

2025 ANNUAL REPORT





Center for Sustainability Science and Strategy

Mission

We conduct actionable, evidence-based research to improve understanding of sustainability challenges. Our research enables decision-makers to devise effective strategies to address global change and enhance well-being for current and future generations. We take an integrated approach to sustainability science that considers the Earth's interconnected, co-evolving natural and societal systems in their full complexity.

Vision

We are natural and social scientists who aim to accelerate the field of sustainability science, collaborating with societal leaders and integrating knowledge from diverse disciplines to:

- Advance fundamental understanding of the Earth's complex, interconnected physical and socio-economic systems.
- Leverage leading-edge computing and data through the development and dissemination of new knowledge, tools and strategies.
- Generate actionable scientific information that mitigates risks to critical life-support systems while supporting equity and justice.

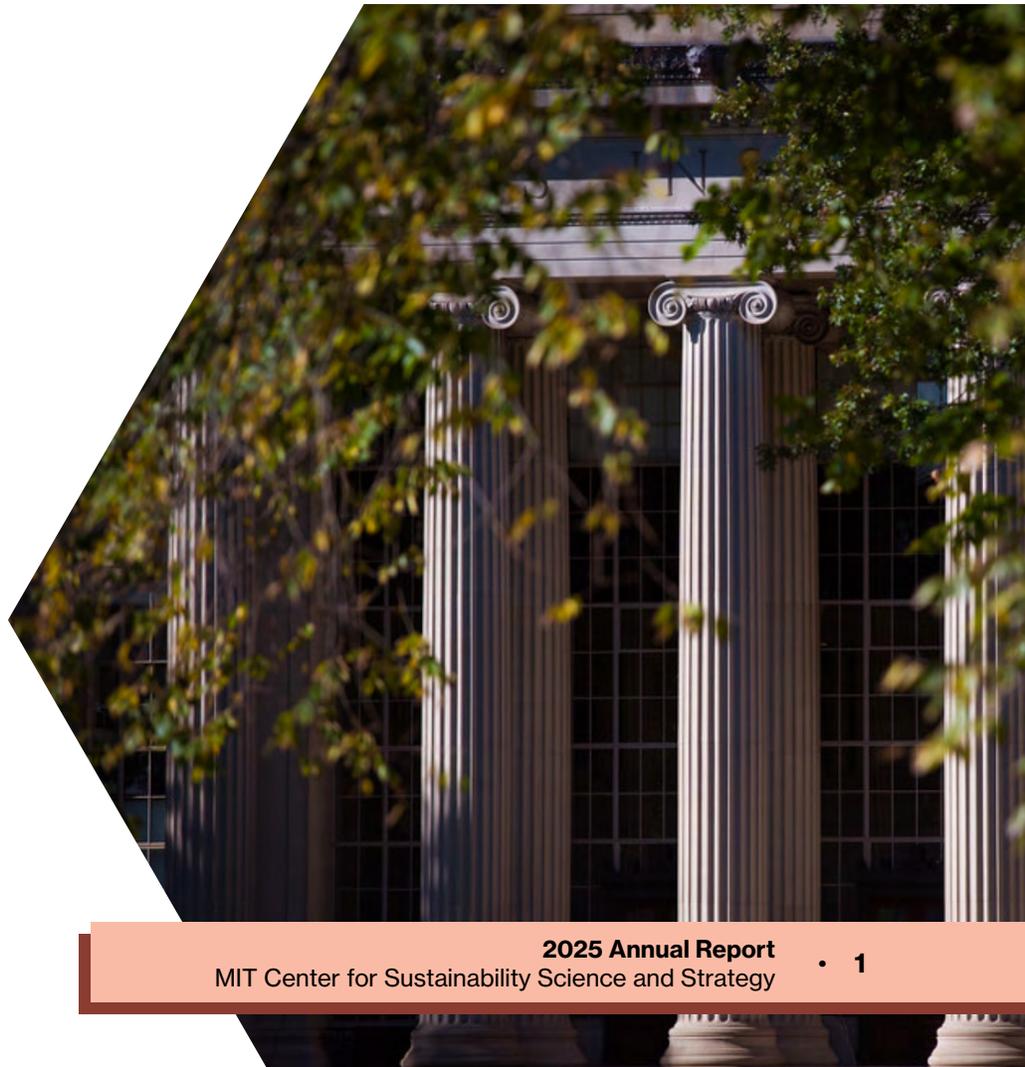
INTRODUCTION

OVERVIEW

The MIT Center for Sustainability Science and Strategy (CS3) advances knowledge and computational capabilities in the field of sustainability science, and supports decision-makers in government, industry, academia and civil society to achieve sustainability goals.

Researchers at CS3 develop and apply expertise from across the Institute to improve understanding of sustainability challenges, and thereby provide actionable knowledge and insight to inform strategies for improving human well-being for current and future generations.

Many CS3 researchers are appointed in the MIT Energy Initiative; the MIT Institute for Data, Systems and Society; the MIT Department of Earth, Atmospheric and Planetary Sciences; and other MIT departments, labs and centers. They also work in close collaboration with the Climate Project at MIT. For a full list of collaborating MIT organizations, see the inside back cover.



