THE NATIONAL JUDICIAL COLLEGE

Judicial Leaders in Climate Science

Woods Hole, MA | September 16-18, 2024

www.judges.org | info@judges.org

THE NATIONAL JUDICIAL COLLEGE

Est. 1963

Dear Friend:

On behalf of the Board of Trustees, faculty and staff, welcome to The National Judicial College.

Last year the college celebrated its 60th Anniversary of our founding by a committee headed by Supreme Court Justice Tom C. Clark. Since then, more than a quarter of a million judges from around the country and abroad have become NJC alumni by taking one course or many. Past participants and instructors include Stephen Breyer, Anthony Kennedy, Antonin Scalia and Sandra Day O'Connor.

Justice Kennedy has said, "Judicial independence cannot exist unless you have skilled, dedicated, professional judges."

Our goal is to help you carry out your sacred responsibilities confidently and expertly -- and sustainably, because judging is often a stressful, isolating experience. Know that as a member of the NJC family, you will never be alone. If you are like most participants, you'll build friendships and mentorships with faculty and classmates that last a lifetime. Please consider me to be a part of your support system. I also invite you to join In Chambers, our private group on Facebook for judges only.

Our college is a nonprofit organization and is, in many ways, a cooperative effort. Many NJC judges choose to give back by donating their time as an instructor (nearly all faculty are volunteers) or by making a financial contribution -- or both. Financial support is necessary to develop new courses, upgrade classrooms, and provide scholarships. You can donate online at any time at the NJC website, judges.org/donate.

Former federal appeals judge Andre Davis, an NJC alumnus and instructor, has said, "No judge aspires to be average." If this is your first NJC experience, rest assured that you are in good company this week and from this point forward in your career.

Welcome to the NJC family of exemplary judges.

Truly yours,

Hon. Benes Z. Aldana (Ret.) President & CEO

NJC Course Policies

THE NATIONAL JUDICIAL COLLEGE

Course and Program Attendance Policy Statement

The National Judicial College (NJC) has a responsibility to the funding agencies that sponsor your attendance. NJC must ensure that the tax dollars spent on continuing education are utilized for the maximum benefit.

It is therefore the policy and practice of the NJC to award Certificates of Completion to participants who attend all educational sessions. If a participant is unable to attend a class session(s) due to an emergency situation, the participant must contact the program attorney or judicial education manager for the course immediately.

If any portion of the course is missed, the participant may be required to submit a written project determined in consultation with the program attorney for the course. Failure to receive written permission or completion of the written project may result in the denial of the Certificate of Completion and notification to the funding agency.

Continuing Judicial or Legal Education Credits (CJE/CLE)

While NJC courses are nationally recognized by CLE Commissions or Boards, participants are asked to please follow their state's specific filing rules to have their CLE/CJE credits approved. The NJC provides each partic-ipant a uniform certificate of attendance form upon completion of applicable NJC courses detailing how many CLE/CJE hours may be possible. Participants are responsible for filing this form with their state's Continuing Legal Education Commissions or Boards where required. Your state may require you to pay a filing fee for CLE approval. If further clarification is needed, please contact the NJC Registrar's Office at (800) 255-8343 or (775) 784-6747 or registrar@judges.org.

The amount of CJE/CLE credit you are eligible to receive may be reduced if you are absent during any class ses-sions. If you need to leave during the class, please make the appropriate deduction from your CJE/CLE request.

Courtesy to Faculty and Fellow Participants

Please note scheduled breaks will be offered during the class. Therefore, out of respect for your colleagues and speakers we ask that you not engage in activities that may be distracting during the class. Before each session, we ask that all electronic devices be muted or turned off. If you must take a call during the presentation, please take the call outside of the room.

Harassment Policy Statement

The National Judicial College continues its long-standing commitment to eliminate and prevent bias and any form of harassment.

Harassment is misconduct which uses words or actions to convey disrespect for the human dignity and worth of a person, thereby creating a hostile, offensive work or study environment. Everyone at The National Judicial College must be assured a work and study environment free from any torment, verbal or physical harassment, and sexual overtures and innuendoes which debilitate morale and interfere with the mission of the College.

Harassment Policy Statement (Continued)

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Staff, faculty, and participants are accountable for their personal behavior and for supporting and encouraging the rights of all others to be free from improper or inappropriate behavior.

Instances of harassment affecting faculty or participants should be reported to the chief academic officer. Instances of harassment affecting staff members should be reported to the human resource specialist. in the absence of these individuals, the report should be made to the president of the College.

This policy applies, without exception, to all College staff, faculty members, and participants.

Title VI Program Rights Compliance Plan Policy Statement

The National Judicial College (NJC) and President Benes Z. Aldana are committed to, and give public notice of, NJC's policy to uphold and assure full compliance with the nondiscrimination requirements of Title VI of the Civil Rights Act of 1964 and related nondiscrimination authority. Title VI and related nondiscrimination authority stipulate that no person in the United States of America shall on the grounds of race, color, national origin, sex, age, disability, income level, or limited English proficiency be excluded from the participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal financial assistance.

Any person who desires more information regarding NJC's Title VI Program may contact NJC's Title VI Program Officer Joy Lyngar at the address noted below.

Any person who believes he or she, individually or as a member of any specific class of persons, has been subjected to discrimination on the basis of race, color, national origin, sex, age, disability, income level, or limited English proficiency has the right to file a formal complaint. Any such complaint must be in writing and submitted to NJC within 180 days following the date of the alleged occurrence.

Mail to: Title VI Program Officer
Joy Lyngar, J.D.
The National Judicial College Judicial College Building / MS 358 Reno, NV 89557
[redacted]

You may also file a Civil Rights complaint directly with the Office for Civil Rights within the U.S. Department of Justice as well as the Nevada Office of the Attorney General's Grants Unit.

Mail to:

U.S. Department of Justice, Civil Rights Division
950 Pennsylvania Avenue, N.W.
Washington, D.C. 20530
Hotline (English & Spanish): (888) 848-5306

Office of the Attorney General, Grants Unit
100 North Carson Street
Carson City, Nevada 89701-4717
Phone: (775) 684-1110

