and analysis as the science advances and economic and political conditions change, and as we experience the success and failure of agreements along the way.

In these demands, the climate issue is perhaps harder than any other environmental problem. Further, given the complicated set of social concerns that intersect at the point of climate discussion, the value of comprehensive, independent sources of analysis is arguably greater than for other issues as well. Indeed, a capacity to provide this type of research and assessment, and sustain it over time in a number of key countries, is itself an important component of needed institutional development.

technology, and political and policy analysis, and applies their talents and more discipline-oriented work to the interdisciplinary challenge of global climate change.

Where capacity is lacking at MIT, cooperative efforts have been formed with groups outside the Institute. In particular, a long-term alliance with the Ecosystems Center of the Marine Biological Laboratory in Woods Hole, Massachusetts, brings to the Program substantial expertise on the impacts of climate change on terrestrial ecosystems.



The coordinated studies of the MIT Program are designed to address both climate-policy issues and questions in global change science. One goal is to study and thereby better understand the key potential nonlinearities and feedbacks among land ecosystems, human activity, climate change, and air pollution. A parallel aim seeks to identify and reduce uncertainties about the responses of the climate system to atmospheric and land-use changes. The Program also develops independent analyses of proposed policies, and provides this information in a useful way to policymakers and the public.

The MIT **Integrated Global System Model** (IGSM) is a linked set of computer models (*see figure*) designed to help realize the Program's objectives. Developed at MIT over many years, the IGSM was constructed in collaboration with the Ecosystems Center of the Marine Biological Laboratory. The IGSM is an analysis tool designed for simulating the global environmental changes that may arise as a result of human causes. Details about the modeling structure, and examples and results of studies carried out using the IGSM, are described on the Program's website (http://mit.edu/globalchange/).

The Program's work falls into two broad categories: Central and Supporting Research. Central Research is organized around the dual use of the IGSM as a research facility. The IGSM is applied to fundamental studies of climate behavior and climate uncertainty, and as a vehicle for analysis of policy proposals. Also central to the effort is the continued development and improvement of the IGSM framework and its components. Supporting Research includes projects on fundamental processes in the science, and on specific issues of climate policy that are not directly connected to the IGSM framework at present, but may be in the future.

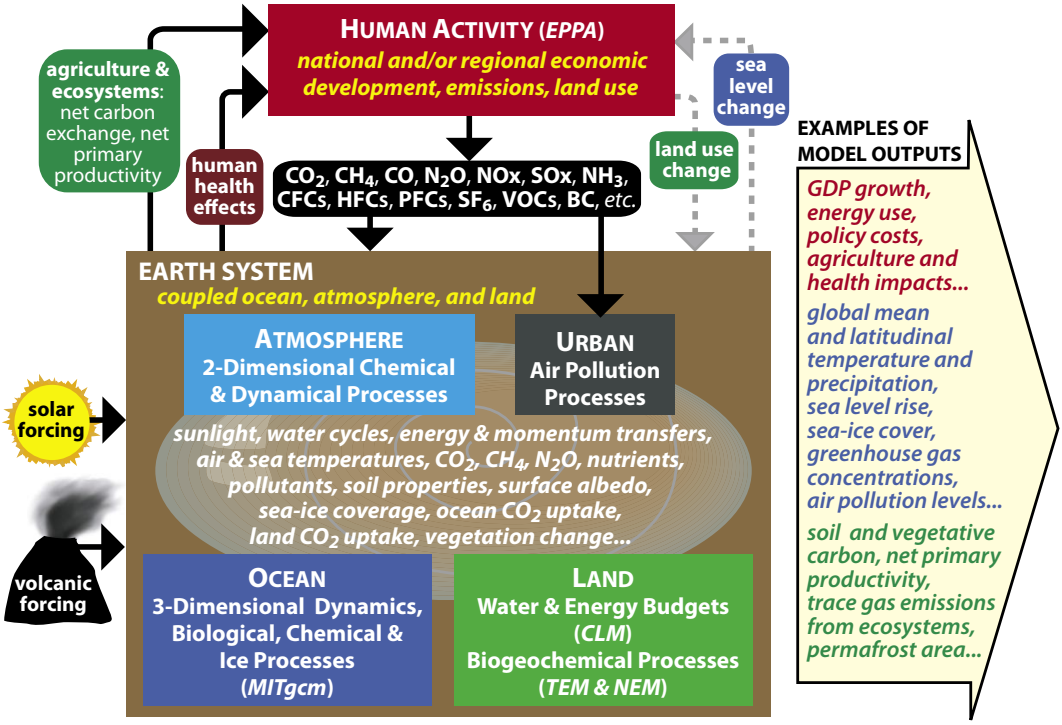
The MIT IGSM has been used to illuminate a number of important science and policy issues. MIT studies have evaluated details of the implementation of Kyoto Protocol-type agreements, including aspects of international permit trading. Analyses of emissions control policies have provided estimates of the magnitude of the costs and the distribution among nations. Studies of the influence of uncertainty in key climate processes have helped to constrain the range of uncertain greenhouse gas and aerosol forcings. And consideration of the chemical processes in urban air masses has established a link between air pollution policies important to human health, and global climate policy.