FROM THE DIRECTORS

This annual report highlights the accomplishments of our first full year as the MIT Center for Sustainability Science and Strategy (CS3). In expanding our efforts to produce more precise and comprehensive knowledge of sustainability challenges, we are continuing to guide decision-makers to formulate more effective strategies that can improve quality of life for all, today and tomorrow.

In 2025, our work involved progress on our three core areas of focus:

Advancing fundamental understanding of the complex interconnected physical and socio-economic systems that affect human well-being.

We continue to conduct basic research that advances fundamental understanding of the Earth in its full complexity with an emphasis on processes that interact with human activities. Highlights of CS3 research this past year include efforts to track emissions of chemicals that damage the ozone layer, and to develop new knowledge of how future ocean warming affects ocean ecosystems. We also expanded our engagement with a broader community of social scientists across MIT, recognizing the importance of understanding not only physical but also societal processes. We anticipate that these new collaborations will yield new insights on how humans interact with the environment.

Developing, establishing and disseminating new computational tools toward better understanding Earth systems.

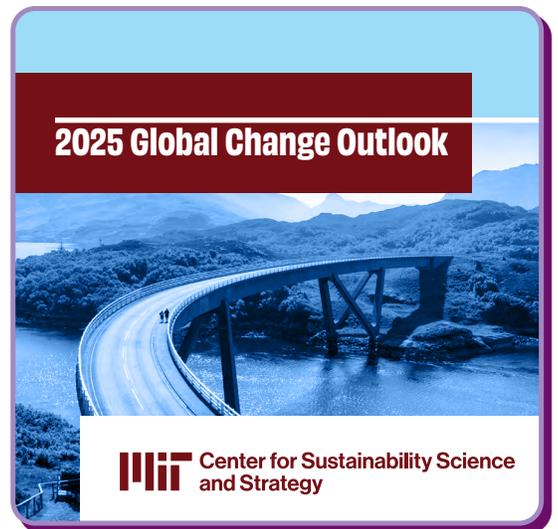
A hallmark of CS3's work is its development of integrated models that can help interpret data and explore the implications of future scenarios. This past year, we enhanced our modeling framework to enable more accurate, higher-resolution assessments of the potential impacts of global changes on land allocated to crops, pastures and forests. We are also working together with researchers from across MIT to develop new, fast-running, simplified versions of our models – called emulators – that are more computationally efficient, and thus useful for helping us simulate a wider range of sustainability impacts. At the same time, we are enhancing our efforts to make our models and analyses widely available. To that end, we were especially pleased to see work that was co-led by CS3-affiliated investigators recognized by the MIT Prize for Open Data.

Producing actionable science that supports equity and justice within and across generations.

CS3's work in 2025 reflected its commitment to provide useful, relevant information contributing to sustainability-related decision-making. Across different sectors, our work is addressing several real-world challenges, including decarbonizing steel, informing nuclear waste management, and assessing health and air quality impacts of companies' net-zero policies. Many of our actionable research results are now integrated in our [STRESS](#) platform, which allows users to map and understand compounding risks that affect their communities.

Finally, our biannual flagship report, the [Global Change Outlook](#), published in late 2025, represented a central effort to integrate our work into actionable insights that inform decision-making. In short, our results showed that current trends do not put the world on track to meeting climate and sustainability goals. Bolder, more collaborative, and urgent actions are required. Our Outlook provides a pathway for scaling up global sustainability ambition.

We hope that our work in 2025, and beyond, can help inform decision-makers in government, industry, academia and civil society in their efforts to better understand and respond to sustainability challenges and opportunities.



CS3 Leadership



Noelle Selin

Director

Professor, MIT Institute for Data, Systems and Society and MIT Department of Earth, Atmospheric and Planetary Sciences



Sergey Paltsev

Deputy Director

Senior Research Scientist



C. Adam Schlosser

Deputy Director

Senior Research Scientist



Anne Slinn

Executive Director

OUR RESEARCH

CS3 RESEARCH GOALS

Our research advances fundamental understanding of the complex, interconnected physical and socio-economic systems that affect human well-being. We apply state-of-the-art computational tools, integrating modeling and data analysis across disciplines in an era of increasing volumes of observational and simulation data. Ultimately, we aim to produce actionable science that supports equity and justice within and across generations.



Interconnected Physical and Socio-Economic Systems. As new policies and technologies are developed amid climate and other global changes, they interact with environmental processes and institutions in ways that can alter the Earth’s critical life-support systems. Fundamental mechanisms that determine many of these systems’ behaviors, including those related to interacting climate, water, food and socio-economic systems, contain knowledge gaps that require updated quantitative evidence. Better understanding can help society mitigate the risks of abrupt changes and “tipping points” in these systems.

Integrated Modeling and Data Analysis. We conduct modeling and data analysis across disciplines in an era of increasing volumes of observational and simulation data. MIT multisystem models and data products, building on and extending from the well-known Integrated Global System Modeling (IGSM) framework and the MIT Economic Projection and Policy Analysis (EPPA) model, provide robust information to inform decision-making and shape the next generation of sustainability science and strategy.

