

# GLOBAL CHANGES

MIT JOINT PROGRAM ON THE SCIENCE & POLICY OF GLOBAL CHANGE  
FALL 2023 NEWSLETTER





## 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: XLVI (46<sup>TH</sup>) GLOBAL CHANGE FORUM

**Mar. 28–29, 2024 • Sponsor Meeting on Mar. 27**

The heat is on: Accelerating climate action at a time of record-breaking temperatures. [More information](#)

*Attendance is by invitation only.*

*The reporting period for this issue is May - October, 2023.*

## MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE

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## FALL 2023 GLOBAL CHANGES

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# Physical Risks: Regional consequences to global targets and prospects beyond 2100

## An excerpt from our [2023 Global Change Outlook](#)

### Context

Physical risks across natural, managed and built environments will emerge, co-evolve and potentially compound as human-forced climate change progresses. While our global-scale results provide important insights on the effectiveness of policy instruments typically driven by a global target, it is the more temporally and spatially granular aspects of these outcomes that directly associate with climate-related physical risks. To elicit that granularity, the Integrated Global System Modeling (IGSM) framework's "hybrid" downscaling method combines the global-scale distribution of human-forced climate change with more spatially-resolved climate-response patterns to provide an objective sampling of the plausible outcomes that result from a global policy or environmental target.

### Key Findings

To provide a broad assessment of emerging trends and their distributions across the world's major continental regions, we focus on changes in surface-air temperature and precipitation, which directly relate to the frequency and intensity of several high-impact climate- and weather-related events, including heat waves, floods and drought. One standout finding is that under our Current Trends and Accelerated Actions scenarios<sup>1</sup>, all major continents will almost certainly pass 1.5°C of warming by mid-century. More precisely, in a Current Trends world, there is at least a 75% chance that across all continents, human-induced annually-averaged warming will exceed 1.5°C by 2050—and by 2075 a nearly 95% chance that all continents but Oceania will experience annually-averaged warming greater than 2°C. Our results also

1 The 2023 *Global Change Outlook* uses the following scenarios:

- *Current Trends*, which assumes implementation of current policy settings;
- *Accelerated Actions*, a 1.5°C stabilization pathway, in which countries impose more aggressive emissions targets that represent an illustrative pathway of increased mitigation.



C. Adam Schlosser – Co-Director, MIT Joint Program

indicate strong seasonality in temperature trends, with continental regions experiencing stronger temperature increases during the cold seasons.

Recent "unprecedented" and record-breaking extreme temperature events worldwide have raised concerns as to whether these conditions can or will be increasingly expected to occur due to human-forced warming. Based on our latest climate-model information, we find that human-forced trends in maximum temperatures will likely outpace mean temperature trends over much of North and South America, Europe, northern and southeast Asia, and southern parts of Africa and Australasia (**Figure 1**). So as human-forced climate warming intensifies, these regions will likely experience more widespread and frequent record-breaking extreme heat events similar to those in recent years.

In view of all these temperature trends, the Accelerated Actions scenario indicates that many of the world's continents could warm above 2°C by the end of the century. Specifically, North America and Asia have at least a 50% likelihood of annual-mean warming to at least 2°C. On the other hand, Africa, Europe, Oceania and South America have at most a 25% likelihood of such warming.



