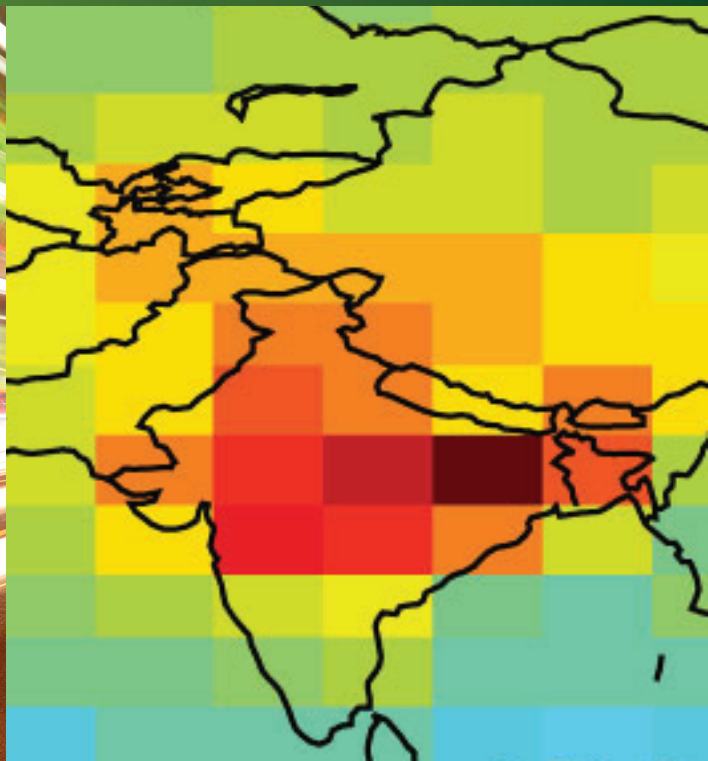
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MIT JOINT PROGRAM ON THE

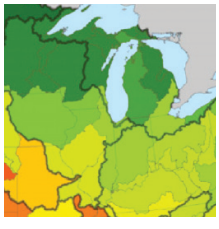
Science & Policy of Global Change



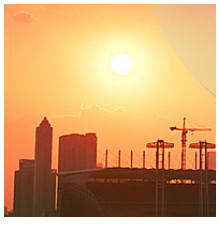
The complex nature of our Earth system, and the intricate interplay of political and economic decisions that influence it, make addressing global change the greatest challenge of our time.

Human activities occur at a scale that affects how Earth functions; the impacts of these forcings range from relatively short-lived— such as increased concentrations of aerosols and tropospheric ozone— to those that persist for decades, centuries, and millennia— such as the accumulation of long-lived greenhouse gas emissions that alter our climate.

Making responsible climate and energy policy decisions requires understanding the risks and probabilities associated with how our global environment will change, and the efficacy of different pathways to mitigate and adapt to those changes. The challenge of addressing global change is compounded by uncertainty and complicated by the interactions between the social and natural systems on which we depend.



Balancing global change risks, probabilities, and uncertainties is crucial to making policy decisions. To do so, policymakers must be informed by comprehensive, relevant analysis. The MIT Joint Program brings together both science and policy to provide a truly independent integrative assessment of the impacts of global change and the expected values of responsive actions.



The Challenge

Understanding the complex, long-term changes in our land, air, and water requires breakthroughs in measurement, modeling, prediction, attribution, and verification.

Responding to these changes requires innovative policies that address uncertainty and risk, while comprehending impacts to agriculture, technology, energy, health, and finance.

Assessing these policies requires integration of diverse sets of environmental, economic, political, and behavioral data within the arena of relevant climate and energy debates.

Organizing a genuinely global approach to confronting the climate challenge requires sustained integrated natural and social science research and authoritative communication of analyses and results.

The Response

The Joint Program on the Science and Policy of Global Change is MIT's response to these research, analysis, and communication challenges, combining the efforts and expertise of two complementary research centers: the Center for Global Change Science (CGCS) and the Center for Energy and Environmental Policy Research (CEEPR).

The Center for Global Change Science is devoted to research on Earth system processes, to further our ability to accurately predict and characterize changes in the global environment. The Center for Energy and Environmental Policy Research provides crucial decision-making support to government and industry policy-makers through rigorous, objective policy and economic analysis. In addition, the Joint Program utilizes resources through its alliance with the Ecosystems Center of the Marine Biology Laboratory and collaborates with other MIT departments, leading research institutions, and nonprofit organizations worldwide.