Actionable Research for Equity and Justice. Our research is designed to inform action associated with measurable outcomes aligned with supporting human well-being across generations. This requires engaging a broad range of stakeholders, including not only nations and companies, but also NGOs and communities that take action to promote sustainable development – with special attention to those who have historically borne the brunt of environmental injustice.

2025 RESEARCH HIGHLIGHTS

[Search all CS3 publications »](#)



Post-COP30, more aggressive policies needed to cap global warming at 1.5°C

New *Global Change Outlook* shows how accelerated action can reduce climate risks and improve sustainability outcomes, while highlighting potential geopolitical hurdles



When companies “go green,” air quality impacts can vary dramatically

Study by CS3 researchers and co-authors shows that cutting air travel and purchasing renewable energy can affect overall air quality, even with the same CO₂ reduction



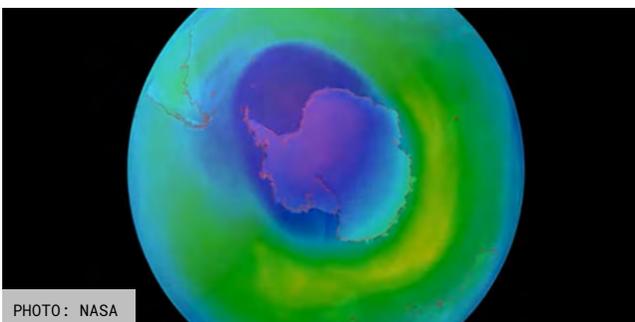
What should countries do with their nuclear waste?

Study co-authored by CS3 faculty affiliate Haruko Wainwright analyzes different nuclear waste management strategies, with a focus on the radionuclide iodine-129



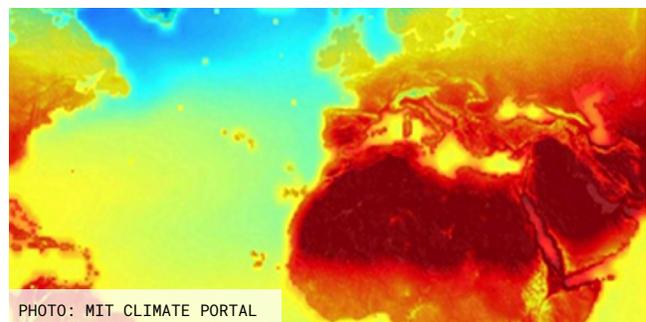
Surprisingly diverse innovations led to dramatically cheaper solar panels

New research can identify opportunities to drive down costs of renewable energy systems, batteries, and many other technologies, finds study co-authored by CS3-affiliated professor Jessika Trancik



Tracing persistent ozone-depleting emissions to their source

MIT CS3 postdoc-led study sheds new light on the global carbon tetrachloride emission gap



When basic science and technology is not enough to address climate change

Institute-wide project taps social science to reframe the problem and identify more viable solutions



PHOTO: CITY OF IRVINE, CA

Reconciling widely varying estimates of climate change's global economic impacts

In [GTAP](#) webinar, MIT CS3 Principal Research Scientist Jennifer Morris presents findings from *Nature Climate Change* study aimed at better understanding and modeling the climate/economy nexus

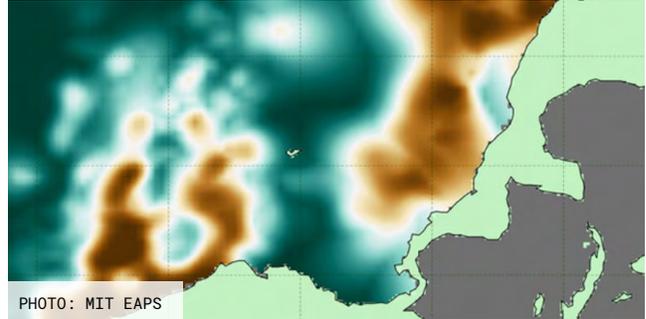


PHOTO: MIT EAPS

MIT CS3-affiliated researcher receives 2025 MIT Prize for Open Data

MIT [EAPS](#) postdoctoral associate Paolo Giani is a collaborator on one of seven projects recognized by the prize, which promotes transparency and reproducibility of research through open data policies



PHOTO: AMERICAN IRON AND STEEL INSTITUTE

Decarbonizing steel is tough as steel

But a new MIT CS3-led study shows how advanced steelmaking technologies could substantially reduce carbon emission



PHOTO: OPEN ACCESS GOVERNMENT

How will U.S. land use change by 2050?