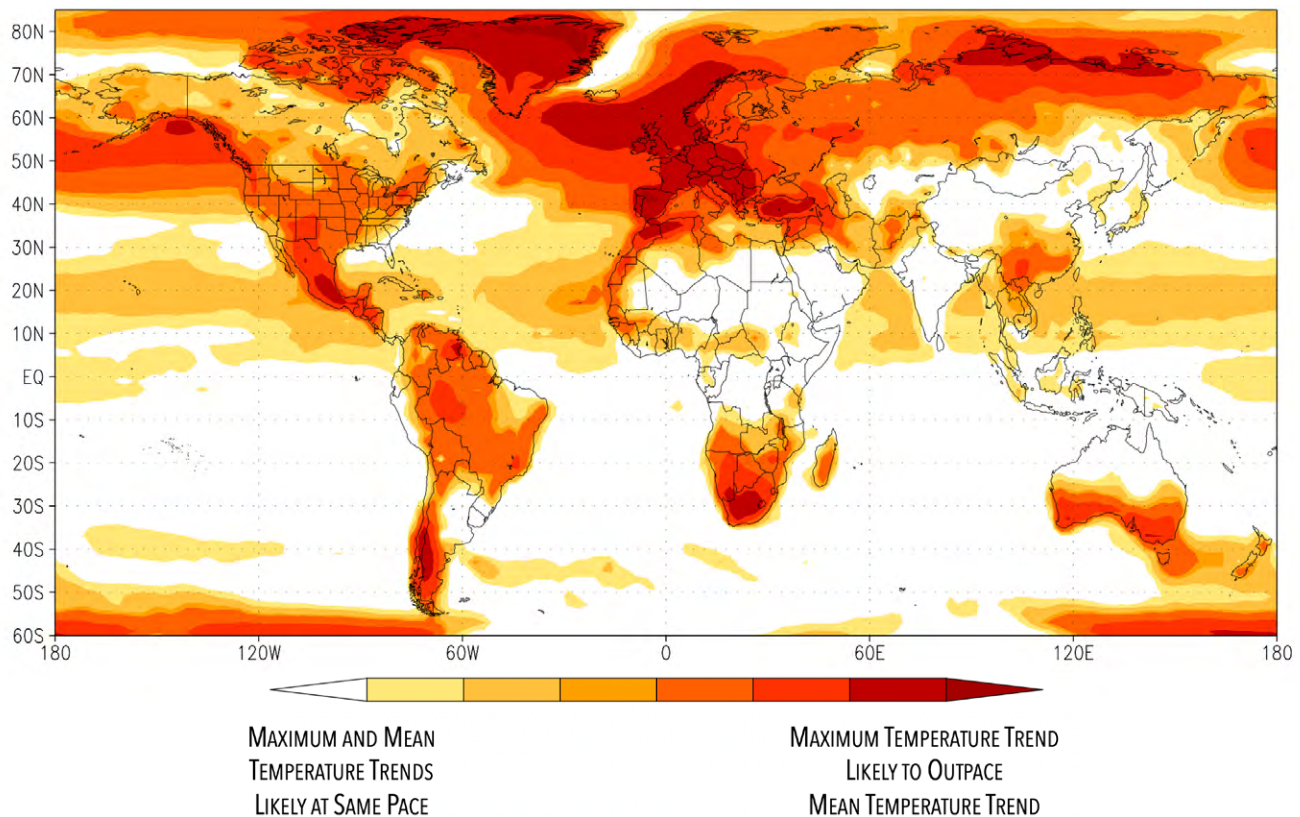
Overall, human-induced climate warming drives a global precipitation response; a warmer climate acts to “accelerate” the hydrologic cycle leading to higher precipitation rates. This underscores an underlying threat of more flood-prone conditions. However, there are exceptionally important regional and seasonal departures. In particular, under the Current Trends scenario, we find that Europe will most likely experience widespread drier summer conditions through the latter half of the century; North America (as well as the contiguous United States) shows a similar but less pronounced conditions. With less precipitation and warmer temperatures, this represents widespread, compounding risks of enhanced heat-stress and drought-prone conditions. For Europe, the central tendency of our projections aligns with this, yet the probability does not exceed 75%. Under the Accelerated Actions scenario, however, the prevailing risk of these summertime conditions is eliminated. However, an elevated risk of increased wintertime precipitation remains.

