MIT JOINT PROGRAM ON THE SCIENCE & POLICY OF GLOBAL CHANGE

GLOBAL CHANGES

MIT JOINT PROGRAM ON THE SCIENCE & POLICY OF GLOBAL CHANGE
SPRING 2022 NEWSLETTER

MIT JOINT PROGRAM
SCIENCE
POLICY
GLOBAL CHANGE

OUR RESEARCH MISSION

Advancing a sustainable, prosperous world through scientific analysis of the complex interactions among co-evolving, interconnected global systems.

The pace and complexity of global environmental change is unprecedented. Nations, regions, cities and the public and private sectors are facing increasing pressures to confront critical challenges in future food, water, energy, climate and other areas. Our integrated team of natural and social scientists produces comprehensive global and regional change projections under different environmental, economic and policy scenarios. These projections enable decision-makers in the public and private sectors to better assess impacts, and the associated costs and benefits of potential courses of action.

OUR VISION

We envision a world in which community, government and industry leaders have the insight they need to make environmentally and economically sound choices.

Toward that end, we provide a scientific foundation for strategic investment, policymaking and other decisions that advance sustainable development.

IMPACT: WHAT WE DO

The MIT Joint Program:

- Combines scientific research with risk and policy analyses to project the impacts of—and evaluate possible responses to—the many interwoven challenges of global socioeconomic, technological and environmental change.
- Communicates research findings through our website, publications, workshops and presentations around the world, as well as frequent interactions with decision-makers, media outlets, government and nongovernmental organizations, schools and communities.
- Cultivates and educates the next generation of interdisciplinary researchers with the skills to tackle ongoing and emerging complex global challenges.

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SAVE THE DATE: XLV (45TH) GLOBAL CHANGE FORUM

Mar 23–24, 2023 • Sponsor Meeting on Mar 22

Attendance is by invitation only.

SPRING 2022 GLOBAL CHANGES

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The latest IPCC report's clear message:

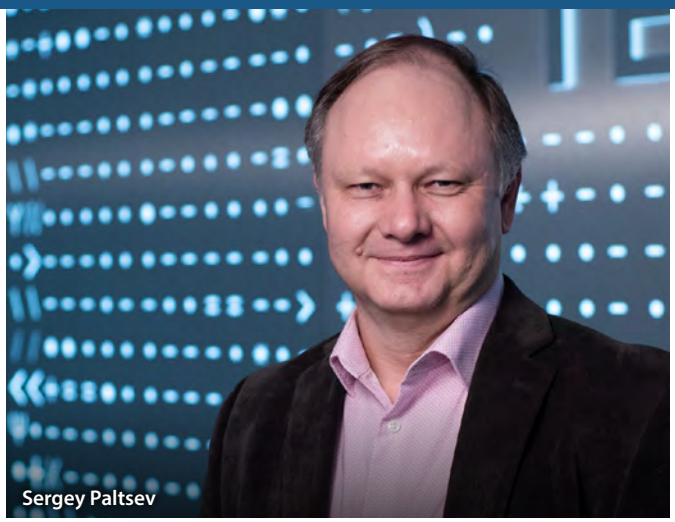
Accelerate mitigation efforts to reach climate stabilization targets

In early April, the UN Intergovernmental Panel on Climate Change (IPCC) released the third part of its newest assessment report. Known as the Working Group III (WG3), this part provides an analysis of recent relevant literature on the mitigation of climate change. According to the IPCC, despite the consistent expansion of policies addressing greenhouse gas (GHG) mitigation, the world is on track to undergo a median global warming of about 3 degrees Celsius (°C) relative to preindustrial levels if current policies are not strengthened.

The previous parts of the latest IPCC report described the severity of climate impacts rising with every fraction of a degree of warming: more frequent and intense heat waves, droughts, flooding, forest fires and other extreme events. Limiting the worst impacts of climate change will require reducing GHG emissions to net-zero, and the WG3 report assesses a wide range of modeled pathways to transform economic and energy systems to cap warming at 1.5°C or 2°C. These pathways envision actions leading to a replacement of fossil fuels with renewable energy, deployment of negative emission technologies, and substantial reduction in global energy demand.

Future emissions scenarios are divided into eight categories based on associated warming outcomes at the end of the 21st century. In addition, several "illustrative mitigation pathways" were introduced to reflect the policies in place today, limited additional climate policies, gradual strengthening of policies, extensive use of negative emissions, high renewables, low demand, and shifting development pathways. The last four pathways limit global warming to 1.5°C, but the use of negative emission technologies may result in a so-called "overshoot" in which the target is exceeded for a period of time before carbon sinks reduce the global surface temperature.