Class Schedule

THE NATIONAL JUDICIAL COLLEGE

JUDICIAL LEADERS IN CLIMATE SCIENCE

September 16-18, 2024

Woods Hole, MA

Monday, September 16, 2024 WHOI and Climate Science	Tuesday, September 17, 2024 Impacts
8:00-9:00 Breakfast on Site 9:00-9:20 **WELCOME AND OVERVIEW** [Divider 1] (Brandt, Hanle, Krasnoff) 9:20-10:00 **PUTTING LEARNING INTO PRACTICE—ROLE OF IMPARTIAL JURIST IN A CHANGING CLIMATE** [Divider 2] (Boulware-Eurie) **10:00-10:10 Break** 10:10-11:00 **LEADERSHIP** [Divider 3] (Stedham, Tait) 11:00-11:50 **SCIENCE AND LEGAL UPDATES** [Divider 4] (Doherty, Page)	**8:00-8:50 Breakfast on Site** 8:50-9:10 **CLIMATE SCIENCE AND PRACTICAL APPLICATION IN THE COURTROOM (Part 1)** [Divider 8] (Boulware-Eurie, Stedham, Tait) 9:10-10:00 **IMPACTS OVERVIEW** [Divider 9] (Schwalm) **10:00-10:10 Break** 10:10-11:00 **SEA-LEVEL RISE AND COMMUNITY RESPONSE** [Divider 10] (Hulst) 11:00-11:50 **HEALTH IMPACTS** [Divider 11] (Bell)
11:50-1:00 Lunch	**11:50-1:00 Lunch**
1:00-1:50 **KEYNOTE—GREETING AND WOODS HOLE WORK** [Divider 5] (de Menocal) **1:50 – 2:00 Break** 2:00-2:50 **JUDICIAL LEADERSHIP** [Divider 6] (Landau) **2:50-3:00 Break** 3:00-3:50 **CLIMATE SCIENCE IN THE FIELD** [Divider 7] (Das) **3:50-4:00 Break** 4:00-5:00 **TOUR of Marine Resources Center** 6:00-9:00 Cape Code Clambake Dinner at Marine Biological Lab	1:00-1:50 **ATTRIBUTION SCIENCE AND THE LAW** [Divider 12] (Doherty, Page) **1:50-2:00 Break** 2:00-3:00 **PREPARING FOR COLLABORATIVE CONVERSATIONS** [Divider 13] (Stedham, Tait) **3:00-3:10 Break** 3:10 – 3:50 **ENSURING FAIR AND IMPARTIAL DECISIONS IN CLIMATE LITIGATION** [Divider 14] (Boulware-Eurie) **3:50-4:00 Break** 4:00-5:00 **TOUR OF WHOI VILLAGE CAMPUS**

THE NATIONAL JUDICIAL COLLEGE

JUDICIAL LEADERS IN CLIMATE SCIENCE

September 16-18, 2024

Woods Hole, MA

Wednesday, September 18, 2024

Emerging Issues

8:00-8:50 Breakfast on site

8:50-9:10
CLIMATE SCIENCE AND PRACTICAL APPLICATION IN THE COURTROOM (Part 2)
[Divider 15] (Boulware-Eurie, Stedham, Tait)

9:10-10:00
HURRICANES AND MODELING
[Divider 16] (Emanuel)

10:00-10:10 Break

10:10-11:00
ENERGY TRANSITION
[Divider 17] (Morris)

11:00-11:50
ECONOMICS OF A CHANGING CLIMATE
[Divider 18] (Knittel)

11:50-1:00 Lunch

1:00-1:50
JUDGES HELPING JUDGES—MODELING CLIMATE EDUCATION IN HOME STATES—ACTION PLANS
[Divider 19] (Boulware-Eurie, Stedham, Tait)

1:50-2:10 Break and Complete Evaluations

2:10-2:40
WORKSHOP GEMS AND RESOURCES

2:40-2:50
GRADUATION

ROSTER

THE NATIONAL JUDICIAL COLLEGE

Judicial Leaders in Climate Science – Woods Hole 2024

September 16, 2024 - September 18, 2024
Woods Hole, MA

Faculty

Jesse E. Bell
Professor of Water, Climate, And Health
984388 Nebraska Medical Center
Omaha, NE 68198
[redacted]

Hon. Stacy Boulware-Eurie
Associate Justice
Court of Appeal
914 Capitol Mall
Sacramento, CA 95814
[redacted]

Sarah Das
Associate Scientist
Woods Hole Oceanographic Institute
Woods Hole, MA
[redacted]

Dr. Peter B. de Menocal
President & Director
Woods Hole Oceanographic Institution
[redacted]

Dr. John M. Doherty
Science and Policy Analyst
Washington, DC
[redacted]

Kerry Emanuel
Professor of Meteorology
Massachusetts Institute of Technology
Cambridge, MA 02139
[redacted]

Dr. Paul A. Hanle
Founder, Climate Judiciary Project 1730
M Street NW
Washington, DC 20036
[redacted]

Shannon Hulst
Guest Investigator
Woods Hole Oceanographic Institute
Woods Hole, MA

Christopher R. Knittel
Associate Dean for Climate and
Sustainability Massachusetts Institute of
Technology Cambridge, MA 02139
[redacted]

Ms. Helene Krasnoff
Senior Attorney/Director
Environmental Law Institute
1730 M Street NW
Washington, DC 20036
[redacted]

Hon. Clemens Landau
Presiding Judge, SLC Justice Court
John L. Baxter Courthouse
333 S. 200 E
Salt Lake City, UT 84111
[redacted]

Jennifer Morris
Principal Research Scientist
Massachusetts Institute of Technology
Cambridge, MA 02139
[redacted]

Judicial Leaders in Climate Science – Woods Hole 2024

September 16, 2024 - September 18, 2024
Woods Hole, MA

Faculty

Mr. Jarryd Page
Fellow
Environmental Law Institute
1730 M Street NW
Washington, DC 20036
[redacted]

Christopher Schwalm
Risk Program Director and Senior Scientist
Woodwell Climate Research Center
[redacted]

Dr. Yvonne Stedham
Professor, Retired
University of Nevada-Reno
[redacted]

Prof. Kelly Tait
KT Consulting
[redacted]

Participants

Hon. Daniel Brock
Judge
Circuit Court
301 W. Arch St.
Searcy, AR 72143
[redacted]

Hon. Daniel A. Bryant
Judge
District Court
1000 New York Ave.
Alamogordo, NM 88310-6937
[redacted]

Hon. Michael A. Flores
District Judge
District Court
124 W. Michigan Ave.
Lansing, MI 48906
[redacted]

Hon. Jeremy Ford
Presiding Judge
Superior Court
Clifton, AZ 85533
[redacted]

Hon. Helene Kazanjian
Justice Of The Superior Court
Superior Court
Boston, MA 02108
[redacted]

Judicial Leaders in Climate Science – Woods Hole 2024

September 16, 2024 — September 18, 2024
Woods Hole, MA

Participants

Hon. Stephen H. Kehoe
Judge
Appellate Court Of Maryland
Annapolis, MD 21401
[redacted]

Hon. Clare Keithley
Judge
Superior Court
1775 Concord Ave.
Chico, CA 95928
[redacted]

Hon. Brian Mccabe
Judge
Superior Court
Merced, CA 95340
[redacted]

Hon. Kristen D. Mickey
County Judge
County Court
1725 10th St.
Gering, NE 69341
[redacted]

Hon. Thainie Reyes
Superior Judge
Superior Court
P.O. Box 267
Carolina, PR 00986
[redacted]

Participants

Hon. Bryan E. Round
Judge
Circuit Court
415 E. 12th St.
Kansas City, MO 64106
[redacted]

Hon. Jennifer L. Valencia
Judge
District Court
Farmington, UT 84025
[redacted]

Hon. Thomas G. Walsh
Superior Court Trial Judge
Superior Court
32 Cherry St.
Burlington, VT 05401
[redacted]

Hon. Eric J. Wildman
Judge
Snake River Basin Adjudication
P.O. Box 2707
Twin Falls, ID 83303-2707
[redacted]

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

JESSE E. BELL

Dr. Jesse E. Bell is the Claire M. Hubbard Professor of Water, Climate, and Health in the Department of Environmental, Agricultural, and Occupational Health at the University of Nebraska Medical Center and the School of Natural Resources within the Institute of Agriculture and Natural Resources at the University of Nebraska-Lincoln. He is the director of the Water, Climate and Health Program at UNMC and the director of Water, Climate and Health at the University of Nebraska's Daugherty Water for Food Global Institute.