## Implications

Our results underscore that elevated climate-related physical risks—including more pronounced extreme-temperature events (Figure 1)—will continue through mid-century and are largely unaffected by climate-policy actions. The salient benefits of climate actions are realized through the latter half of the century. This is a critically important aspect in the strategic planning and preparation to secure and sustain resource systems (land, water, energy), socio-economic sectors, equitable human health, and biodiversity. The “multi-sector” analyses that our researchers pursue take all these factors into consideration, and bring the full spectrum of physical risks to bear toward a more holistic vision of sustainable development.

—C. Adam Schlosser, Deputy Director

MIT Joint Program research scientist Andrei Sokolov and postdoctoral fellow Popat Salunke contributed to this analysis.



**Figure 1.** Map of an “Extreme Temperature Trend” index indicating the (unitless) relative degree and consensus to which daily maximum temperature trends outpace mean temperature change in response to human-forced climate warming. Consensus determined by the number of model responses that agree in the sign of temperature changes. IGSM “hybrid” downscaling based on aggregate climate-model response from the Coupled Model Intercomparison Project Phase 6 (CMIP6). Darker shades indicate greater likelihood of maximum daily temperature increase outpacing the mean warming rate, leading to more pronounced “unprecedented” extreme-temperature events as warming intensifies.

The following news and media coverage summaries are listed along with the Research Focus Area(s) that they represent. To view all of our news and media coverage, and detailed descriptions of our research focus areas and modeling tools, please visit our website at [globalchange.mit.edu](https://globalchange.mit.edu).