In all scenarios consistent with limiting warming to 1.5°C, there is a need for a drastic GHG emissions reduction in the next decades. Global emissions should peak before 2025 and decline between 25% and 50% by 2030 relative to 2020 levels. The IPCC report sends a clear message that a failure to reduce emissions in the coming decade will render the long-term goals of the Paris Agreement increasingly unachievable. The current emissions reduction commitments (known as Nationally Determined Contributions, or NDCs) made by signatory nations for 2030 are not sufficient to prevent warming from exceeding 1.5°C. Limiting the temperature increase to below 2°C would require a rapid acceleration of mitigation efforts after 2030.


Sergey Paltsev

The MIT Joint Program's response

We at the MIT Joint Program continue to provide our own assessment of climate stabilization pathways, most prominently in our MIT Global Change Outlook, which we plan to update to reflect the latest developments. Critical to achieving long-term climate targets will be the deployment of advanced technologies, the development of more comprehensive and equitable policies, and the use of sophisticated modeling tools to guide decision-makers.

In the advanced technology space, we are investigating decarbonization of hard-to-abate sectors (e.g., cement and steelmaking), industrial carbon capture and storage (CCS), hydrogen, sustainable aviation fuels and bioenergy. Following on our recent analysis of bioenergy with CCS (BECCS), we continue to explore techno-economic and policy-support aspects of negative emission technologies.

As development of large-scale bio-based projects will likely increase competition for land, we are studying global and regional land availability for different uses to assess corresponding agriculture/food security implications. One carbon dioxide removal option assessed by the IPCC report, direct air capture (DAC), requires relatively smaller land use, but needs a large amount of energy input. We plan to explore energy implications for DAC deployment scenarios. For all options (including DAC and BECCS), the cost of negative emission technologies has to come way down and/or the price of carbon needs to go way up in order to incentivize the scale that would be needed for these technologies to make a considerable impact.

There is a growing recognition that climate targets focused only on temperature do not appropriately account for other important factors, such as air and water quality and human health—and that policy benefits and unintended consequences are unequally distributed. We are beginning to reconfigure our modeling framework and metrics to address these more integrated targets with greater precision. We plan to expand on our analysis of distributional impacts to assess policy designs that increase support for more aggressive climate actions.

Recent geopolitical tensions may affect climate mitigation activities, including wider ramifications for the global food system and economy. Beyond the suffering and humanitarian crisis within Ukraine, the global economy will likely grow at a lower rate for as long as the conflict lasts. In the near future, recovery and rebuilding efforts will very likely take highest priority—and therefore not necessarily lead to low-emission actions. These geopolitical tensions will likely lead to more carbon-intensive options in the short term, and to a faster decrease in the use of fossil fuels in different sectors and regions in the longer term. Impacts on the global food system will result in higher expenditures on food purchases in many parts of the world, leaving less available funding for other uses.

To address the complexities of future development, it is essential to obtain a clear understanding of the linkages between emissions mitigation, climate adaptation and sustainable development. To provide decision-makers with that understanding and actionable research results, we continue to refine our Integrated Global System Modeling (IGSM) framework. The release of the latest version of a key component of the IGSM, the Economic Projection and Policy Analysis (EPPA) model, is forthcoming.

—Sergey Paltsev, Deputy Director

MIT DEPARTMENT ACRONYMS

Due to space considerations, MIT departments, labs and centers referenced here are referred to by their acronyms.

EAPS	Earth, Atmospheric and Planetary Sciences
IDSS	Institute for Data, Systems and Society
ESI	Environmental Solutions Initiative
MITEI	MIT Energy Initiative

MIT Joint Program News Releases:
Latest research developments and their implications

MIT Joint Program in the Media:
Latest coverage of our research

The following summaries are listed by primary research focus area, but may span multiple research focus areas. For more information on Joint Program research, please visit our website at globalchange.mit.edu.

Earth Systems

Changes and risks to interconnected land, ocean, atmosphere and biosphere systems

Different kinds of marine phytoplankton respond differently to warming ocean temperatures

Findings in study co-authored by Joint Program Senior Research Scientist Stephanie Dutkiewicz could improve accuracy of climate change projections (Univ. of Rhode Island)

A *Nature Communications* study of how four key groups of phytoplankton will respond to ocean temperatures forecast to occur between 2080 and 2100 suggests that their growth rates and distribution patterns will likely be dissimilar, resulting in significant implications for the future composition of marine communities around the globe.