Before coming to UNMC, Dr. Bell developed and served in an interagency position between the National Oceanic and Atmospheric Administration and the Centers for Disease Control and Prevention. During his time in this role, his work built the foundation for novel and innovative approaches to use climate data to assist with health research. He was able to unite each organization's efforts toward better understanding the impact of climate change on health.

Dr. Bell has also authored more than 70 scientific articles and technical reports, including serving as a lead author for the U.S. Global Change Research Program report "The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment" that was released by the White House in 2016. He is an author of Human Health chapter for the congressionally mandated Fifth National Climate Assessment. Dr. Bell is a native Nebraskan and received his Ph.D. from the University of Oklahoma. Dr. Bell joined the faculty of The National Judicial College in 2024.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

JUSTICE STACY BOULWARE EURIE

Justice Stacy Boulware Eurie was unanimously confirmed as an Associate Justice of the Court of Appeal, Third Appellate District, on August 4, 2022. Previously, she served as a trial judge on the Sacramento Superior Court for 15 years, presiding over civil, criminal, coordinated California Environmental Quality Act (CEQA) litigation, and appellate matters. She also served as Presiding Judge of the Juvenile Court for eight years.

Prior to her tenure on the trial court, Justice Boulware Eurie was Senior Assistant Attorney General, the statewide head of the Government Law Section at the Attorney General's Office, where she was counsel to California's constitutional officers and the California judicial branch.

Justice Boulware Eurie has been an active member of the California legal community for more than 25 years. She served on the California State Bar's Litigation Section's Executive Committee, was a voting member of the California Judicial Council for six years, was a board member of the Women Lawyers of Sacramento for more than a decade and is a former President of the Sacramento County Bar Association. Justice Boulware Eurie was an executive member of the Commission on the Future of California's Court System, the Judicial Council of California, and the California Child Welfare Council. Justice Boulware Eurie has served as faculty for more than 10 years for the California Judicial Council's Center for Judicial Education and Research on a wide range of substantive and administrative topics, including environment and water law.

Justice Boulware Eurie has been the recipient of numerous awards, including the California Judges Association Juvenile Court Judge of the Year in 2014, the Sacramento County Bar Association Judge of the Year for 2020, the Chief Probation Officers of California Judge of the Year for 2015, and the Wiley Manuel African American Bar Association of Sacramento Judge of the Year in 2010 and 2022.

Justice Boulware Eurie received a Bachelor of Arts degree from the University of California, Los Angeles, and a Juris Doctor degree from the University of California, Davis. Justice Boulware Eurie joined the faculty of The National Judicial College in 2024.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

SARAH DAS, PH.D

Dr. Sarah Das is a tenured Associate Scientist in the Department of Geology and Geophysics at the Woods Hole Oceanographic Institution. Her research interests include the reconstruction of past climate from ice-cores; understanding and measuring polar ice sheet mass balance and ice dynamics; exploring the interaction between the coupled cryosphere-atmosphere-ocean systems; and investigating biogeochemical processes in polar environments. Dr. Das has participated in over 20 Antarctic and Greenlandic research expeditions, primarily as lead PI and science team leader. She recently completed two terms as a member of the Polar Research Board of the National Academies, served on the National Research Council's Committee for Future Science Opportunities in Antarctica and the Southern Ocean, and was an invited expert in the AAAS 'What We Know' Climate Change project. Dr. Das is active in training the "next generation" of polar and climate scientists, regularly teaching and mentoring post-docs and Ph.D students as a faculty member of the MIT-WHOI Joint Program in Oceanography, as well as working closely with K-12 teachers and students. She is also committed to sharing the importance and excitement of scientific discovery with policy makers and the public, and has been a featured scientist at the Woods Hole Film Festival, at Climate Science Day on Capitol Hill, on NPR, NOVA, at the Smithsonian National Museum of Natural History Ocean Portal, the MIT Museum, and in the popular science book "Science On Ice," among many other outlets. She received her Ph.D. in Geosciences from Penn State University and her AB in Geological Sciences from Cornell University. Dr. Das joined the faculty of The National Judicial College in 2024.

PETER B. DE MENOCAL, Ph.D

Dr. Peter B. de Menocal is the eleventh president and director of Woods Hole Oceanographic Institution, effective Oct. 1, 2020. A marine geologist and paleoclimatologist, de Menocal's research uses deep-sea ocean sediments as archives of how and why Earth's ocean and climate have changed in the past in order to predict how they may change in the future. Prior to assuming leadership of WHOI, de Menocal was the Thomas Alva Edison/Con Edison Professor in the Department of Earth and Environmental Sciences at Columbia University's Lamont-Doherty Earth Observatory. In 2015, he became the founding director of Columbia's Center for Climate & Life, a research accelerator of 120 scientists and other experts dedicated to understanding how climate affects life's essentials-the security of food, water, and shelter-and to exploring sustainable energy solutions in partnership with industry, finance, and government. From 2016 to 2019, de Menocal served as Columbia's Dean of Science for the Faculty of Arts & Sciences, overseeing 240 faculty across the university's nine scientific departments. During his tenure as dean, de Menocal developed and carried out a strategic plan that helped double philanthropic support for the sciences at Columbia, significantly increase success in winning large center and institute awards, and increase faculty hiring rates for women and under-represented minorities in the natural sciences. De Menocal has published more than 150 scientific papers over his decades-long career in oceanography. He has received numerous awards and distinctions, including Fellow of the American Geophysical Union and the American Association for the Advancement of Science, AGU Emiliani lecturer, a Lenfest Columbia Distinguished Faculty award, and a Distinguished Brooksian award. He earned a doctorate in geology from Columbia University and a master's degree in oceanography from the University of Rhode Island, and was awarded an honorary doctorate from St. Lawrence University.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

DR. JOHN M. DOHERTY

Dr. John Doherty is a Science and Policy Analyst at the Environmental Law Institute, an internationally recognized non-partisan research, publishing, and education center working to strengthen environmental protection by improving law and governance worldwide. In this role, John supports the efforts of ELI's Climate Judiciary Project to provide neutral, objective information to the judiciary about the science of climate change as it is understood by the expert scientific community and relevant to current and future litigation. Prior to joining ELI, John earned a PhD in Earth Sciences from the University of Hong Kong, an MS in Environmental Science from American University, and a BA in Political Science from American University. For his doctoral research, John studied the behavior of ocean circulation in the North Atlantic and its relevance to the global climate system on different geological timescales. Dr. John M. Doherty joined the faculty of The National Judicial College in 2023.

PROFESSOR KERRY EMANUEL

Kerry Emanuel is an American professor of meteorology at the Massachusetts Institute of Technology (MIT) in Cambridge. In particular he has specialized in atmospheric convection and the mechanisms acting to intensify hurricanes. He hypothesized in 1994 about a super-powerful type of hurricane which could be formed if average sea surface temperature increased another 15°C more than it's ever been.