Each gain in understanding of the climate system brings with it a new awareness of what remains unknown. In contrast, with political attention focused on policies to reduce fossil fuel burning, there is a growing tendency to assume that we know all we need to know for now. In fact, many complex questions are just beginning to be addressed with the help of the assembled MIT integrated framework.

For example, how effective, and how costly, would specific policy measures be in alleviating relevant environmental and economic concerns? How will the uptake of carbon by the oceans and the terrestrial biosphere be affected by changing climate? What are the advantages and risks of waiting for better scientific information and observational evidence before taking stronger policy measures?

The MIT Joint Program's research will continue to focus on the largest uncertainties in climate science, and on issues of decision-making over time under our uncertain knowledge. Selection of the most important uncertainties is guided by the need for better estimates of the likely outcomes of multiple environmental changes. For example, can changes in land ecosystems caused by climate change and human activity feed back significantly to climate and air quality

The MIT Integrated Global System Model



The framework and processes of the MIT Integrated Global System Model (IGSM) Version 2 are depicted in the schematic above. The IGSM includes models of the earth's ecosystems, of greenhouse gas and aerosol chemistry, and of the world's economies and energy use. The emissions from human activities and natural systems are driving forces for the coupled ocean, atmosphere and land model, the essential components of which are atmospheric and oceanic circulation and biogeochemistry, land hydrology, and terrestrial ecosystem dynamics. Feedbacks among the component models that are currently included, or under development, are shown as solid and dashed lines, respectively.

through changes in albedo, terrestrial carbon storage, and trace gas exchange rates? Are there potential nonlinear surprises, such as a possible shutdown of surface to deep water transfers in the North Atlantic and circum-Antarctic oceans, and a resultant collapse of the global thermohaline ocean circulation?

The analysis efforts of the MIT Joint Program will continue to follow the evolving policy questions. For example, with the U.S. and other nations proceeding along separate paths from those countries accepting Kyoto Protocol commitments, new sets of issues will begin to command attention. Various ways to modify the existing structure of targets and timetables and associated flexibility mechanisms are garnering interest. Different architectures for international negotiation are being proposed. And the focus of policy attention is broadening beyond fossil fuels to give greater consideration to the non-CO_2 greenhouse gases and aerosols, and to the development of improved ways to access credit for carbon sinks.

Meanwhile, public attention on the climate issue will surely be sustained as trends in atmospheric and oceanic temperatures, ice coverage and other climate change indicators continue to be monitored and reported in the news media.

Our goal of informing the policy-making process demands that we remain abreast of the ever-growing knowledge base. Further, it is crucial to continue to improve the MIT modeling capability so that our analysis is up to date and on a par with the best of the scientific and economic studies conducted by groups that are not trying to make the policy link.

A continuing goal of the MIT Joint Program is improved public and policymaker understanding of the risk of climate change and an informed public debate about the issue. This objective is pursued with the communication of research results and policy studies through publications, the periodic MIT Global Change Forum, and involvement in international studies, conferences, and workshops. Additional outreach activities include interactions with media and government organizations, and an extensive website.

The MIT Joint Program is not an academic degree-granting entity. The MIT faculty and staff associated with the Global Change Joint Program are, however, intensely involved in the activities of academic development, classroom teaching, and mentoring. Both graduate and undergraduate students learn through direct participation as research assistants and research fellows.

The Joint Program's website provides unrestricted public access to research results, links to sponsoring organizations, details on models and data, contacts for personnel, and more. Research findings are summarized and complete descriptions are made available in over 250 publications. A Report Series documents the Program's assessments of policy proposals, research results, and student theses. A Reprint Series provides Program articles that have appeared in peer-reviewed professional outlets, popular journals, and book chapters.

The website also contains technical information about the modeling components and an archive of data utilized in Program studies. A series of Technical Notes document details of the research methodologies and analyses, and a set of Policy Notes highlight issues of particular policy relevance in an effort to better serve an audience of policymakers, the media, and the public. All of the publications emanating from the Program's efforts are also provided in print to interested colleagues, institutions, and sponsors, or to others upon request, with no charge.

