Center for Sustainability Science and Strategy

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2024 ANNUAL REPORT

Massachusetts Institute of Technology

INTRODUCTION

OVERVIEW

On July 1, 2024, the MIT School of Science launched the MIT Center for Sustainability Science and Strategy (CS3).

The purpose of CS3 is to advance knowledge and computational capabilities in the field of sustainability science, and support decision-makers in government, industry and civil society to achieve sustainability goals.

Aligned with the Climate Project at MIT, 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.

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.

FROM THE DIRECTORS

As critical challenges such as climate, health, energy, and food security increasingly affect people's lives around the world, decision-makers need a better understanding of the Earth in its full complexity—and that includes people, technologies and institutions as well as environmental processes. Better knowledge of these systems and how they interact can lead to more effective strategies that avoid unintended consequences and ensure an improved quality of life for all.

To that end, the MIT School of Science launched the MIT Center for Sustainability Science and Strategy (CS3) on July 1, 2024. The new Center aims to advance knowledge and computational capabilities in the field of sustainability science, and support decision-makers in government, industry and civil society to achieve sustainability goals. Aligned with the Climate Project at MIT, CS3 researchers will 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.

Incorporating and succeeding both the Center for Global Change Science and Joint Program on the Science and Policy of Global Change while adding new capabilities, the Center aims to produce leading-edge research to help guide societal transitions toward a more sustainable future. Drawing on the long history of MIT's efforts to address global change and its integrated environmental and human dimensions, CS3 is well-positioned to lead burgeoning global efforts to advance the field of sustainability science, which seeks to understand nature-society systems in their full complexity. This understanding is designed to be relevant and actionable for decision-makers around the world in their efforts to develop viable pathways to improve quality of life for multiple stakeholders.

Advancing knowledge, computational capability and decision support

To produce more precise and comprehensive knowledge of sustainability challenges and guide decision-makers to formulate more effective strategies, the Center has set the following goals:

- Advance fundamental understanding of the complex interconnected physical and socio-economic systems that affect human well-being.
- Develop, establish and disseminate new computational tools toward better understanding Earth systems.
- Produce actionable science that supports equity and justice within and across generations.

The Center's work will advance fundamental understanding in sustainability science, leverage leading-edge computing and data, and promote engagement and impact. Our researchers will help lead scientists and strategists across the globe who share MIT's commitment to mobilizing knowledge to inform action toward a more sustainable world.

Building a better world at MIT

Building on existing MIT capabilities in sustainability science and strategy, the Center aims to:

- Focus research, education and outreach under a theme that reflects a comprehensive state of the field and international research directions, fostering a dynamic community of students, researchers and faculty;
- Raise the visibility of sustainability science at MIT, emphasizing links between science and action, in the context of existing Institute goals and other efforts on climate and

sustainability, and in a way that reflects the vital contributions of a range of natural and social science disciplines to understanding human-environment systems; and

- Re-emphasize MIT's longstanding expertise in integrated systems modeling while leveraging the Institute's concurrent leading-edge strengths in data and computing, establishing leadership that harnesses recent innovations, including those in machine learning and artificial intelligence, toward addressing the science challenges of global change and sustainability.

The Center builds on more than three decades of achievements by the Center for Global Change Science and the Joint Program on the Science and Policy of Global Change, both of which were directed or co-directed throughout their lifetimes by MIT Professor of Atmospheric Science Ronald Prinn.

This, the first CS3 annual report, highlights the Center's overarching goals and notable achievements in 2024.

We are grateful to our many funders for making this work possible. As we begin to pursue plans for 2025, we look forward to continuing to share our research findings with our Center Members through their exclusive communications channels, and with the public through our website.

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 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, remain largely unknown and poorly quantified. 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 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.

2024 RESEARCH HIGHLIGHTS

Search all CS3 publications »

PHOTO SOURCE: PNAS

Upgrading computational tools for sustainable development

PNAS special feature shows potential of recent modeling advances to improve sustainability decision-making

PHOTO SOURCE: CLIMEWORKS

Technologies to remove carbon dioxide from the air: A reality check

MIT study: Many climate-stabilization plans are based on questionable, unreliable assumptions about "direct air capture" technology.

PHOTO SOURCE: AGU

AGU Fall Meeting to explore next steps for science

MIT CS3 presentations highlight several sustainability challenges and solutions

PHOTO SOURCE: US DOE

Is there enough land on Earth to fight climate change and feed the world?