First-ever Climate Grand Challenges recognizes 27 finalists

MIT Joint Program research scientists are co-investigators on one-third of the selected projects, with a focus on decarbonizing complex industries and preparing for climate extremes. (MIT News)

All-carbon buildings, climate-resilient crops, and new tools to improve the prediction of extreme weather events are just a few of the 27 bold, interdisciplinary research projects selected as finalists from a field of almost 100 proposals in the first MIT Climate Grand Challenges competition. Each of the finalist teams received $100,000 to develop a comprehensive research and innovation plan.

MIT announces five flagship projects in first-ever Climate Grand Challenges competition

Joint Program researchers participating in three: Bringing Computation to the Climate Challenge, Preparing for a new world of weather and climate extremes, *and* The Climate Resilience Early Warning System *(MIT News) (Coverage:* Boston Business Journal*)*

MIT announced the five flagship projects selected in its first-ever Climate Grand Challenges competition. These multiyear projects will define a dynamic research agenda focused on unraveling some of the toughest unsolved climate problems and bringing high-impact, science-based solutions to the world on an accelerated basis. The five projects will receive additional funding and resources from MIT and others to develop their ideas and swiftly transform them into practical solutions at scale.

At Climate Grand Challenges showcase event, an exploration of how to accelerate breakthrough solutions

Special Presidential Envoy for Climate John Kerry calls the initiative "classic MIT." The MIT Joint Program is contributing to three of its five flagship projects. (MIT News) (Coverage: Bloomberg, Boston Globe, WBUR, NBC-Boston)

On the eve of Earth Day, more than 300 faculty, researchers, students, government officials and industry leaders gathered in the Samberg Conference Center, along with thousands more who tuned in online, to celebrate MIT's first-ever Climate Grand Challenges and the five most promising concepts to emerge from the two-year competition.

When scientists say the Earth has warmed by 1° Celsius, which parts of the planet are being measured?

The parts of the planet being measured are our land and ocean surfaces: what we call global average surface temperatures. (MIT Environmental Solutions Initiative)

"If we affect the troposphere on the whole, that affects the biosphere," says MIT Joint Program Deputy Director C. Adam Schlosser, referring to the worldwide ecosystem of all living things. Already observable impacts of a warming troposphere include sea-level rise, more severe weather and more compounding climate change effects like storm surges and heightened flooding.

Special Presidential Envoy for Climate John Kerry and MIT President L. Rafael Reif discussed strategies to help the world avert the worst consequences of climate change and make the United States a leader again in bringing technology into commercial use.

Infrastructure & Investment

Physical and transition risk; adaptation and resilience to climate change and extreme events

Bank of Canada/OSFI pilot project helps Canadian financial sector assess climate change risks

MIT Joint Program contributes to assessment of market and credit risks to key Canadian economic sectors

Along with six Canadian financial institutions, the Bank and OSFI developed scenarios to help the financial sector identify, measure and disclose climate-related risks. These scenarios were specifically designed to capture a range of potential outcomes and illustrate stresses on the financial system and economy that could occur as the world transitions to a low-carbon future.

How the industry's fastest growing sector Is pushing managers to change their behavior (Institutional Investor)

Wellington, Schroders and others are taking a more activist approach to managing their environmentally-sustainable funds (Additional coverage: Pensions & Investments)

Wellington Management and the MIT Joint Program announce climate change research collaboration

Focus on transition risks complements Wellington's existing physical-risk capability

Wellington Management and the MIT Joint Program announced the formation of a climate change research collaboration. The alliance will bolster Wellington's current research on the transition to a low-carbon economy, enhance its understanding of the expected financial impacts of various transition pathways on industries and economies, and deepen its decarbonization engagement practices.

Empowering people to adapt on the frontlines of climate change

New platform will unite climate models, impact predictions, random control trial evaluations, and humanitarian services to bring cutting-edge tools to Bangladeshi communities. MIT Climate Grand Challenges flagship project includes seven Joint Program-affiliated contributors. (MIT Lincoln Laboratory)

A platform being developed in a collaboration between MIT and BRAC aims to inform and empower climate-threatened communities to proactively adapt to a changing future. The Climate Resilience Early Warning System (CREWSnet) will forecast the local impacts of climate change on people's lives, homes and livelihoods, thus guiding BRAC's development of resident-focused climate-resiliency programs.