In a March 2008 paper published in the Bulletin of the American Meteorological Society, he put forward the conclusion that global warming is likely to increase the intensity but decrease the frequency of hurricane and cyclone activity. Along with Daniel Rothman, Emanuel co-founded the MIT Lorenz Center in 2011, named for Edward N. Lorenz. Emanuel received both his bachelor's and doctorate from MIT: Ph.D., Meteorology, Massachusetts Institute of Technology, 1978, S. B., Earth and Planetary Sciences, MIT, 1976.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

PAUL HANLE, Ph.D.

Dr. Paul A. Hanle is a Visiting Scholar and the Founder of the Climate Judiciary Project of the Environmental Law Institute in Washington, DC. He retired in 2018 from his role as President and CEO of Climate Central, which he had filled since 2011. Dr. Hanle has devoted his 50-year career to public understanding of science through scholarship, museums, public education, and environmental conservation. From 1987 to 2011, he served serially as chief executive officer of the Maryland Science Center in Baltimore, president of the Academy of Natural Sciences of Philadelphia, and first president of the Biotechnology Institute in Washington, DC. From 1974 to 1987, Dr. Hanle worked at the Smithsonian's National Air and Space Museum as a curator of science and technology and rose to the positions of space department chair and associate director for research. From 1987 to 2000, at the Maryland Science Center and the Philadelphia Academy, Dr. Hanle launched new educational initiatives including major national exhibits on women's health, mathematics, a volunteer-based environmental education program in aquatic ecology, and two IMAX films on the science of the human body and meteorology.

Among his volunteer services, he advised the Obama Administration on the attribution of extreme weather events to climate change, served on the planning group for its "Educate to Innovate" initiative, and served on the Steering Committee of the Business and Industry STEM Education Coalition. Earlier he served on boards of Maryland's State Systemic Initiative and Morgan State University's Minorities in Science Program. He also served on Pennsylvania's 21st Century Environment Commission.

Dr. Hanle earned a Ph.D. in the History of Science and Medicine and an M.S. in Physics from Yale University. He is a former Member of The Institute for Advanced Study in Princeton and in 2018 was a Director's Visitor at the Institute. Dr. Hanle served for eight years on the Board of Trustees of the Bermuda Institute of Ocean Sciences.

SHANNON HULST

Shannon Hulst is Deputy Director of Cape Cod Cooperative Extension and Floodplain for Barnstable County, MA through Cape Cod Cooperative Extension and Woods Hole Sea Grant. She is a Certified Floodplain Manager® with a Master's degree in Marine Affairs from the University of Rhode Island, and serves on the board of the Massachusetts Association for Floodplain Management. With a strong background in climate change issues related to flooding, Shannon has worked in floodplain management and sea level rise adaptation since 2012. She assists communities, businesses, and residents with the National Flood Insurance Program's Community Rating System (CRS) and flood-related technical assistance with an overall goal of improving flood resiliency. To this end, Shannon works with flood insurance, development regulations, public outreach, and planning.

The regional CRS program Shannon manages for Barnstable County has been recognized nationally, earning the Association of State Floodplain Managers' 2017 James Lee Witt Local Award for Excellence in Floodplain Management and serving as the inspiration for a federal House bill from Congressman Keating in the pending National Flood Insurance Program reauthorization. Shannon is also the recipient of the 2019 CRS Award for Excellence from the Federal Emergency Management Agency.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

PROFESSOR CHRISTOPHER R. KNITTEL

Christopher Knittel is the Associate Dean for Climate and Sustainability*, the George P. Shultz Professor* and a Professor of Applied Economics at the MIT Sloan School of Management. Prior to MIT Sloan, Knittel taught at the University of California, Davis, and at Boston University. His research focuses on industrial organization, environmental economics, and applied econometrics.

Knittel is an associate editor of *The American Economic Journal— Economic Policy*, *The Journal of Industrial Economics*, and the *Journal of Energy Markets*. His research has appeared in *The American Economic Review, The Review of Economics and Statistics, The Journal of Industrial Economics, The Energy Journal,* and other academic journals. He also is a Research Associate at the National Bureau of Economic Research in the Productivity, Industrial Organization, and Energy and Environmental Economics groups.

Knittel holds a BA in economics and political science from California State University, Stanislaus; an MA in economics from the University of California, Davis; and a PhD in economics from the University of California, Berkeley.

MS. HELENE KRASNOFF

Helene Krasnoff is the Director of ELI's Climate Judiciary Project (CJP) and is responsible for the leadership, strategy, and management of the project. Prior to joining ELI in 2024, Helene spent more than 20 years at Planned Parenthood Federation of America, working on and leading a team of attorneys who support the Federation and its forty-nine affiliates with respect to public policy matters that implicate the Federation's mission.

Helene has litigated and supervised dozens of high-profile cases in all levels of both the federal and state courts on matters that involve complex issues of constitutional, statutory, procedural, and administrative law. She also has extensive experience working with lawmakers on Capitol Hill as well as Executive Branch and state government officials. At the core of her work was presenting scientific facts to decision-makers as well as lay audiences, and Helene is excited to bring these as well as her leadership skills to CJP in order to provide judges with the scientific information needed to adjudicate the growing body of climate-related litigation. Helene was previously an associate with the law firm of Arnold & Porter, and she is a graduate of Duke University and the University of Michigan Law School.

JUDGE CLEMENS LANDAU

Judge Clemens Landau was appointed to the Salt Lake City Justice Court in 2018 by Mayor Jackie Biskupski. Prior to his appointment, he worked as a civil litigator at Parr, Brown, Gee & Loveless before moving to the appellate firm of Zimmerman Booher. Before becoming an attorney, Judge Landau worked as a paramedic in Boston, MA, and managed a woodworking and musical instrument-making company in Metten, Germany. Judge Landau currently serves as the presiding judge of the Salt Lake City Justice Court. He is a member of Utah's Access to Justice Commission, the AOC's Standing Committee on Technology, the AOCs Community Relations Subcommittee, the Implicit Bias Subcommittee of the MUJI Civil Committee, and Salt Lake County's working group on improving the criminal justice system's response to individuals suffering from mental illness. He also serves on several boards, including the Salt Lake County Bar Association, the Utah Center for Legal Inclusion (a nonprofit organization dedicated to advancing the goals of equity and inclusion in Utah's legal profession), and the Utah Bar's Leadership Academy. In addition, he teaches a Law and Literature class at the Utah State Prison that is part of the University of Utah's Prison Education Project (UPEP), and has team-taught courses on legal design, access to justice, and racial equity/law at the University of Utah Law School, Stanford Law School, and the Harvard School of Design. Judge Landau has also presented on a variety of topics for the National Center for State Courts, the Institute for the Advancement of the American Legal System, and the Women Lawyers of Utah.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

DR. JENNIFER MORRIS

Dr. Jennifer Morris is a Principal Research Scientist at the MIT Joint Program on the Science and Policy of Global Change and the MIT Energy Initiative. Much of her research focuses on energy transitions and economic development pathways as well as uncertainty and decision-making. Jennifer is a key contributor to the development of the MIT Integrated Global System Modeling (IGSM) framework, focusing on the human system component, the Economic Projection and Policy Analysis (EPPA) model. With this modeling framework, she develops integrated economic and climate scenarios, generates large ensembles, analyzes policy impacts, explores technology and mitigation pathways and transitions, and examines multi-sector dynamics. Her uncertainty-related work involves quantifying key uncertainties and applying different methodological approaches to models in order to formally represent such uncertainties and explore how they impact near-term decisions. A key focus is evaluating risks to different investment options in energy and water and identifying those that are robust to potential risks. Jennifer holds a PhD in Engineering Systems and a M.S. in Technology and Policy from MIT.