Study shows how smart policies could address competing land-use needs

PHOTO SOURCE: FLICKR/TOM SHOCKEY

Pathways to more resilient power systems

Study highlights factors that could reduce climate risk

PHOTO SOURCE: ISTOCK

Study: Fusion energy could play a major role in the global response to climate change

Experts in energy systems modeling and fusion technology explore the future role of fusion at various costs and carbon constraints

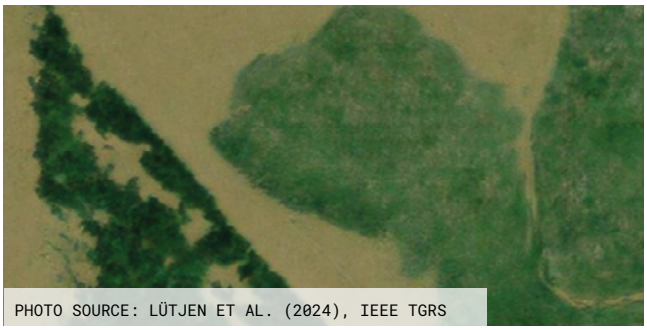

PHOTO SOURCE: LÜTJEN ET AL. (2024), IEEE TGRS

New AI tool generates realistic satellite images of future flooding

The method could help communities visualize and prepare for approaching storms

PHOTO SOURCE: ARTHUR BÖTTCHER

Atmospheric observations in China show rise in emissions of SF_6, a potent greenhouse gas

Global warming potential of sulfur hexafluoride (SF_6) is more than 24,000 times that of CO_2

PHOTO SOURCE: UNSPLASH / 張峻嘉

Preparing Taiwan for a decarbonized economy

The MIT Energy Initiative and a consortium of Taiwanese companies are exploring how Taiwan can secure its energy future as the world transitions away from fossil fuels

PHOTO SOURCE: ISTOCK

How climate change will impact outdoor activities in the US

Using the concept of "outdoor days," a study shows how global warming will affect people's ability to work or enjoy recreation outdoors

PHOTO SOURCE: ISTOCK / AUDIOUNDWERBUNG

New climate chemistry model finds "non-negligible" impacts of potential hydrogen fuel leakage

MIT study confirms climate impacts of hydrogen; recommends prioritizing leak prevention as infrastructure for handling this clean-burning fuel is built

PHOTO SOURCE: UNSPLASH/@ROZETSKY

China-based emissions of three potent, climate-warming greenhouse gases spiked in past decade

Two studies pinpoint their likely industrial sources and mitigation opportunities

MEDIA COVERAGE

Britain ditched coal

The UK showed that with the right policies, a smooth transition away from coal power is possible, says CS3 Principal Research Scientist Jennifer Morris (Washington Post)

How a gas company and environmentalists united on a first-of-its-kind geothermal project

CS3 Deputy Director Sergey Paltsev comments on first U.S. trial of this innovative technology to be provided to an entire neighborhood by a major utility (Christian Science Monitor)

Tesla news looks grim. But the bigger picture for EVs is a bright one.

EV lifecycle emissions clearly lower than those of conventional vehicles, says CS3 Deputy Director Sergey Paltsev (Christian Science Monitor)

Why the world's oceans are changing colour

Study confirms previous findings by CS3 Principal Research Scientist Stephanie Dutkiewicz (BBC)

Hydrogen-powered boat drops anchor in Boston, offering a glimpse of what's possible

CS3 Deputy Director Sergey Paltsev views boat as good proof of concept for hydrogen storage (Boston Globe)

Is climate change is an even faster-moving crisis than we thought?

CS3 Deputy Director C. Adam Schlosser offers his perspective on local, regional and global climate trends (Boston Globe)

China's emissions of two potent greenhouse gases rise 78% in decade

Figure represents 64-66% of global output of tetrafluoromethane and hexafluoroethane, MIT study finds (The Guardian)

News outlets that have covered Center activities include:

Associated Press
BBC
Boston Globe
Christian Science Monitor
Daily Mail
FactCheck.org
FastCompany
The Guardian
The Indian Express
LatinAmerican Post
Litoral Press
MIT Technology Review
MSN
NPR
Popular Science
Science Magazine
Washington Post

US, India, Russia, Japan are building out wind power much too slowly for climate change, report says

CS3 researcher John Reilly highlights key challenges (Associated Press)

Why aren't we driving hydrogen powered cars yet? There's a reason EVs won.