Looking forward to forecast the risks of a changing climate

To better inform local policy in the face of changing weather extremes, MIT researchers--including seven affiliated with the Joint Program--seek to advance the modeling of long-term weather risks (MIT School of Science)

In one of five MIT Grand Challenges flagship projects, an interdisciplinary group of MIT scientists, engineers and designers plans to improve modeling of weather extremes, and incorporate that capability in a scalable toolkit. The toolkit will initially focus on cities in the United States and Africa, for communities and stakeholders to prepare and adapt.

The Climate Resilience Early Warning System (CREWSnet) will help front-line communities prepare for climate change impacts and minimize losses.

Energy Transition

National and global projections of the future energy mix; prospects for different sectors and technologies

Global net-zero emissions goals: Challenges and opportunities

Key takeaways from the XLIV (44th) MIT Global Change Forum

Held on the MIT Campus in March, the XLIV (44th) MIT Global Change Forum explored how global net-zero emissions goals are creating challenges and opportunities for carbon budgets, decarbonizing energy and industry, nature-based solutions, climate and health, negative emission technologies, and policy design.

MIT Joint Program at COP26

2021 Global Change Outlook results presented in session on net-zero emissions

At the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow, MIT Joint Program Deputy Director Sergey Paltsev delivered a presentation on the Program's 2021 Global Change Outlook. His remarks set the scene for a session on "Contributing to a Net-Zero Future" organized by the International Petroleum Industry Environmental Conservation Association (IPIECA).

Nuclear power Is COP26's quiet controversy (Time)
MIT Joint Program Deputy Director Sergey Paltsev shares his perspective

Corn-based ethanol may be worse for the climate than gasoline, a new study finds (Inside Climate News)
Long touted as a renewable fuel emitting 20 percent fewer greenhouse gases than gasoline, ethanol's emissions may be 24 percent higher. If verified, one expert said the finding shows ethanol failed spectacularly.

Deployment of offshore wind at utility scale is one of many strategies to reduce greenhouse gas emissions in alignment with net-zero emissions targets.

MITEI 2021 Annual Research Conference addresses "Getting to net-zero by 2050"

Sergey Paltsev and other speakers call for rapid deployment of integrated strategies to meet global energy needs and mitigate climate change (MIT Energy Initiative)

"Some were disappointed that [the pledges at COP26] weren't aggressive enough," said Paltsev, "but I think realistically, we are quite successful in trying to make sure that we are not providing false starts and false solutions. We are increasing pressures on emitters and developing the mechanisms for global emission reduction in the most efficient way."

MIT Joint Program at CERAWeek

Sergey Paltsev speaks on decarbonization pathways at international energy forum

In a presentation at CERAWeek, the world's premier energy conference, Paltsev discussed multiple technology and policy options, as well as the economic and climate impacts of energy decisions in different regions of the world. He delivered his presentation at a session on Energy Choices: Pathways for Decarbonization.

Scaling up low-carbon energy: Challenges and opportunities

Sergey Paltsev explores technology and policy options at international energy symposium

In a keynote presentation "Scaling up low-carbon energy: Economic, Geopolitical and Environmental Impacts" that he delivered at the international symposium *The Future of Energy: Tackling Climate Change* in Madrid, Paltsev described a framework developed at the MIT Joint Program for addressing pathways to global decarbonization.

Policy Scenarios

Environmental and economic change under different climate, air pollution, and economic policies

Can the world meet global climate targets without coordinated global action?

Growing demand for an energy transition could move the needle, but not far enough

A study in *Environmental Economics and Policy Studies* by the MIT Joint Program and Shell Scenarios Team projects that without a globally coordinated mitigation effort to reduce greenhouse gas emissions, the planet's average surface temperature will reach 2.8 C, much higher than the Paris Agreement 2 C goal, but a lot lower than what many widely used "business-as-usual" scenarios project.

Pricing carbon, valuing people

Optimizing U.S. climate policy design for a just energy transition

An MIT Joint Program study in *Energy Economics* finds that carbon-penalty policies that combine rebates to lower-income households with payroll tax reductions result in an optimal blend of sufficiently progressive financial results at the household level and economy efficiency at the national level.

At UN climate change conference, trying to "keep 1.5 alive"

A delegation from MIT traveled to Glasgow for COP26, where international negotiators sought to keep global climate goals on track (MIT Office of the Vice President for Research)

At COP26, MIT Joint Program Deputy Director Sergey Paltsev called on all countries to do more, faster, to cut emissions. "We need to employ an integrated approach of moving to zero emissions in energy and industry, together with sustainable development and nature-based solutions, simultaneously improving human well-being and providing biodiversity benefits," said Paltsev.