A distinguishing characteristic of the MIT Joint Program is its team of close-working specialists from a wide range of disciplines. Researchers, including physicists, oceanographers, atmospheric chemists, hydrologists, energy and environmental economists, decision analysts, energy technologists, and scholars of politics and the policy process, all work together to create truly integrated assessments of global change issues.

CEEPR + CGCS

Ecosystems Center
Marine Biological Laboratory
(in Woods Hole, MA)

Center for Energy and Environmental Policy Researh

CEEPR

Sloan School of Management

Economics Department

MIT Energy Initiative

Urban Studies and Planning Department

Chemical Engineering Department

Engineeering Systems Division

MIT Joint Program on the Science & Policy of Global Change

Center for Global Change Science

CGCS

School of Science

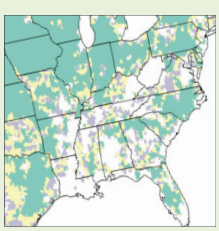
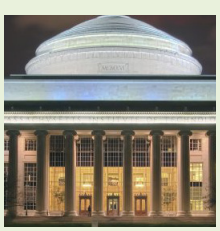
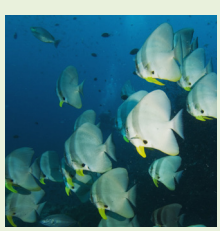
Earth, Atmospheric and Planetary Science Department

Civil and Environmental Engineering Department

Biology Department

Electrical Engineering and Computer Science Department

Other MIT Faculty, Program Visitors and Other Collaborators


The MIT Integrated Global System Model Framework

The MIT Integrated Global System Model (IGSM) is a linked set of computer models designed to simulate the global environmental changes that arise as a result of human causes. Developed at MIT over many years, the IGSM was constructed in collaboration with the Ecosystems Center of the Marine Biological Laboratory. This comprehensive tool analyzes interactions between human and climate systems, to better understand the nonlinearities and feedbacks among economic activity and land, ocean, and atmospheric systems. Our central research efforts are organized around the IGSM and strive to improve uncertainty in forecasts of the potential social and environmental consequences of global change. By bringing together science and policy to identify probabilities, uncertainties, risks, and impacts, the MIT Joint Program is a unique source for integrated assessment of global change issues.