New modeling framework projects how pressures on the global food system could impact cropland, pastureland and forests

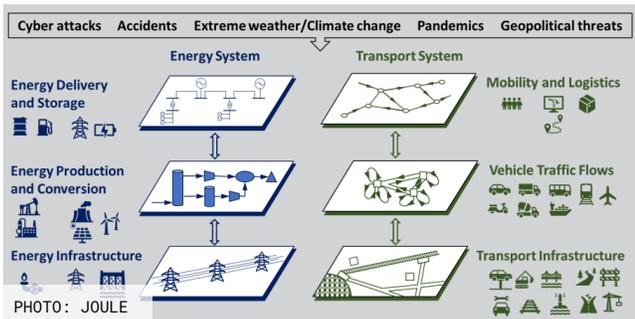


PHOTO: JOULE

A vision for transportation resilience in the energy transition

How a holistic strategy can minimize risks and disruptions



PHOTO: SIMON DOOLEY/FLICKR

Smart carbon dioxide removal yields economic and environmental benefits

MIT study shows that a diversified portfolio of CDR options delivers the best return on investment

2025 GLOBAL CHANGE OUTLOOK

“Our comparison of outcomes highlights the risks of remaining on the world’s current emissions trajectory—and the benefits of pursuing a much more aggressive strategy.”

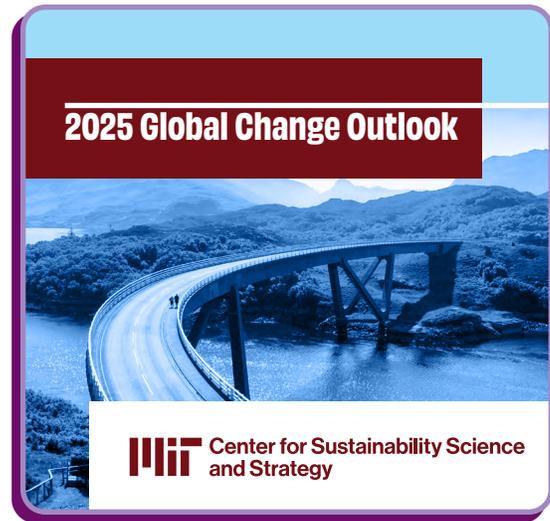
– Noelle Selin, CS3 Director

The 2025 Global Change Outlook presents CS3’s latest projections for Earth’s energy and climate systems under two policy scenarios – *Current Trends* and *Accelerated Actions*.

By quantifying the risks posed by today’s climate policies – and the extent to which accelerated climate action could reduce them – the Global Change Outlook aims to clarify what’s at stake for environments and economies around the world.

Our modeled projections imply significantly different risk levels under the two scenarios for water availability, biodiversity, air quality, human health, economic well-being and other sustainability indicators.

Additionally, CS3’s new [data-visualization platform](#) provides efficient, screening-level mapping of current and future climate, socio-economic and demographic-related conditions and changes – including global mapping for many of the model outputs featured in the Outlook.



2025 Outlook Policy Scenarios

Current Trends: Current measures for reducing greenhouse gas emissions, projected indefinitely

Accelerated Actions: What may happen if regions impose more aggressive GHG emissions reduction targets

Table: Key projections from the 2025 Global Change Outlook.

Category	Subcategory	Year(s)	Current Trends	Accelerated Actions
Primary Energy	Energy consumption	2025–2050	+17%	-16%
Electricity	Electricity Use	2025–2050	+90%	+100%
	Wind & Solar Generation	2025–2050	+770%	+1170%
Greenhouse Gas Emissions	Anthropogenic emissions, including land-use change	2025–2050	-10%	-60%
Global Climate <i>(median of ensemble of simulations)</i>	Mean surface temperature change <i>(°C relative to 1850-1900)</i>	2050	1.79	1.62
		2100	2.74	1.56
		2150	3.72	1.5
	Precipitation change from 2025 <i>(mm/day)</i>	2050	+0.04	+0.03
		2075	+0.07	+0.04
		2100	+0.11	+0.04
		2150	+0.18	+0.03

MEDIA COVERAGE HIGHLIGHTS

The planet passed a dangerous threshold for warming last year. Why is nobody talking about it?

Here's why scientists say it's far from "game over" for the planet (*Boston Globe*)

Is the world ready for the transformational power of fusion?

MIT CS3 experts in energy systems modeling and colleagues explore the future role of fusion energy in a decarbonized electricity system (*World Economic Forum*)

From asteroids to climate change: what are the risks threatening Earth?

MIT CS3 Deputy Director C. Adam Schlosser assesses worst-case climate impacts on human populations (*Geographical*)

U.S. carbon capture storage hit by inflation, Trump

Developers face about 30% higher capital costs due to post-pandemic inflation, high interest rates and permitting difficulties, says MIT Energy Initiative Senior Research Engineer and CS3-affiliate Howard Herzog (*Reuters*)

Green, clean, or just real? Rethinking our climate vocabulary

MIT CS3 Principal Research Scientist Jennifer Morris cautions that all energy sources – fossil-based or renewable – have environmental footprints (*The American Bazaar*)

Brazil bets on macaúba palm to make renewable diesel and aviation biofuel

The palm has potential, but it is too early to assess, says MIT CS3 Deputy Director Sergey Paltsev (*Mongabay*)

Study by MIT CS3 researchers finds that climate change may make it harder to reduce smog in some regions

MIT CS3 Director and senior author Noelle Selin underscores the importance of policies that reduce air pollution (*WBUR*) (*Audio*)

News outlets that have covered CS3 activities include:

ABC News	The Indian Express
The American Bazaar	Motor Trend
Associated Press	NPR
Boston Globe	Reuters
Daily Mail	Scientific American
Earth.com	Texas Observer
E&E News	Times Brazil
Grist	Washington Post
Independent	

Fighting climate change, one yard at a time

Planting new vegetation is one way to remove carbon from the air, says CS3 Deputy Director C. Adam Schlosser (*Boston Globe*)

COMMENTARY: A thought experiment reveals the fingerprints of climate change came early

Climate change left its signature on the atmosphere early in the industrial revolution, reveals a thought experiment investigation by MIT Professor/CS3 faculty affiliate Susan Solomon and co-authors (*Scientific American*)

Why hydrogen-powered cars have yet to achieve widespread adoption

To gain traction with consumers, hydrogen cars have a long way to go in reducing vehicle and fuel costs, says MIT CS3 Deputy Director Sergey Paltsev (*Motor Trend*)

Report: Big businesses are doing carbon dioxide removal all wrong

Ultimately, proper regulation of corporate climate commitments – including of durable CDR – will fall on governments, says MIT CS3's John Reilly (*Grist*)

Brazil proposes global integration of carbon markets at COP30

MIT Professor/CS3 faculty affiliate Catherine Wolfram observes that the Brazilian proposal represents a practical advance in the creation of a global carbon pricing structure (*Times Brazil*) (*Related: MIT Sloan School of Management*)

Highway to 'climate hell': What breaching the 1.5°C warming threshold could mean

MIT CS3 Deputy Director Sergey Paltsev shares his perspective (*The Indian Express*)

PODCAST: Climate Reveal

MIT CS3 researchers share their expertise in conversations that explore specific aspects of the climate crisis and ongoing work toward solutions (*Boston College Creative Communication Lab*)

MIT at COP30: How Research, Policy, and Collaboration is Leading to Actionable Outcomes

Inspired and informed by a [Global Climate Policy Project \(GCPP\) at Harvard and MIT](#) report spearheaded by MIT Professor/CS3 faculty affiliate Catherine Wolfram, leaders from 20 countries and the European Union eventually signed on to a new [Open Coalition for Compliance Carbon Markets](#) (*MIT Climate Policy Center*) (Coverage: *E&E News*)

Ocean warming puts planet's most abundant photosynthetic organism at risk

Steep decline in *Prochlorococcus* could significantly alter marine food web and carbon cycle, according to study co-authored by MIT CS3 Principal Research Scientist Stephanie Dutkiewicz (*CBIOMES*) (Coverage: *University of Washington*, *Washington Post*, *Associated Press*, *ABC News*)

Simpler models can outperform deep learning at climate prediction

New study co-authored by MIT CS3 researchers shows the natural variability in climate data can cause AI models to struggle at predicting local temperature and rainfall (*MIT News*) (Coverage: *ScienceBlog*, *Sustainable Brands*)

Study links rising temperatures and declining moods

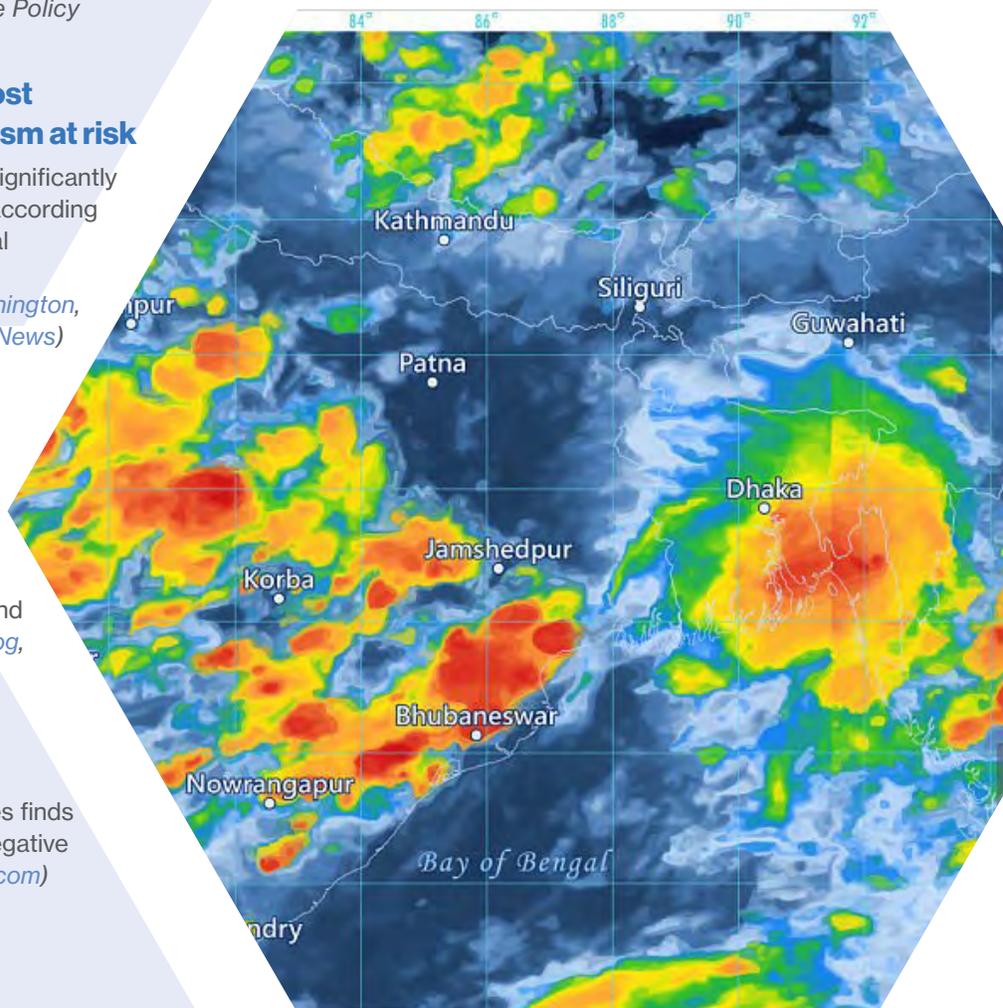
An analysis of social media in 157 countries finds hotter weather is associated with more negative sentiments (*MIT News*) (Coverage: *Earth.com*)