COMMENTARY **The 1.5 degrees goal: Beware of unintended consequences (Yale Climate Connections)**

The 1.5 degrees goal can be a 'useful spur to action,' but it's not a make or break point. Importantly, each 0.1-degree increase avoided is 'cause for celebration and hope.'

MIT Joint Program/NREL study featured in UN video "The Truth about Carbon Taxes" (United Nations)

Study shows how a carbon tax can both accelerate reductions in greenhouse gas emissions and not hurt low-income households

Report: Corporate climate pledges are weaker than they seem (Associated Press)

MIT Joint Program Co-Director Emeritus John Reilly suggests some avenues for improvement (Additional coverage: Washington Post)

DC Youth Climate Strike 2019 at the U.S. Capitol

Regional Analysis

Science and policy studies at subnational, national and multinational levels

Absent legislative victory, the President can still meet U.S. climate goals

Activating a Clean Air Act provision could deliver major climate, health and economic benefits

A new study led by MIT Joint Program researchers explores how, under a federally coordinated carbon dioxide emissions cap-and-trade program aligned with the U.S. Paris Agreement pledge and implemented through Section 115 of the Clean Air Act, the EPA might allocate emissions cuts among states. The study highlights the policy's net economic benefits to the nation.

MIT Joint Program at COP26

Former visiting scientist delivers first Nationally Determined Contribution of Brunei Darussalam

At COP26 in Glasgow, former MIT Joint Program Visiting Scientist Dina Yahya delivered the first Nationally Determined Contribution (NDC) of Brunei Darussalam. An official with the nation's Ministry of Energy, Yahya oversaw development of the NDC based on its first-ever National Climate Change Policy (NCCP).

Bringing climate reporting to local newsrooms

Inaugural MIT Environmental Solutions Initiative Journalism Fellows reflect on their experiences telling local climate stories (ESI)

The ESI Journalism Fellowship was created to help local reporters around the United States connect climate change science and solutions with issues that are already of importance to their audiences—particularly in areas where many people are still unclear or unsure about climate change.

A new study finds a Clean Air Act provision could enable the U.S. to accelerate the transition away from fossil fuels and toward low- and zero-carbon energy sources.

Multi-Sector Dynamics

Potential tipping points and transition states of Earth and human systems

Gathering storm: The industrial infrastructure catastrophe looming over America's Gulf Coast (Bulletin of the Atomic Scientists)

Analysis led by MIT Joint Program Deputy Director C. Adam Schlosser identifies the scope and severity of storm and flood risks to key U.S. petrochemical industry facilities in Texas and Louisiana

What choices does the world need to make to keep global warming below two degrees Celsius?

New study reveals multiple pathways for a successful energy transition by 2050

A new modeling strategy developed at the MIT Joint Program that explores hundreds of potential future development pathways provides new insights on the energy and technology choices needed for the world to reduce emissions sufficiently to achieve the Paris Agreement's long-term 2 C goal.

Using a unique modeling strategy, MIT Joint Program researchers find several possible patterns of energy and technology development under a specified long-term climate target or economic outcome.

Modeling Systems

Our state-of-the-art models and analytical methods project global and regional changes and potential risks under different policy scenarios

Four new videos highlight the impact of the MIT Joint Program on the Science and Policy of Global Change

Earth Day release underscores the program's mission to advance a sustainable, prosperous world

Reflecting the aspiration of Earth Day, the mission of the MIT Joint Program is to advance a sustainable, prosperous world; its projections provide a scientific foundation for strategic investment, policymaking and other decisions that promote sustainable development. To showcase how it is pursuing this mission, the Program released four videos in conjunction with Earth Day 2022.

Computing global change

The MIT Joint Program uses MGHPCC computing resources to make projections of future risks to the sustainability of energy, food, water and climate systems under different policy scenarios (MGHPCC)

To produce the 2021 Global Change Outlook, program researchers used the MIT Integrated Global System Modeling (IGSM) framework, a linked set of computer models developed by the MIT Joint Program to analyze interactions among human and Earth systems. The models, and the expansive data sets they use and generate, are run and housed on MIT computers located at the MGHPCC.