The Human System: Emissions Prediction and Policy Analysis (EPPA) model

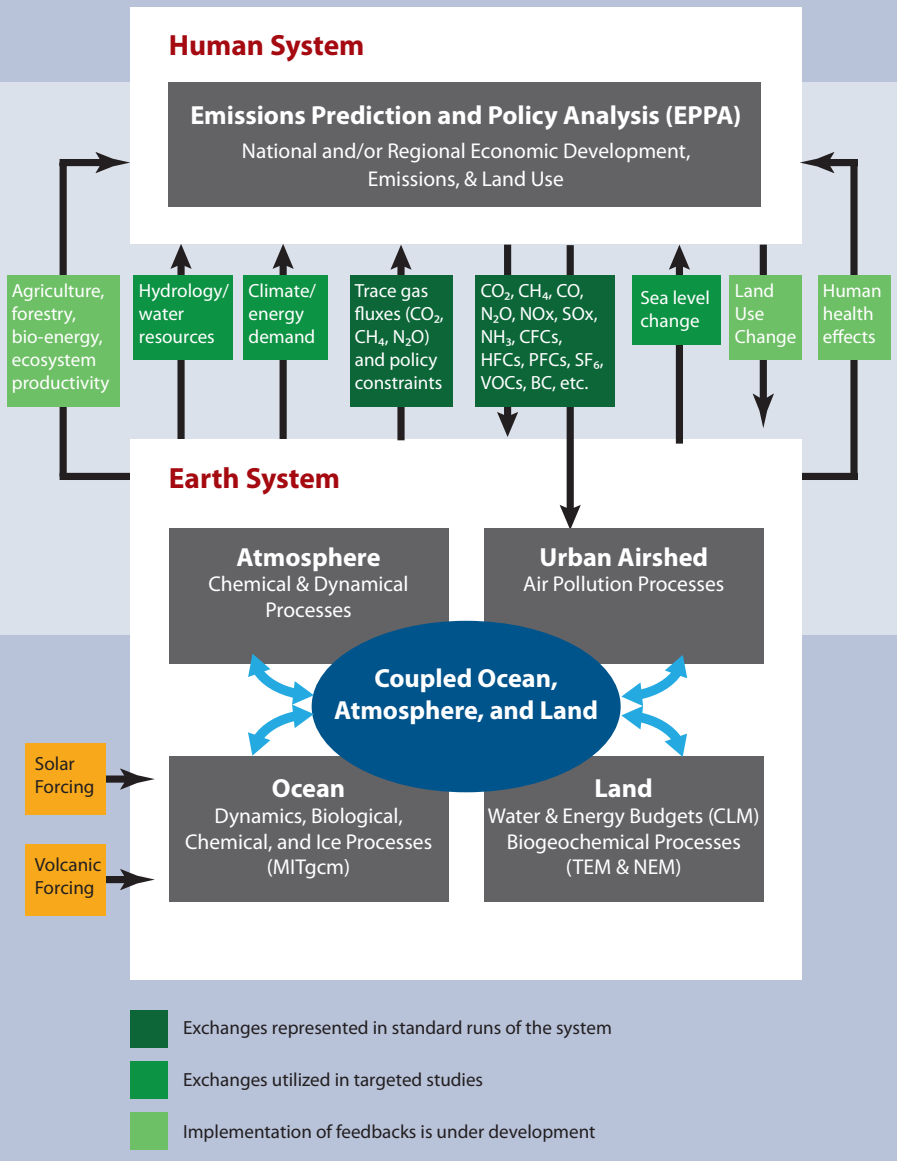
Human activities, as they contribute to or are affected by environmental change, are represented in multi-region, multi-sector models of the economy. The MIT Emissions Predictions and Policy Analysis (EPPA) model provides projections of world economic development and emissions of greenhouse gases and other air pollutants from combustion of carbon-based fuels, industrial processes, waste handling, agricultural activities, and land use. It is used to analyze the processes that produce greenhouse-relevant emissions and to assess the consequences and costs of policy proposals and emissions control measures.

The Earth System: Coupled ocean, atmosphere, and land models

Ocean: Ocean physics and biogeochemistry are modeled with either a 2-dimensional (latitude-longitude) mixed-layer anomaly-diffusing ocean model or a 3-dimensional ocean general circulation model (GCM). Components model heat uptake, nutrient cycling, and primary productivity, and include a thermodynamic sea-ice module.

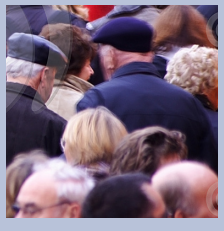
Atmosphere: Atmospheric chemistry and dynamics are modeled using either a 2- or 3-dimensional global model. The models capture all climate-relevant reactive gases and aerosols and measure transport, convection, and local production/loss due to surface emission/deposition at regional and global scales. An urban chemical model represents aerosol processing at sub-grid scale.

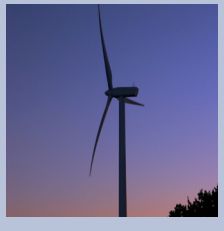
Land: The Global Land System (GLS) links biogeophysical, ecological, and biogeochemical components, which calculate hydrological processes, water and energy balances, and carbon, nitrogen, and methane dynamics. When coupled, the model system represents changes in plant productivity, distribution, diversity, and land use.

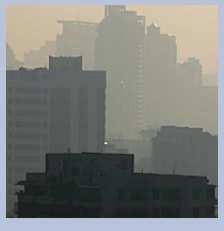


Examples of Model Outputs

Changes in:
GDP growth
energy use
policy costs
agriculture and health impacts
global mean temperature
precipitation patterns
sea level rise
permafrost coverage
vegetative processes
soil carbon cycles
trace gas emissions
ecosystem management...