### Earth Systems

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



### Managed Resources

Changes and risks to managed agriculture, water, land and energy systems



### Infrastructure & Investment

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



### Energy Transition

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



### Policy Scenarios

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



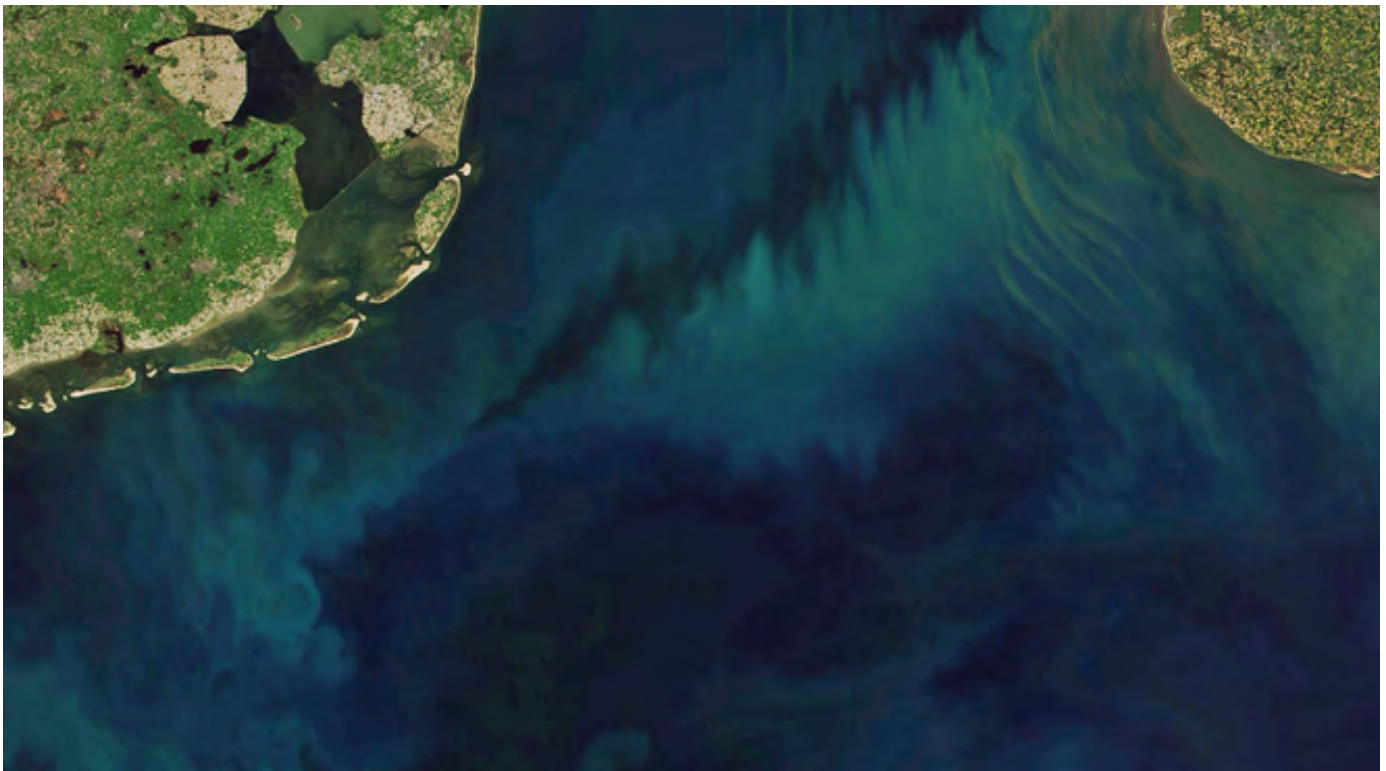
### Regional Analysis

Science and policy studies at subnational, national and multinational levels



### Multi-Sector Dynamics

Potential tipping points and transition states of Earth and human systems



## EARTH SYSTEMS

## Study: The ocean's color is changing as a consequence of climate change

*The color changes reflect significant shifts in essential marine ecosystems (MIT News) (Coverage: [Washington Post](#), [The Guardian](#), [Boston Globe](#), [CNN](#), [CBS](#), [Bloomberg](#), [National Geographic](#), [U.S. News & World Report](#), [Forbes](#), [Scientific American](#), [New Scientist](#), [Popular Science](#), [Smithsonian](#), [Axios](#), [The Daily Beast](#))*

The ocean's color has changed significantly over the last 20 years, and the global trend is likely a consequence of human-induced climate change, report MIT and collaborating scientists. In a study appearing in *Nature*, the team writes that they have detected changes in ocean color over the past two decades that cannot be explained by natural, year-to-year variability alone.

## MANAGED RESOURCES

## ENERGY TRANSITION

## POLICY SCENARIOS

### Cutting carbon, restoring ecosystems, creating jobs

*How forests can become more effective 'Natural Climate Solutions'*

A team of researchers at Imperial College London and the MIT Joint Program recently studied how environmental scientists, local stakeholders, and project funders perceive the risks and benefits of NCS projects, and how these perceptions impact project goals and performance. The team's analysis appears in the journal *Frontiers in Climate*.

## EARTH SYSTEMS

## POLICY SCENARIOS

## REGIONAL ANALYSIS

### Probing the atmosphere, protecting the biosphere

*AGAGE network marks 45 years of tracking and tracing potentially harmful atmospheric gases*

Scientists gathered in October at the MIT Endicott House and online to attend a conference celebrating the 45<sup>th</sup> anniversary of the [AGAGE](#) network. Measuring the ozone-depleting and greenhouse gas composition of the Earth's atmosphere continuously for the past 45 years through a global network of sophisticated monitoring stations, AGAGE has contributed significantly to the protection of life on Earth.



EARTH SYSTEMS | MANAGED RESOURCES | ENERGY TRANSITION | POLICY SCENARIOS

## Net-zero emissions by 2050: Is the world willing to pay more to lock in its long-term climate goal?

*Study finds tradeoffs between policy costs and ensuring that global warming does not exceed 1.5°C*

Despite the focus on 2050, there are different timelines for meeting a net-zero target that could be consistent with achieving the 1.5°C goal. In a study in the journal *Climate Change Economics*, MIT Joint Program researchers explore the energy, environmental and economic implications of meeting a global net-zero-emissions target by 2050 versus choosing other pathways of limiting global warming to 1.5°C.