"The answer is very simple: economics," says CS3 Deputy Director Sergey Paltsev (Popular Science)

Eating the earth

The global food trade is a lifeline for billions, but it's fragile and hard on the planet. Smart policy will take a holistic approach, says CS3 Research Scientist Kenneth Strzepek (Science Magazine)

PODCAST: Do carbon offsets help with airplane emissions?

CS3 Principal Research Scientist Angelo Gurgel shares his expertise as a guest on the Anti-Dread Climate Podcast (NPR/KCRW)

Electric vehicles contribute fewer emissions than gasoline-powered cars over their lifetimes

EV's higher manufacturing emissions are more than offset by their lower operational emissions, says CS3 Deputy Director Sergey Paltsev (FactCheck.org)

Drone footage shows 1,500 new Teslas loading onto carrier ship — here's what it means for fans awaiting deliveries

CS3 Deputy Director Sergey Paltsev highlights lower climate impact of EVs over conventional vehicles (MSN, The Cool Down)

"Sustainable aviation fuel is going to be the main component to decarbonize this sector"

So said CS3 Deputy Director Sergey Paltsev in a presentation at the April 10-11 Wings of Change Americas conference in Santiago, Chile (Litoral Press, Spanish)

Innovative approaches to decarbonize aviation in Latin America

CS3 study aims to provide a comprehensive analysis of sustainable aviation fuel deployment scenarios up to 2050 (LatinAmerican Post)

EPA says it's 'looking into' study that found electric cars are MORE toxic than gas-powered vehicles

CS3 Deputy Director Sergey Paltsev critiques study suggesting EVs expel more particulate matter through their tires and brakes than modern gas-powered vehicles due to added weight from batteries (Daily Mail)

Highway to 'climate hell': What breaching the 1.5 degree Celsius warming threshold could mean

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

ONGOING 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

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

CS3 Leader: Arlene Fiore
Funded by: US National Science Foundation

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: US EPA; RTI International

Energy at Scale

CS3 Leaders: Sergey Paltsev, C. Adam Schlosser
Funded by: Bank of Canada; J-Power; Morgan Stanley; Fidelity; TotalEnergies; Shell

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 J-WAFS

Global biomass availability for Sustainable Aviation Fuel (SAF) production

CS3 Leader: Sergey Paltsev
Funded by: US FAA

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

Identifying Strategic Pathways Toward Sustainability: An integrated approach to address climate and human health

CS3 Leaders: Noelle Selin, C. Adam Schlosser
Funded by: Biogen

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

CS3 Leader: Stephanie Dutkiewicz
Funded by: NOAA

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

MIT Climate Grand Challenges Flagship Project: Reinventing climate change adaptation with CREWSnet

CS3 Leader: Elfatih Eltahir
Funded by: MIT; Jameel Observatory

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

Negative Emissions Technologies & Hydrogen

CS3 Leaders: Sergey Paltsev, Howard Herzog
Funded by: ExxonMobil

Options for decarbonizing aviation in Latin America in a sustainable way: an assessment of carbon policies, carbon prices and fuel consumption in aviation up to 2050

CS3 Leader: Sergey Paltsev
Funded by: Airbus; LATAM Airlines

Projecting and Quantifying Future Changes in Socio-economic Drivers of Air Pollution and Its Health-Related Impacts

CS3 Leaders: Noelle Selin, Susan Solomon, John Reilly
Funded by: US EPA

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

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: US DOE

Taiwan's Innovative Green Economy Roadmap (TIGER)

CS3 Leader: Sergey Paltsev
Funded by: MIT Energy Initiative

The Impact of Climate Change on Global Health

CS3 Leader: C. Adam Schlosser
Funded by: Novartis

The role and value of carbon dioxide removal pathways in delivering the Paris Agreement's 1.5-2°C objectives

CS3 Leader: Sergey Paltsev
Funded by: IFP Energies Nouvelles

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

U.S. Regional Energy Model

CS3 Leaders: Sergey Paltsev, Mei Yuan, John Reilly
Funded by: CS3 Consortium

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

CS3 Leader: Jennifer Morris
Funded by: US DOE

US GEOTRACES: Inorganic Carbon Cycling in the South Pacific and Southern Oceans by Direct Measurement

CS3 Leader: Ryan Woosley
Funded by: US National Science Foundation

Using the ECCO-Darwin data assimilative global-ocean biogeochemistry model to quantify the drivers and uncertainty of ocean carbon sources and sinks

CS3 Leaders: Stephanie Dutkiewicz
Funded by: NASA

MIT Center for Sustainability Science and Strategy

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- J-Power
- Jameel Observatory
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