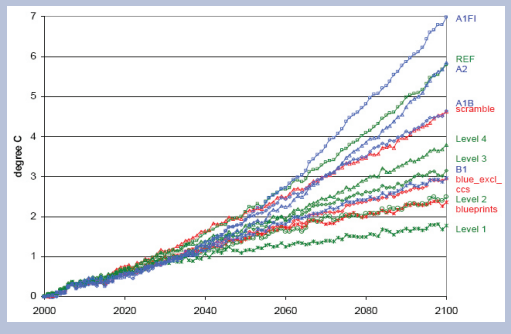
Current Projects using the MIT IGSM Framework

Quantifying uncertainties in emissions targets and climate impacts

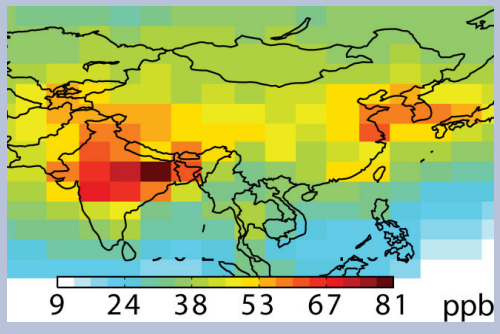
Policymaking in response to climate change is essentially a challenge of risk management. Researchers use the IGSM to analyze uncertain outcomes that result from emissions targets, including atmospheric concentrations, radiative forcing, temperature change, and sea level rise. Uncertainty studies can also estimate the odds of achieving particular target levels and the global costs of associated mitigation policy. In a recent study, the IGSM was used to assess the climate system response to scenarios developed by three external groups, representing intergovernmental, government, and industry sectors. Despite differences in detail, these three approaches painted a similar picture of a world at risk from climate change—even when substantial abatement policies were implemented.

Measuring the health and economic burden of air pollution

Conventional approaches to estimating the health damages from air pollution fail to capture the complex interactions linking emissions to welfare loss. To reflect these complexities, researchers use the IGSM to integrate climate effects with the Emission Prediction and Policy Analysis (EPPA) model. EPPA estimates emissions depending on the changes in economic activity, values the health impacts that result from exposure to pollutant concentrations, and creates relationships between lost productivity and changes in the medical services sector. The model can then determine the economy-wide costs and benefits of emissions regulations. Integrated assessment has allowed MIT researchers to understand the uncertainty involved in estimating health impacts, while calculating national, regional and global health costs now, and into the future.



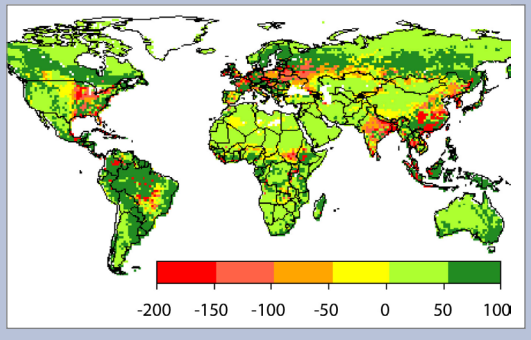
Projections of increase in global mean temperature under different emissions scenarios.



Model simulated change in ozone concentration across Asia, relative to population, in 2050.

Exploring the impacts of future land use and energy policy scenarios on climate

Biofuels, along with other technologies (nuclear, hydro, wind, solar), have been proposed as a potential means to meet future energy demands with low-carbon sources. However, the demand for biofuels occurs in a complex context of economic factors (food prices, land prices), population growth, and environmental regulations. Researchers use the IGSM to investigate the direct climatic impact of extensive land cover change due to future large scale planting of biofuels. Current decisions on land management and energy policies will have significant effects on land surface characteristics, impacting projected climate changes and the availability of food and water. Linking the economic and ecosystem models in the IGSM allows for dynamic interactions and feedbacks among economic activity, climate, mitigation policies, land use change, and energy technology options.



Regional level percentage change in crop yield between 2000 and 2100 under a high pollution (e.g. ozone) and no emissions policy scenario.

Research Goals

Discovering new interactions, impacts, and feedbacks among natural and human climate systems

Objectively assessing uncertainty and risk in economic and climate projections

Critically and quantitatively analyzing mitigation, management, and energy policy proposals

Understanding connections between climate change and other environmental policy issues

Improving methods to model, monitor, and verify greenhouse gas emissions and climatic impacts

FUNDING & SPONSORSHIP

The work of the Joint Program is funded by an international partnership of government, industry, and foundation sponsors, and by private donations. Our sponsor consortium provides the long-term substantial commitment needed to support our dedicated and specialized staff, and to realize a coordinated integrated research effort.

Funding is provided by eight U.S. Government agencies and approximately forty corporations, foundations, and industrial organizations. Industrial sponsorship is drawn nearly equally from U.S.-based and international corporations.

Sponsors have the opportunity to interact with researchers through executive board briefings, educational webinars, visits from presenters, and an open invitation to visit us at MIT. Sponsors also benefit by early access to MIT analyses, quarterly newsletters, and networking with researchers and fellow sponsors through the MIT Global Change Forum.