EARTH SYSTEMS | MANAGED RESOURCES | INFRASTRUCTURE & INVESTMENT | ENERGY TRANSITION | POLICY SCENARIOS | REGIONAL ANALYSIS | MULTI-SECTOR DYNAMICS

### AGU Fall Meeting to encourage the pursuit of Open Science

*MIT Joint Program presentations highlight multiple sustainability challenges and solutions*

At this year's meeting, 13 MIT Joint Program core members or faculty affiliates will serve as co-authors of oral or poster presentations, or conveners of conference sessions. Their 23 presentations and sessions, which span multiple Joint Program research focus areas, highlight recent findings on several sustainability challenges and solutions.

MANAGED RESOURCES | ENERGY TRANSITION | POLICY SCENARIOS

### Airbus, LATAM Airlines Group fund MIT Joint Program study on options for decarbonizing aviation in Latin America

*Airbus/LATAM press release describes study's purpose and objectives (Airbus/LATAM)*

(Project: [Options for decarbonizing aviation in Latin America in a sustainable way](#) • Press release: [LATAM website](#) • Coverage: [Biofuels Digest](#))

Airbus and LATAM Airlines Group have funded an MIT Joint Program analysis of (1) scenarios for the deployment of Sustainable Aviation Fuels up to the year 2050, and explore pathways related to low-carbon hydrogen, direct air capture, and bioenergy with carbon capture and storage, and (2) the use of various policy instruments to compensate emissions in aviation.

EARTH SYSTEMS ENERGY TRANSITION POLICY SCENARIOS REGIONAL ANALYSIS

## Improving U.S. air quality, equitably

*Climate policy alone cannot meaningfully reduce racial/economic disparities in air pollution exposure*

To evaluate the effectiveness of current federal decarbonization policies in reducing U.S. racial and economic disparities in PM<sub>2.5</sub> exposure, researchers at MIT and Stanford University recently evaluated a range of policies which, like current U.S. federal carbon policies, reduce economy-wide CO<sub>2</sub> emissions by 40-60 percent from 2005 levels by 2030. Their findings appear in the journal *Nature Communications*.

MANAGED RESOURCES ENERGY TRANSITION

POLICY SCENARIOS REGIONAL ANALYSIS

## EPA releases report: Electricity Sector Emissions Impacts of the Inflation Reduction Act

*Report relies substantially on MIT Joint Program's U.S. Regional Energy Policy (USREP) model projections (U.S. EPA)*

The EPA has developed a report that relies upon results from state-of-the-art multi-sector and electric sector models to assess how the Inflation Reduction Act's provisions reduce emissions. The report examines the projected reductions in CO<sub>2</sub> emissions due to the Inflation Reduction Act provisions included in the modeling tools.

MANAGED RESOURCES ENERGY TRANSITION

POLICY SCENARIOS REGIONAL ANALYSIS

## IRA could accelerate economy-wide decarbonization up to 40%, new analysis finds

*MIT Joint Program Research Scientist Mei Yuan contributes to study in the journal Science (EPRI)*

Clean energy investments incentivized through the climate provisions of the U.S. Inflation Reduction Act (IRA) could accelerate economy-wide decarbonization but would fall short of the federal government's goal to reduce emissions by at least 50% below 2005 levels by 2030, according to a new multi-model comparison of the emissions and energy system impacts of the law.

EARTH SYSTEMS MANAGED RESOURCES

INFRASTRUCTURE & INVESTMENT REGIONAL ANALYSIS

## US and UAE governments highlight early warning system for climate resilience

*One of MIT's five Climate Grand Challenges flagship projects involving significant Joint Program contributions, the Jameel Observatory-CREWSnet project will pilot in Bangladesh and Sudan to help communities adapt to the impacts of climate change (MIT Office of the Vice President for Research)*

The Jameel Observatory Climate Resilience Early Warning System Network aims to empower communities worldwide, specifically within the agriculture sector, to adapt to climate shocks by launching cross-sector collaborations and by combining state-of-the-art climate and socio-economic forecasting techniques with technological solutions to support communities' resilience.