The MIT Global Change Forum serves as a primary vehicle to convey results to the broader community involved in climate science research and policy debate. The MIT Forum promotes interaction among disparate stakeholders, and provides a non-official, neutral setting for independent assessment of studies and policy proposals. Convened approximately every nine months in various locations around the world, each Forum brings together 100 to 120 participants from industry, government, international bodies and research organizations, for discussion of the evolving understanding of climate issues. The MIT Forum has gained a reputation as a successful outreach activity, and is instrumental in providing the work of the Joint Program in a timely and constructive way to industry and both national and international policy-making bodies.

Joint Program members also communicate research results, and interpret the policy relevance of the analytical work, through many professional activities. These activities include workshops, corporate and public briefings, and media interviews. Special briefings from Program members have been requested by the U.S. Congress and federal and state agencies, by governments working through their ministries and international organizations, and by independent research panels. In addition, the Program facilitates international cooperation through affiliate relationships with organizations working in the climate area worldwide.

The MIT Joint Program is supported

by an international partnership of government and industrial sponsors, and one foundation. Over one-half of the Program's funding is provided by five U.S. government agencies; the rest is received from approximately twenty U.S. domestic and non-U.S.-based corporations, foundations, and industrial R&D organizations. The consortium provides the substantial and long-term commitment that is needed to support the dedicated and specialized staff to realize a coordinated research effort.

Support from the U.S. federal government includes grants for specific tasks, and general support of Program development. Most of the industrial funding is made without specification of particular work tasks. Industry associates benefit by quick access to new research insights and policy assessments, short and long-term visits to MIT, participation in the Global Change Forums and the network of public and private sector experts who attend, and involvement in the internal MIT discussion of plans for climate research and policy assessment.

For a list of current sponsors, related financial details, and information about how to become a sponsor, please visit the Program website.

For More Information

Visit the website at:

http://mit.edu/globalchange/

THE JOINT PROGRAM'S WEBSITE PROVIDES:

- *Summaries of research findings and policy analyses*
- *Access to Program publications (by download, or request)*
- *Directory of Program members and associates*
- *List of personnel to contact regarding specific topics*
- *Details of the modeling system and components*
- *Links to all Sponsor organizations*
- *Overview of revenue and allocation of funds*
- *Archive of data utilized in Program studies*
- *MIT Global Change Forum themes and locations*
- *Links to Program Affiliate organizations*
- *and more...*

Program Personnel and Associates

A distinguishing characteristic of the MIT Global Change Joint Program is its team of disciplinary specialists who work closely together in carrying out the integration of the science and policy of this issue. The research group includes faculty, staff, and students, supplemented by affiliated researchers from outside MIT.

Consistent with the Joint Program's multidisciplinary nature, each of the two co-directors come from one of the two parent MIT centers, and participants originate from many academic departments. The natural sciences group includes meteorologists, climatologists, oceanographers, atmospheric chemists, hydrologists and ecologists. The social science and policy analysis group involves economists with expertise in energy and environmental quality, decision analysts, energy technologists, and scholars of politics and the policy process.

The Program's research and analysis team includes approximately fifteen faculty members, with twelve full-time and five part-time professional research staff assisting in the work of model construction, maintenance and documentation, and application to climate issues. Also involved are approximately twenty-five graduate students, and twenty post-doctoral fellows, visiting scholars from sponsor organizations, and associates involved through cooperative agreements.

Administrative support is provided by part-time commitments of several staff members in the Program's parent organizations. The total staff devoted to publication, communication and administrative support includes approximately six full-time equivalent personnel, although none are full-time on Program budgets.

A directory of personnel, and a guide for whom to contact about specific topics, are provided on the website. A key to who is pictured at right is also available on the website (http://mit.edu/globalchange/).

PHOTO CREDITS • Covers: *USDA (tractor harvest), NOAA (Hurricane Ivan), Christine Tsien Silvers (traffic), Sam Rowell (vegetation), Chris Cammett (clouds), Anne Slinn (smokestacks, water, coins, MIT campus buildings);* Page 8: *Lallo Photography (Schmalensee, Skolnikoff), Frances Goldstein (Jacoby, Reilly, Sokolov, Wang, Paltsev, Forest, Ellerman, Henderson, Eckaus, McFarland, Webster, Panday), Various/Anonymous (most of the rest)* • ***Thanks!***

***GLOBAL CLIMATE CHANGE ASSESSMENT** involves the integrated study of many components, including: human activity, atmospheric chemistry, economics, energy technology, ocean circulation, uncertainty, ecology, technological change, decision analysis, aerosols, international equity, hydrology, policy processes, climate observations, risk evaluation, air pollution, political action, biospheric feedbacks, international trade, water resources, tax structure, agricultural policy, meteorology, energy security, mobility, land–use, carbon storage, environmental quality, adaptation, public understanding...*