Hundred-year storm tides will occur every few decades in Bangladesh, scientists report

With projected global warming, the frequency of extreme storms will ramp up by the end of the century, finds new study co-authored by CS3-affiliated principal research scientist Sai Ravela (*MIT News*) (Coverage: *Independent*)

Study: The ozone hole is healing, thanks to global reduction of CFCs

Study co-authored by MIT Professor/CS3 faculty affiliate Susan Solomon shows with high statistical confidence that ozone recovery is going strong (*MIT News*) (Coverage: *The Weather Channel*, *Earth.com*, *Yahoo*)



PROJECTS WITH CS3 CONTRIBUTORS

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

CS3 Leader: Ronald G. Prinn
Funded by: NASA

Analysis of Climate Change Uncertainties and Risks

CS3 Leaders: Noelle Selin, C. Adam Schlosser, Sergey Paltsev
Funded by: CS3 Consortium

Application of MIT Modeling Tools to Sustainability Strategy and Policy Analysis

CS3 Leaders: Noelle Selin, Sergey Paltsev, C. Adam Schlosser
Funded by: CS3 Consortium

Assessment of Global and Regional Sustainability Challenges

CS3 Leaders: Noelle Selin, C. Adam Schlosser, Sergey Paltsev
Funded by: CS3 Consortium

Closing the carbon cycle loop: Quantifying land-to-sea carbon fluxes

CS3 Leader: Stephanie Dutkiewicz
Funded by: NASA

Competing uses for clean electricity

CS3 Leader: Jennifer Morris
Funded by: MIT Energy Initiative (MITEI)

Data Gathering, Monitoring and Reporting on Hydrofluorocarbons

CS3 Leader: Luke Western
Funded by: Quadrature Climate Foundation via Georgetown University

Development and applications of GEOS-Chem atmospheric chemistry in CESM and MUSICA

CS3 Leader: Arlene Fiore
Funded by: U.S. National Science Foundation (NSF)

Economy-Wide Impacts of Environmental Changes and Responses

CS3 Leader: Jennifer Morris
Funded by: Millennium Challenge Corporation

Economy-Wide Modeling of Energy/Environment Policy Scenarios

CS3 Leader: Mei Yuan
Funded by: U.S. EPA; RTI International

Energy at Scale

CS3 Leaders: Sergey Paltsev, C. Adam Schlosser
Funded by: Fidelity, J-Power, LATAM Airlines, Shell, TotalEnergies, Woodside Energy

Food security in Africa under a changing climate – Navigating the energy and agricultural transition to net zero

CS3 Leaders: Jennifer Morris, C. Adam Schlosser, Kenneth Strzepek
Funded by: MIT Abdul Latif Jameel Water & Food Systems Lab (J-WAFS)

Global outlook for turquoise hydrogen

CS3 Leaders: Sergey Paltsev
Funded by: Shell

Hydrogen: Assessing vulnerabilities in global terrestrial & atmospheric sinks & leakage risks to unintended climate consequences

CS3 Leaders: C. Adam Schlosser, Arlene Fiore, Ronald G. Prinn
Funded by: MITEI Future Energy Systems Center

Industry-University Research Partnerships Planning Grant - Center for Climate Risks Assessment

CS3 Leader: C. Adam Schlosser
Funded by: U.S. NSF

Inflation Reduction Act: Modeling Impact of Offshore Wind Development on Circulation & Biological Productivity of Nantucket Sound

CS3 Leader: Stephanie Dutkiewicz
Funded by: NOAA



Jameel Observatory Climate Resilience Early Warning System Network (Jameel Observatory-CREWSnet, an MIT Climate Grand Challenges Project)

CS3 Contributors: Sai Ravela, C. Adam Schlosser, Sergey Paltsev, Henry Chen, Xiang Gao, Angelo Gurgel, Jennifer Morris

Funded by: MIT; Jameel Observatory

Mercury Pollution and Human-Technical Environmental Interactions in Artisanal Mining