White House releases white paper on how better modeling of broader economic impacts of climate change can help quantify economic and fiscal impacts of climate change and climate action (White House)
Council of Economic Advisers/OMB white paper highlights MIT Joint Program's EPPA and USREP as model examples (pp. 25-26)

Computing our climate future

To put global climate modeling at the fingertips of local decision-makers, some scientists think it's time to rethink the system from scratch. Five Joint Program-affiliated researchers will help advance an MIT Climate Grand Challenges flagship project to do just that. (MIT School of Science)

"How can we use new computational techniques, new understandings, new ways of thinking about modeling, to really bridge that gap between state-of-the-art scientific advances and modeling, and people who are actually needing to use these models?" says EAPS/IDSS Professor Noelle Selin. To that end, the project aims to refine current climate models and build a new one from the ground up.

New Research Projects

Biomass availability for producing transportation fuels

Sponsor: MIT Energy Initiative Future Energy Systems Center
Leaders: Sergey Paltsev, Kristala Prather (MIT Chemical Engineering)
Duration: 2 years

Replacing fossil fuels with biofuels is one of the major ways to decarbonize transportation. Biofuels are particularly important for aviation, shipping and trucking, where the potential applications of other low-carbon technologies are limited. While demands for biofuels are large, estimates of biomass supply vary substantially due to differing sustainability considerations. We will assess the scalability of biomass availability and focus on plausibility and ranges of pathways to get simultaneously to large scales of biofuel production and land-intensive nature-based solutions, while satisfying food requirements for a growing global population. On the biofuels demand side, we will evaluate global and regional transportation demands, with a particular focus on aviation and shipping, and investigate a range of bio-based advanced low-carbon fuels suitable for satisfying transport applications to meet climate targets. To quantify the tradeoffs for biomass supply and demand, we will enhance the global multi-region, multi-sector, economy-wide MIT Economic Projection and Policy Analysis (EPPA) model, that considers many complex physical and socio-economic relationships and feedbacks. As large-scale deployment of biofuels will likely depend on continuing policy support, we will evaluate policies leading to sufficient growth of advanced biofuels at a regional and global level.

Advanced Global Atmospheric Gases Experiment (AGAGE) collaborative project: MIT component

Sponsor: NASA
Leader: Ronald Prinn
Duration: 5 years

The case for real-time, high-frequency measurement networks is very strong, and AGAGE observations and their interpretation are recognized widely for their importance to ozone depletion and climate change studies—and to verification issues arising from the Montreal Protocol (ozone) and Paris Agreement (climate) Protocols. AGAGE is distinguished by its capability to measure globally, at high frequency, all the important species in the Montreal Protocol and non-CO_2 gases in the Paris Agreement. Among the project's scientific objectives are to: measure accurately the temporal and spatial distributions of anthropogenic gases that contribute the majority of reactive halogen to the stratosphere and/or are strong infrared absorbers; measure accurately the global distributions and temporal behaviors and determine sources and sinks of non-CO_2 biogenic-anthropogenic gases important to climate change and/or ozone depletion; identify new long-lived greenhouse and ozone-depleting gases.

Joint Program Reports

356. Transition Scenarios for Analyzing Climate-Related Financial Risk

357. The Changing Nature of Climate-Related Risks in Global Wind Power Resources

358. Assessing the Changing Risk of Flood-producing Events in Cambridge

Peer-Reviewed Studies

Toward a just energy transition: A distributional analysis of low-carbon policies in the USA (*Energy Economics*)

The Impact of Assuming Perfect Foresight When Planning Infrastructure in the Water–Energy–Food Nexus (*Frontiers in Water*)

Future energy: In search of a scenario reflecting current and future pressures and trends (*Environmental Economics and Policy Studies*)

Representing socio-economic uncertainty in human system models (*Earth's Future*)

Electricity trade impacts on regional power pools in Sub-Saharan Africa (*Renewable Energy Focus*)

Impacts of a near-future supersonic aircraft fleet on atmospheric composition and climate (*Environmental Science: Atmospheres*)

Meeting U.S. greenhouse gas emissions goals with the International Air Pollution Provision of the Clean Air Act (*Environmental Research Letters*)

Testing the skill of a species distribution model using a 21st century virtual ecosystem (*Geophysical Research Letters*)

Climate change and the green transition in South Africa (*The Oxford Handbook of the South African Economy*)

Bottom-heavy trophic pyramids impair methylmercury biomagnification in the marine plankton ecosystems (*Environmental Science & Technology*)

Marine phytoplankton functional types exhibit diverse responses to thermal change (*Nature Communications*)

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Our work 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.

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