JARRYD PAGE

Jarryd is a Staff Attorney at ELI, having previously served as a Law Clerk and Public Interest Law Fellow. Jarryd works on a variety of projects at ELI, including public lands management, coastal protection and restoration, communicating the science of climate impacts, and the fundamental rights aspects of climate change litigation. He has experience in both domestic and international environmental law and policy issues. Prior to joining ELI, Jarryd held law clerk and internship positions at the U.S. Department of Justice's Environment and Natural Resources Division, the Chesapeake Legal Alliance, and the Center for Progressive Reform. He received his J.D. with Honors from The George Washington University Law School, where he earned the Charles and Kathryn Miller Environmental Law Award for excellence in the field of environmental law. He received his B.S. in Environmental Law & Policy from the University of Maryland and holds both an M.A. and B.A. in Art History.

CHRISTOPHER SCHWALM, Ph.D.

Dr. Christopher R. Schwalm is an internationally-recognized global change ecologist and Earth system modeler. His research focuses on climate extremes, with emphasis on drought impacts, as well as understanding how carbon, water, and plant nutrients move through land ecosystems. Dr. Schwalm leads Woodwell Climate's Risk Program, which assesses physical climate risk to human and natural systems. He also leads Woodwell Climate Research Center's work with Wellington Management, connecting climate risk to capital markets, and directs Woodwell's initiative with McKinsey & Company, which led to the January 2020 report Climate risk and response: Physical hazards and socioeconomic impacts. His research has been published in leading scientific journals and has been featured by the New York Times, CBS News, and NPR.

Judicial Leaders in Climate Science – Woods Hole 2024
September 16 – September 18, 2024
Faculty Biographies

PROFESSOR YVONNE STEDHAM

Professor Yvonne Stedham is professor emerita in the Management Department in the College of Business Administration at the University of Nevada, Reno (UNR) and is a foundation professor. Previously, she served as a professor of management, and chair of the Management Department at the College of Business at the University of Nevada, Reno (UNR). She joined the UNR faculty in 1988 and from 1999-2002 served as chair for the Managerial Sciences Department. Professor Stedham received a Ph.D. in business and M.B.A. from the University of Kansas, and undergraduate degrees in economics and business from the University of Bonn, Germany. She teaches undergraduate and graduate courses in international management and mindful leadership. She is also a faculty member of the social psychology Ph.D. program. Her research covers a broad spectrum of management issues with a special focus on international and gender aspects. Most of her publications address cultural differences in business ethics. She has investigated ethical judgment and gender-based differences in compensation across a variety of countries, including Japan, the U.S., and Australia, and issues related to sexual harassment and business ethics in Germany, Italy, Brazil, Russia, and the U.S. Her most recent research concerns the relationship cultural differences, trust, and business ethics. She has served on the board of directors of numerous non-profit organizations in Northern Nevada and provides consulting and training services to many companies nationally and internationally. Her research has been published in many publications, including the "Journal of Management," "Women in Management Review," "Journal of Management Studies," "Journal of Business Ethics," "Business Ethics: A European Review," "Journal of European Industrial Training," and "Journal of Knowledge Management Practice." Professor Stedham has completed the training required for the teaching certificate for the Mindfulness Based Stress Reduction (MBSR) Program at the Center for Mindfulness at the University of Massachusetts. She has taught MBSR based Mindfulness Programs at a variety of companies and organizations, including Microsoft, Nevada Department of Transportation, Custom Ink, National Judicial College, Nevada Air National Guard, Healing Healthcare Systems, and UNR. Professor Stedham has served as faculty for The National Judicial College since 2004.

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Faculty Biographies

PROFESSOR KELLY E. TAIT

Kelly Tait has taught at the University of Nevada, Reno in the School of Social Research and Justice Studies for over twenty-four years, including classes on intercultural communication, business and professional speaking, and small group communication. She also taught communication for the University of Maryland in Heidelberg, Germany. Professor Tait is a communication consultant who has specialized in justice system education for over twenty-two years. Her areas of expertise include courtroom communication skills, procedural fairness, communicating with the self-represented, listening skills, group dynamics and leadership, working with challenging people, diversity and access issues, and faculty development. She has taught justice system professionals across the United States and Canada as well as in Mexico, Ukraine, Macedonia, Russia, Philippines, and the Caribbean. In addition to teaching for NJC, she has taught for organizations including the Canadian National Judicial Institute, Association of Women Judges, Judicial Division of the American Bar Association, National Tribal Judicial Center, National Association for Court Management, National Association of Administrative Law Judges, and state judicial systems across the country. She is a past president of the National Association of State Judicial Educators (NASJE) and is a long-term member of the NASJE Communications Committee and Diversity, Fairness, and Access Committee. One of her recent publications is "Procedural Fairness: A Treat for the Brain" in Case In Point (http://www.judges.org/news/case-in-point/), and she is a co-author of "Handling Cases Involving Self-Represented Litigants: A National Bench Guide for Judges." She has been on faculty of the National Judicial College since 2002.

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Woods Hole, MA

Staff Biographies

HON. BENES Z. ALDANA (RET.)

With over two decades of decorated service in the U.S. Coast Guard, Benes Aldana retired with the rank of Captain (O-6) in 2017 and began his role as the President and CEO of The National Judicial College (NJC), America's leading judicial education institution. He made history as the U.S. military's first Asian Pacific American chief trial judge, following roles as an appellate judge, trial judge, and prosecutor. His leadership extended as the chief legal officer of the Eighth Coast Guard District in New Orleans, overseeing legal support for extensive operational units across 26 states. Benes's global legal impact was significant during his tenure as chief counsel of the Legal Engagements Division at the U.S. Africa Command in Stuttgart, Germany, where he collaborated with African militaries and international organizations to advance the rule of law and human rights. In the aftermath of 9/11, he was on the front lines in Guantanamo Bay, contributing to critical anti-terrorism investigations. He further distinguished himself as a trial attorney for the U.S. Department of Justice's Environmental Enforcement Section. His service in these pivotal roles earned him several military honors, including the Department of Defense Meritorious Service Medal.

His military justice expertise secured his appointment by the Secretary of Defense to an eight-year term on the Military Justice Review Panel, a body established by Congress to ensure the military justice system's integrity.