CS3 Leader: Noelle Selin

Funded by: U.S. NSF

MIT Climate Grand Challenges Flagship Project: Bringing computation to the climate challenge

CS3 Leaders: Raffaele Ferrari, Noelle Selin

Funded by: MIT; Schmidt Sciences, LLC

MIT Climate Grand Challenges Flagship Project: Preparing for a new world of weather and climate extremes

CS3 Leaders: Paul O’Gorman, Kerry Emanuel

Funded by: MIT; Schmidt Sciences, LLC

Model Development for Sustainability Science and Strategy

CS3 Leaders: Noelle Selin, Sergey Paltsev, C. Adam Schlosser

Funded by: CS3 Consortium

Nature-Based Solutions for Accelerating Climate Action

CS3 Leader: Sergey Paltsev

Funded by: MISTI - MIT Global Experiences

Negative Emissions Technologies & Hydrogen

CS3 Leaders: Sergey Paltsev, Howard Herzog

Funded by: ExxonMobil

Ocean acidification in Massachusetts and Cape Cod Bay

CS3 Leader: Ryan Woosley

Funded by: MIT Sea Grant

Opening the black box of oxygen deficient zone biogeochemistry through integrative tracers

CS3 Leaders: Andrew Babbin, Ryan Woosley

Funded by: U.S. NSF

Reducing deforestation in the Brazilian Amazon

CS3 Leader: Angelo Gurgel

Funded by: MIT Center for International Studies (MIT-Amazonia Seed Fund)

Role of Methane in Net-Zero Scenarios

CS3 Leader: Sergey Paltsev

Funded by: Shell

Rural Landscape Heritage & Carbon Sequestration

CS3 Leaders: Angelo Gurgel, Filippo Brandolini

Funded by: European Commission

Rwanda Climate Observatory Project

CS3 Leader: Ronald G. Prinn

Funded by: Rwanda Space Agency

SCOPE synthesis: vDarwin Initiative

CS3 Leader: Stephanie Dutkiewicz

Funded by: The Simons Foundation

Sectoral Interactions, Compounding Influences and Stressors, and Complex Systems: Understanding Tipping Points and Non-Linear Dynamics

CS3 Leaders: Jennifer Morris, C. Adam Schlosser, Ronald Prinn, Sergey Paltsev

Funded by: U.S. Department of Energy (DOE)

Sustainable energy pathways for Africa

CS3 Leaders: Jennifer Morris, Angelo Gurgel

Funded by: MITEI

Taiwan's Innovative Green Economy Roadmap (TIGER)

CS3 Leader: Sergey Paltsev

Funded by: MITEI

The Impact of Climate Change on Global Health

CS3 Leader: C. Adam Schlosser

Funded by: Novartis

The role of boreal wildfires in the global carbon budget: A process-based analysis using satellite-derived fire burn severity data

CS3 Leader: Ronald G. Prinn

Funded by: NASA

Trade-offs of the ammonia economy

CS3 Leader: Adam Schlosser

Funded by: MITEI

U.S. Regional Energy Model

CS3 Leaders: Sergey Paltsev, Mei Yuan, John Reilly

Funded by: CS3 Consortium

Uncertainty Characterization and Scenario Discovery in the Global Change Intersectoral Modeling System (GCIMS)

CS3 Leader: Jennifer Morris

Funded by: U.S. DOE

Unifying global seawater pH measurements of ocean acidification & climate

CS3 Leader: Ryan Woosley

Funded by: MIT Center for International Studies (MIT Spain INDITEX Circularity Seed Fund)