EARTH SYSTEMS ENERGY TRANSITION POLICY SCENARIOS

## Explained: The 1.5°C climate benchmark

*After a summer of weather extremes, where does the world stand in its goal to stem rising temps? (MIT News)*

Keeping the average global temperature below 1.5 degrees Celsius is no guarantee of avoiding extreme, global warming effects. "There is nothing magical about the 1.5 number, other than that is an agreed aspirational target," says MIT Joint Program Deputy Director Sergey Paltsev. "What is known: The lower the target for an increase in temperature, the lower the risks of climate impacts."



## MIT Joint Program in the Media

MANAGED RESOURCES ENERGY TRANSITION

### Are electric cars really better for the environment? *(Washington Post)*

Overall, they're much less harmful than gasoline cars, says MIT Joint Program Deputy Director Sergey Paltsev

EARTH SYSTEMS POLICY SCENARIOS

### This study upends how we think about the ozone layer and our health *(Washington Post)*

The ozone layer's effect on our lives may be more complicated than it seems

POLICY SCENARIOS

### COMMENTARY: Young Republicans want action on climate change — so why is the party ignoring them? *(The Hill)*

Studies show an emerging divide between younger and older Republicans that could help shift the party's stance on climate policy

EARTH SYSTEMS POLICY SCENARIOS

### MIT climate scientist urges action after hottest days on record *(WCVB (ABC Affiliate))*

MIT Joint Program Deputy Director Sergey Paltsev responds to new report showing global average temperature reaching 17.18°C (62.9°F)

EARTH SYSTEMS MANAGED RESOURCES ENERGY TRANSITION

MULTI-SECTOR DYNAMICS

### PERSPECTIVE: Progress in modeling dynamic systems for sustainable development *(PNAS)*

MIT Joint Program faculty affiliate Noelle Selin and co-authors highlight recent advances in modeling Earth/human systems dynamics to inform sustainable development



EARTH SYSTEMS MANAGED RESOURCES ENERGY TRANSITION

POLICY SCENARIOS

### COMMENTARY: Health effects of a global carbon price *(Nature Sustainability)*

A study shows that while air quality gains from carbon policies are widespread, some regions could see pollution increases

EARTH SYSTEMS MANAGED RESOURCES ENERGY TRANSITION

### Will the drive for EVs destroy Earth's last untouched ecosystem? *(Live Science)*

In the hunt for minerals needed in electric car batteries, some companies are turning to the deep sea. But mining this ecosystem could threaten its very existence

MANAGED RESOURCES ENERGY TRANSITION

### Dubai and India accelerate sustainable mobility ahead of COP28 *(The Economic Times)*

Ahead of COP28, the UAE's EV market is booming, bolstered by private investments, government initiatives, and partnerships with countries such as India

MANAGED RESOURCES INFRASTRUCTURE & INVESTMENT

ENERGY TRANSITION

### Internal combustion vs. EVs: Learning from the past to boost sustainability *(Mongabay)*

MIT Joint Program Deputy Director Sergey Paltsev identifies opportunities to make EVs more sustainable

EARTH SYSTEMS

### PODCAST: Don't throw away your refrigerator *(MIT Climate Portal)*

MIT Joint Program Director Ronald Prinn joins TILclimate to discuss the past, present and future of how refrigerants affect our planet

MANAGED RESOURCES ENERGY TRANSITION

## Why have electric vehicles won out over hydrogen cars (so far)? (MIT Climate Portal)

Today's battery electric vehicles are cheaper than hydrogen-powered ones, and they also need less new infrastructure

EARTH SYSTEMS MANAGED RESOURCES

INFRASTRUCTURE & INVESTMENT

## ASK MIT CLIMATE: Will climate change drive humans extinct or destroy civilization? (MIT Climate Portal)

Almost certainly not—but unless we act quickly to stop warming the planet, there will be very severe consequences for many, many people