In the legal community, Benes is recognized for his advocacy for diversity and inclusion, evident through leadership roles in various legal associations and within the ABA. Benes chairs the ABA Commission on Sexual Orientation and Gender Identity and has served as president of the National Asian Pacific American Bar Association Judicial Council and the Asian Bar Association of Washington. He also held positions on the ABA Commission on Diversity and Inclusion 360, the ABA Commission on Racial and Ethnic Diversity in the Profession, the ABA President's Advisory Council, and had a groundbreaking term as the first Diversity Director of the ABA Young Lawyers Division. Benes's contributions to the ABA further include roles as chair of the ABA Solo, Small Firm and General Practice Division, assembly speaker for the ABA Young Lawyers Division, and memberships in the ABA House of Delegates, ABA Standing Committee on Judicial Independence, ABA Rule of Law Initiative Board, and ABA Section of Litigation Judicial Intern Opportunity Program. He co-founded the Filipino Lawyers of Washington, the National Filipino American Lawyers Association, and the Filipino American Lawyers Association of Washington, DC. His work has garnered respect and awards such as the Daniel Inouye Trailblazer Award, NAPABA's "Best Lawyer Under 40," and the ABA Outstanding Young Military Service Lawyer Award. He recently was honored by the ABA as a 2024 recipient of the Spirit of Excellence Award.
A Fellow of the American Bar Foundation, he served as co-chair of the Washington State Fellows and received the Outstanding State Chair Award in 2011.
Under his visionary and transformative leadership, the NJC has experienced unprecedented growth and a record-breaking enrollment surge in 2020, thanks to innovative online programming addressing contemporary challenges like the COVID-19 pandemic and social justice issues. His initiatives include the first-of-its-kind Judicial Academy for aspiring judges, with 28 graduates having ascended to the bench — more than half of them women and people of color. He also introduced courses addressing contemporary issues such as artificial intelligence, climate science, and anti-racism, underscoring his dedication to evolving judicial education to meet modern challenges.

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Staff Biographies

JOY LYNGAR, J.D., CHIEF ACADEMIC OFFICER

Joy D. Lyngar joined The National Judicial College in 2007 and was named Chief Academic Officer in 2008. As such, she is ultimately responsible for the quality and relevance of all education offered by the oldest and largest school for judges in the U.S. For over fifteen years, she has been an executive leader working to improve the justice system by educating judges, providing technical assistance, facilitating cross-jurisdiction sharing of best practices, encouraging judicial leadership, and by setting the bar for the highest standards of judicial ethics and competence. Over the past decade, Ms. Lyngar has led NJC to record academic achievement; NJC now educates more than 10,000 judges and court service professionals each year through in-person and on-line courses. Before joining the NJC, Ms. Lyngar spent 10 years at the National Council of Juvenile and Family Court Judges, most recently as director of the Juvenile and Family Law Department. Ms. Lyngar is a regular faculty member for NJC, Immediate Past-President of the National Association of State Judicial Educators. Prior to her work in national judicial education, Ms. Lyngar practiced law in Canada working in a general practice firm that handled criminal defense, civil litigation, and family law. Ms. Lyngar received a bachelor's degree and Juris Doctor from the University of Saskatchewan.

ALF W. BRANDT, J.D.

Alf W. Brandt develops courses for judges on water, the environment, and judicial independence, as Associate Director of Justice Solutions and Innovation at The National Judicial College (NJC). Brandt joined the college in 2023, after more than 30 years working on water law and policy in all three branches of government, and at all three levels (federal, state, and local).

Most recently, Brandt served as General Counsel to California State Assembly Speaker Anthony Rendon, who he served for more than a decade. Drawing on his extensive experience in California water policy, Brandt developed, analyzed and advocated for California water legislation. Working in the Assembly for almost 19 years, he played critical roles in the development and/or passage of the 2019 Safe Drinking Water Fund (SB 200), 2018 Water Bond, the 2014 Water Bond, 2014 Sustainable Groundwater Management Act, the 2009 Delta/Water Legislation, and the 2007 flood protection package. As Counsel to the Speaker, he also addressed a wide range of Assembly organizational issues, including protesters and meetings during COVID. His greatest pride was the Legislature's response to the "Me Too" movement, when he developed and negotiated its policy on creating a workplace "culture of respect, civility and diversity." Brandt received his JD from UC Berkeley and his BA from UCLA. He joined the faculty of the National Judicial College in 2011.

WELCOME AND OVERVIEW

DIVIDER 1

Mr. Alf Brandt
Dr. Paul Hanle
Ms. Helene Krasnoff

PUTTING LEARNING INTO PRACTICE - ROLE OF IMPARTIAL JURIST IN A CHANGING CLIMATE

DIVIDER 2

Hon. Stacy Boulware-Eurie

LEADERSHIP

DIVIDER 3

Yvonne Stedham, Ph.D.
Professor Kelly Tait

RECOMMENDED READING
YVONNE STEDHAM , PHD

Online

1. Posner, Barry *I make a difference, but I can't do it alone* TEDx https://www.youtube.com/watch?v=3cpLFFZsbWY
2. Kouzes, Jim *Characteristics of Admired Leaders: A Conversation with Jim Kouzes*, May 2023
3. https://www.leadershipchallenge.com/lead-on/characteristics-of-admired-leaders-a-conversation-with-jim-kouzes.aspx

Books

1. Adams, Marilee *Change your questions, change your life.*
2. Bass, B. M., & Riggio, R. E. *Transformational leadership*
3. Brewer, Judson *The Craving Mind*
4. Goleman, Daniel and Richard Davidson *Altered Traits*
5. Goleman, Daniel *Emotional Intelligence*
6. Goleman, Daniel *Focus – The hidden driver of excellence*
7. Grant, Adam *Think Again*
8. Kabat-Zinn, Jon *Full Catastrophe Living*
9. Kouzes, J. M., & Posner, B. Z. *Learning leadership: The five fundamentals of becoming an exemplary leader*
10. Kouzes, J. M., & Posner, B. Z. *The leadership challenge* (Vol. 3)
11. Nohria, N., & Khurana, R. (Eds.). (2010). *Handbook of leadership theory and practice*. Harvard Business Press.
12. Oliver, Mary *Felicity*
13. Reb, Jochen and Paul Atkins *Mindfulness in Organizations*
14. Sofer, O.J. *Say what you mean*

Leadership

Yvonne Stedham, Ph.D.
Professor Kelly Tait

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
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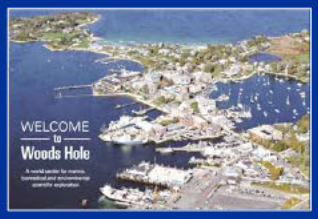
THE NATIONAL JUDICIAL COLLEGE



Instructions for living a life

Pay attention.
Be astonished.
Talk about it.

Mary Oliver
(1935-2019)

JLCS July 2024 Webinar Key Insights

Who was able to attend?

Reflection Questions

1. Considering the three presentations at the Webinar in July [Judge Scheele from Indiana, Justice Duncan from Oregon, and Judge Toro from PR] what **one "thing" intrigued you** about each of the three presenters and about what they did?
2. What was a key takeaway for you?

Reflection Questions - Possible Responses

1. **One "thing" that intrigued you about each of the three presenters and about what they did?**
   1. Clear about motivation and purpose [Judge Duncan]
   2. Persistence and collaboration [Judge Scheele]
   3. Not acting in self-interest but in the interest of the collective [Judge Toro]
2. **Key takeaways**
   1. Support from Chief
   2. Focus on helping self and others to develop competence needed to understand and use evidence in climate related cases
   3. Information must be delivered by credible, objective, preferably local experts
   4. Programs must have a local focus, local jurisdiction, local experts

Individually and in Groups of Three

1. **Explain what leadership is** – what happens when someone is leading?
2. How do effective leaders produce extraordinary results?
3. **Organizations must be aligned** with the conditions in their external environment (political, economic, social, technological, physical environmental, legal conditions – PESTEL) to maintain the ability to provide relevant services and products efficiently and effectively. How do organizations ensure the continuous alignment with their environment?