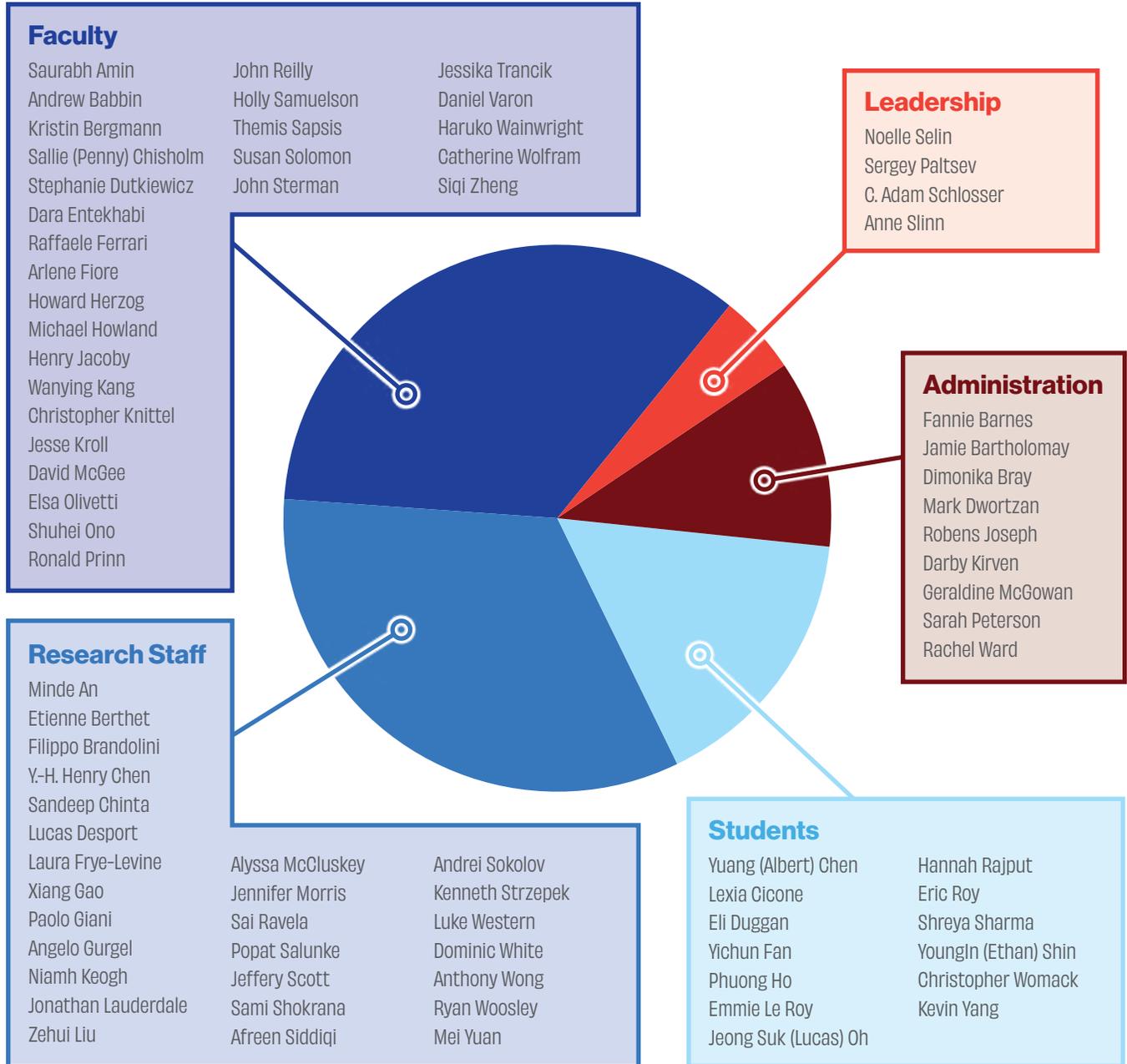
U.S. GEOTRACES: Inorganic Carbon Cycling in the South Pacific and Southern Oceans by Direct Measurement

CS3 Leader: Ryan Woosley

Funded by: U.S. NSF

CS3 PERSONNEL

Our interdisciplinary research community advances sustainability science and strategy from across MIT.



CS3 collaborated across 28 other MIT organizations in 2025:

- | | | | |
|---|--|---|-------------------------------------|
| Advanced Global Atmospheric Gases Experiment | MIT Center for Real Estate | MIT Dept. of Urban Studies & Planning | MIT Lorenz Center |
| MIT Abdul Latif Jameel Water & Food Systems Lab | MIT Chemical Engineering | MIT Energy Initiative | MIT Materials Science & Engineering |
| MIT Aeronautics & Astronautics | MIT Climate Project | MIT Engineering Systems Laboratory | MIT Mechanical & Ocean Engineering |
| MIT Aerospace Computational Engineering | MIT Dept. of Architecture | MIT Institute for Data, Systems & Society | MIT Nuclear Science & Engineering |
| MIT Anthropology | MIT Dept. of Biology | MIT Laboratory for Aviation & the Environment | MIT Sloan School of Management |
| MIT Center for Energy & Environmental Policy Research | MIT Dept. of Chemistry | MIT Livable Spaces Lab | MIT Sloan System Dynamics Group |
| | MIT Dept. of Civil & Environmental Engineering | | MIT Sustainable Urbanization Lab |
| | MIT Dept. of Earth, Atmospheric & Planetary Sciences | | MIT Terrascope |

MIT Center for Sustainability Science and Strategy

*Advancing integrated science. Informing decision-makers.
Addressing global change.*

Our work is funded by an evolving, international consortium of government, industry and foundation **sponsors and contributors**. Those listed below provided financial support in 2025.

Federal Sponsors



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U.S. Congressional Budget Office [CBO]



U.S. Environmental Protection Agency [EPA]



U.S. National Science Foundation [NSF]

Program Sponsors



WELLINGTON MANAGEMENT



Project Contributors

Airbus

Consortium of Taiwan-based companies (via MITEI)

European Commission

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Fidelity

J-Power

Jameel Observatory

LATAM Airlines

MISTI - MIT Global Experiences

MIT Center for Int'l Studies (MIT-Brazil Amazonia Seed Fund)

MIT Center for Int'l Studies (MIT Spain INDITEX Circularity Seed Fund)

MIT Climate Project

MIT Energy Initiative (MITEI)

MITEI Future Energy Systems Center Consortium

MIT Abdul Latif Jameel Water & Food Systems Lab (J-WAFS)

MIT Office of the Vice President for Research: Climate Grand Challenge

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Shell

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