EARTH SYSTEMS REGIONAL ANALYSIS

## Rwanda's president appoints atmospheric scientist Gasore as new Infrastructure Minister (The New Times)

Former MIT EAPS PhD student Jimmy Gasore developed Africa's only AGAGE atmospheric gases monitoring station



## New Research Projects

### Taiwan's Innovative Green Economy Roadmap (TIGER)

**Sponsor:** Consortium of Taiwan-based companies (via MITEI)

**Duration:** 2 years

**Leaders:** Robert Armstrong and Sergey Paltsev

The Taiwan Innovative Green Economy Roadmap (TIGER) Consortium focuses on engaging Taiwan-based industry leaders and MIT experts in developing a long-term, robust roadmap for Taiwan in its transition to a green economy based on innovative, low-carbon technologies. The goal is to better inform leaders from different industries in Taiwan about upcoming challenges and ways to convert these challenges into opportunities for maintaining and expanding leadership.

## Milestones

**Horacio Caperan** (MIT Joint Program, MIT Energy Initiative) left his position as the MIT Joint Program's Executive Director of External Affairs.

He is currently the Director of the [MIT Sloan Latin America Office](#) at the MIT Sloan School of Management. Horacio has been a valued contributor to the Joint Program's sponsor engagement and development activities for nearly seven years. He is expecting to continue to collaborate with the Joint Program in his new role as well.

**MIT Joint Program collaborator David Kicklighter**, a research scientist at Marine Biological Laboratory (MBL), has retired.

His research focuses on understanding the role of land ecosystems on global biogeochemistry and the impacts of human activities on interactions of the terrestrial biosphere with the atmosphere and the hydrosphere. He has collaborated with MIT's Center for Global Change Science (CGCS) and Joint Program since 1992 to utilize MBL's Terrestrial Ecosystems Model with the MIT Integrated Global System Modeling (IGSM) framework.

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## Peer-Reviewed Studies

A Large Ensemble Global Dataset for Climate Impact Assessments (*Scientific Data*)

Logs or permits? Forestry land use decisions in an emissions trading scheme (*Australian Journal of Agriculture and Resource Economics*)

Progress in modeling dynamic systems for sustainable development (*PNAS*)

Overlooked Long-Term Atmospheric Chemical Feedbacks Alter the Impact of Solar Geoengineering: Implications for Tropospheric Oxidative Capacity (*AGU Advances*)

Air Quality Related Equity Implications of U.S. Decarbonization Policy (*Nature Communications*)

Scenario Discovery Analysis of Drivers of Solar and Wind Energy Transitions Through 2050 (*Earth's Future*)

A Global Comparison of Marine Chlorophyll Variability Observed in Eulerian and Lagrangian Perspectives (*JGR Oceans*)

COMMENTARY: Health effects of a global carbon price (*Nature Sustainability*)

Emissions and energy impacts of the Inflation Reduction Act (*Science*)

Challenges and opportunities in connecting gene count observations with ocean biogeochemical models: Reply to Zehr and Riemann (2023) (*Limnology and Oceanography*)

Assessing the performance of backscattering-based phytoplankton carbon algorithms (*Global Biogeochemical Cycles*)

Assessing the performance of backscattering-based phytoplankton carbon algorithms (*bioRxiv*)

Global climate-change trends detected in indicators of ocean ecology (*Nature*)

Natural Climate Solutions must embrace multiple perspectives to ensure synergy with sustainable development (*Frontiers in Climate*)

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## Joint Program Reports

**366.** An investigation into the effects of border carbon adjustments on the Canadian economy

**367.** Quantifying the recreation use value of New England natural lands

**368.** The Changing Nature of Human-Forced Hydroclimatic Risks across Africa

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(a) See p 4

(b) See p 7(a)

(c) See p 6





# MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

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