* Pick a spokesperson

Leadership is about influencing others' behavior!

Judges Scheele, Duncan, and Toro were able to influence others' behavior


Bases of Power


Position versus person-based power
Expert Power and Referent Power are the SUPER POWERS

Creating Trust

Perceived competence/expertise

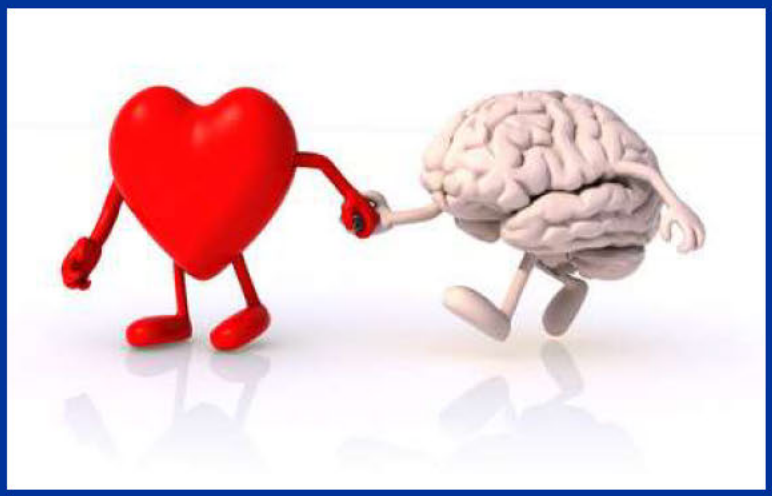
Perceived integrity

Perceived benevolence

https://www.leadershipchallenge.com/lead-on/characteristics-of-admired-leaders-a-conversation-with-jim-kouzes.aspx

Humility

Emotional Intelligence




Transformational Leadership
Process of engaging with others and creating a connection that results in mutual trust and raises the level of motivation and ethics in both the leader and the followers
Tries to help followers to reach their highest potential. Followers become leaders.

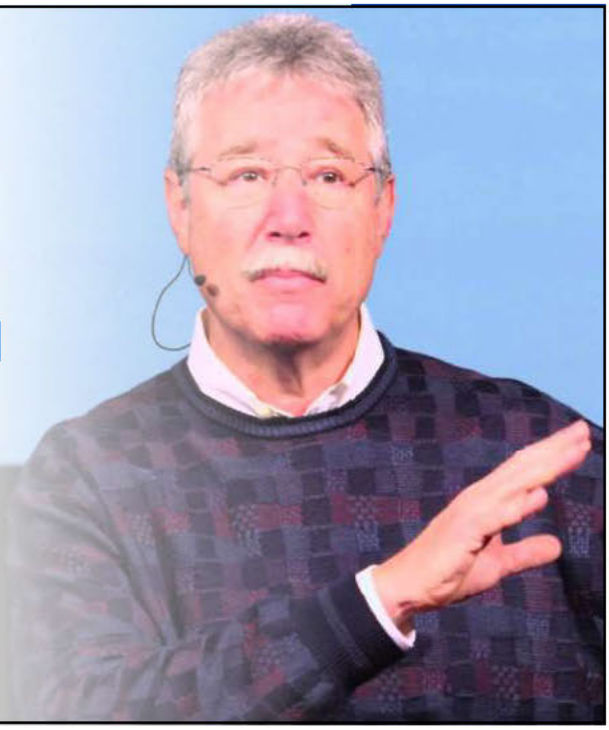

Transformational Leadership Practices

Barry Posner –
About Leadership

I make a difference, but I can't do it alone!

The first person who has to follow you is you!

https://www.youtube.com/watch?v=3cpLFFZsbWY



Mindfulness

Five Leadership Practices (MICEE)

Modeling	Modeling the way
Inspiring	Inspiring a shared vision
Challenging	Challenging the process
Enabling	Enabling others to act
Encouraging	Encouraging the heart

Do you remember your assessment results?

- Leadership is about taking action.
- Leadership is about inspiring others to take action.
- Transformational leaders transcend their own self interest, create trust-based relationships, and influence others' behavior.
- Leaders shape the world we live in.

Bonus Material:
Transformational Leader Behaviors

Model the Way

4. I set an example of what is expected.
9. I ensure that people adhere to agreed-on standards.
14. I follow through on the promises and commitments.
19. I am clear about my “philosophy” of leadership
24. I ensure that goals and milestones are set.
29. I make progress toward goals one step at a time.

Inspire a Shared Vision

2. I talk about future trends.
7. I describe a compelling image of the future.
12. I appeal to others to share a dream of the future.
17. I show others how their interests can be realized.
22. I am enthusiastic and positive about the future.
27. I speak with conviction about the meaning of work.

Challenge the Process

1. I seek out challenging opportunities.
6. I challenge people to try out new approaches.
11. I look outside the organization for ways to improve.
16. I ask, “What can we learn from this?”
21. I experiment and take risks.
26. I take the initiative to overcome obstacles.

Enable Others to Act

3. I develop cooperative relationships.
8. I listen to diverse viewpoints.
13. I treat people with dignity and respect.
18. I support others' decisions.
23. I let people chose how to do their work.
28. I ensure that people grow in their jobs.

Encourage the Heart

5. I praise people for a job well done.
10. I express confidence in people's abilities.
15. I creatively reward people for their contributions.
20. I recognize people for commitment to shared values.
25. I find ways to celebrate accomplishments.
30. I give team members of the team appreciation and support.

JLCS Transformational Leadership

Dr. Yvonne Stedham

Dr. Stedham's July Webinar Takeaways

1. One "thing" that intrigued you about each of the three presenters and about what they did?
    1. Clear about motivation and purpose [Judge Duncan]
    2. Persistence and collaboration [Judge Scheele]
    3. Not acting in self-interest but in the interest of the collective [Judge Toro]

2. Key takeaway
    1. Support from Chief
    2. Focus on helping self and others to develop competence needed to understand and use evidence in climate related cases
    3. Information must be delivered by credible, objective, preferably local experts
    4. Programs must have a local focus, local jurisdiction, local experts

Leadership (Stedham)

Leadership is about taking action.

Leadership is about inspiring others to take action.

Transformational leaders transcend their own self-interest, create trust-based relationships, and influence others' behavior.

Leaders shape the world we live in.

forethought

A survey of ideas, trends, people, and practices on the business horizon

Jessica Hische

GRIST

To Lead, Create a Shared Vision

by James M. Kouzes and Barry Z. Posner

Being forward-looking – envisioning exciting possibilities and enlisting others in a shared view of the future – is the attribute that most distinguishes leaders from nonleaders. We know this because we asked followers.

In an ongoing project surveying tens of thousands of working people around the world, we asked, "What do you look for and admire in a leader (defined as someone whose direction you would willingly follow)?" Then we asked, "What do you look for and admire in a colleague (defined as someone you'd like to have on your team)?" The number one requirement of a leader – honesty – was also the top-ranking attribute of a good colleague. But the second-highest requirement of a leader, that he or she be forward-looking, applied only to the leader role. Just 27% of respondents selected it as something they want in a colleague, whereas 72% wanted it in a leader. (Among respondents holding more-senior roles in organizations, the percentage was even greater, at 88%.) No other quality showed such a dramatic difference between leader and colleague.