The MIT Global Change Forum has gained an international reputation as a successful outreach activity and is instrumental in communicating the work of the Joint Program in a timely and constructive way to industrial and governmental policy-making bodies. The Forums promote interaction among disparate stakeholders, and provide a non-official, neutral setting for independent assessment of studies and policy proposals. In addition to participation by MIT faculty and staff, the Forums routinely involve selected experts from other universities and government research laboratories, as well as high-level representatives involved in the ongoing Intergovernmental Panel on Climate Change efforts. Highly valuable to the discussions is input from a range of industries and organizations that have an interest in industrial economics and energy technology.

For information on how to become a sponsor, please visit http://globalchange.mit.edu/sponsors/.

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Updated October 2011

The MIT Global Change Forum:

Convened approximately every nine months in various locations around the world, each Forum brings together more than 100 international participants from industry, government, non-profit groups, and research organizations to partake in serious, frank, and informed discussions on evolving climate issues.

Communications:

As leaders in both science and policy, Joint Program researchers provide expertise to national and international policy-making bodies, scientific agencies, and other researchers via publications, briefings, workshops, Congressional testimony, invited talks and conference presentations around the world.

Publications:

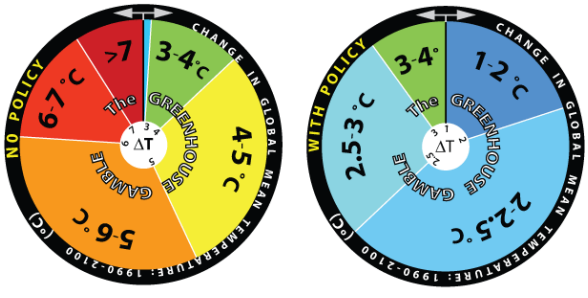
With more than 400 publications available for download, our extensive website provides open access to MIT Joint Program Reports, reprints of peer-reviewed journal articles, technical reports, student theses, and Congressional testimonies. The site documents over 20 years of integrated assessment research and is a testament to the significant contribution our prolific researchers have made to scientific understanding and policy development.

Education and Outreach

A continuing goal of the Joint Program is to improve public and policy-maker understanding of the risks of climate change and to contribute to an informed public debate on global change issues. This objective is pursued by communicating research results and policy studies through publications, presentations, MIT Global Change Forum discussions, press releases, and involvement in international studies, conferences, and workshops. Additional outreach activities include interactions with media outlets, museums, schools, government organizations, and our local community. In addition, the Joint Program facilitates international cooperation through affiliate relationships with organizations worldwide.

One critical dimension of the Joint Program's mission is cultivating the next generation of researchers. Though the MIT Joint Program is not an academic degree-granting entity, students participate directly in our core work, within collaborative, multidisciplinary research teams. Students involved in Joint Program research gain unique access to state-of-the-art computing and policy analysis. They also find many opportunities to publish and present their research, to work as research and teaching assistants, and to develop important professional skills. Faculty and staff associated with the Joint Program are intensely involved in the activities of academic development, classroom teaching, and mentoring.

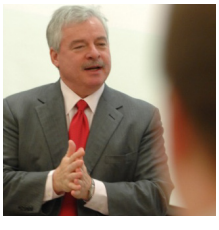
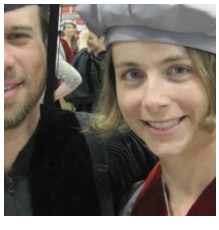
The Greenhouse Gamble is a communication method created by the Joint Program to help convey how policies to reduce greenhouse gas emissions could reduce the risk of climate impacts, emphasizing that human-induced climate change is a problem of risk management. The roulette-style wheels present estimates of the uncertainty in climate change predictions and the likelihood of potential global average surface warming over the next hundred years under different possible policy scenarios.



LOOKING AHEAD

Global changes are complex issues that can only truly begin to be addressed by sustained interdisciplinary research. The integrated assessment studies we conduct provide comprehensive results on impacts, risks, and uncertainties needed to inform decision-makers. Our program is a dedicated source of unbiased and authoritative analyses, developed by researchers from a wide network of expertise. With our ability to conceptualize interactions between Earth and human systems, the MIT Joint Program is the definitive institution for integrated assessment analyses relevant to today's climate and energy policy debates.

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