This points to a huge challenge for the rising executive: The trait that most

separates the leaders from individual contributors is something that they haven't had to demonstrate in prior, nonleadership roles. Perhaps that's why so few leaders seem to have made a habit of looking ahead; researchers who study executives' work activities estimate that only 3% of the typical business leader's time is spent envisioning and enlisting. The challenge, as we know, only escalates with managerial level: Leaders on the front line must anticipate merely what comes after current projects wrap up. People at the next level of leadership should be looking several years into the future. And those in the C-suite must focus on a horizon some 10 years distant.

So how do new leaders develop this forward-looking capacity? First, of course, they must resolve to carve out time from urgent but endless operational matters. But even more important, as leaders spend more time looking ahead, they must not put too much stock in their own prescience. This point needs to be underscored because, somehow, through all the talk over the years about the importance of vision, many leaders have reached the unfortunate conclusion that they as individuals must be visionaries. With leadership development experts urging them along, they've taken to posing as emissaries from the future, delivering the news of how their markets and organizations will be transformed.

Bad idea! This is not what constituents want. Yes, leaders must ask, "What's new? What's next? What's better?" – but they can't present answers that are only theirs. Constituents want visions of the future that reflect their own aspirations. They want to hear how their dreams will come true and their hopes will be fulfilled. We draw this conclusion from our most recent analysis of nearly one million responses to our leadership assessment, "The Leadership Practices Inventory." The data tell us that what leaders struggle with most is communicating an image of the future that draws others in – that speaks to what others see and feel.

Buddy Blanton, a principal program manager at Rockwell Collins, learned this lesson firsthand. Blanton asked his team for some feedback on his leadership, and the vast majority of it was positive and supportive. But he got some strong advice from his team about how he could be more effective in inspiring a shared vision. One of his direct reports said to him, "You would benefit by helping us, as a team, to understand how you got to your vision. We want to walk with you while you create the goals and vision so we all get to the end vision together."

As counterintuitive as it might seem, then, the best way to lead people into the future is to connect with them deeply in the present. The only visions that take hold are shared visions – and you will create them only when you listen very, very closely to others, appreciate their hopes, and attend to their needs. The best leaders are able to bring their people into the future because they engage in the oldest form of research: They observe the human condition.

James M. Kouzes (jim@kouzes.com) is the Dean's Executive Professor of Leadership, and **Barry Z. Posner** (bposner@scu.edu) is the dean of the Leavey School of Business, at Santa Clara University. They are the coauthors of *The Leadership Challenge* and over a dozen other books on leadership, including *A Leader's Legacy, Credibility,* and *Encouraging the Heart.*

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FORETHOUGHT FOCUSES ON

Leadership Transitions

Leadership

Professor Kelly Tait

Judicial Leaders in Climate Science
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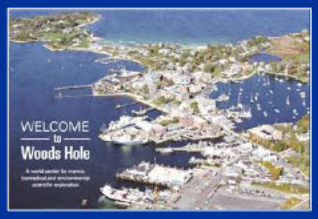


Group Dynamics, Change, and Communication

Key Points re: Leadership & Group Dynamics

- Groups require both a **task-focus** (accomplishing goals) and a **relational-focus** (socio-emotional aspects)
- **Norms**—explicit and implicit rules of behavior—can have a huge impact on group performance
- Groups tend to go through phases of development

Tuckman's **Group Development Model**

1. Forming:
Cautious, polite, anxious, eager

2. Storming:
Resistance, conflict, competition

3. Norming:
Resolving differences, commitment, group ID

4. Performing:
Getting things done, fluid, supportive

Critical Concepts for Group Development and Change Management:

Psychological safety: Confidence they won't be rejected, embarrassed, or punished for speaking up

Growth mindset: Seeing challenges as opportunities to learn

Change Takes Energy!

- Lasting change requires addressing three levels: **thinking**, **feeling**, and **behaving**
- For conflict and disagreement, be proactive and responsive
  - **Establishing and returning to common ground: critical**
- Remember conflict *can* be constructive

The Continuing Importance of Getting Someone Else's Perspective

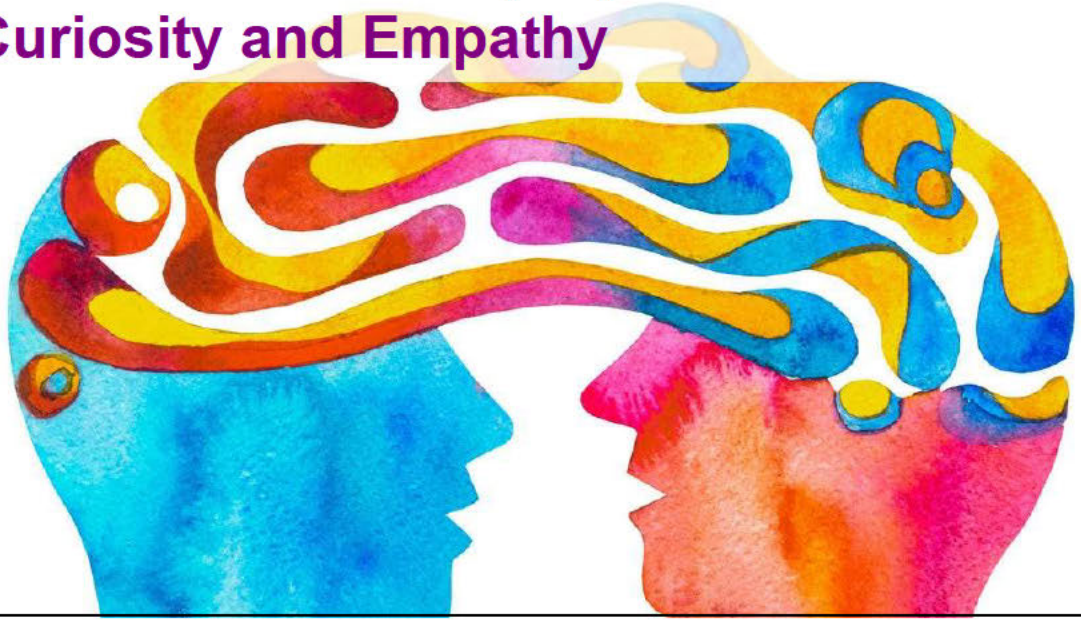
More effective than perspective-taking:

Perspective-seeking: Trying to get the other person's perspective directly

➡ Whenever possible: Ask and listen rather than guessing

What challenging questions have people asked you or are you worried they might ask related to climate science and/or your goal(s) for this program?

Communication Superpowers: Curiosity and Empathy



SCIENCE AND LEGAL UPDATES

DIVIDER 4

Dr. John Doherty
Mr. Jarryd Page

Science and Legal Updates

Dr. John M. Doherty
Mr. Jarryd Page

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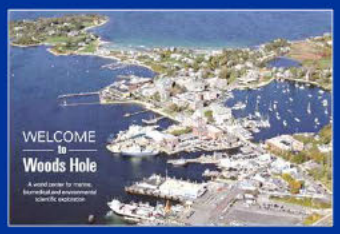


ENVIRONMENTAL LAW INSTITUTE
CJP CLIMATE JUDICIARY PROJECT™

Judicial Leaders in Climate Science

Science Recap

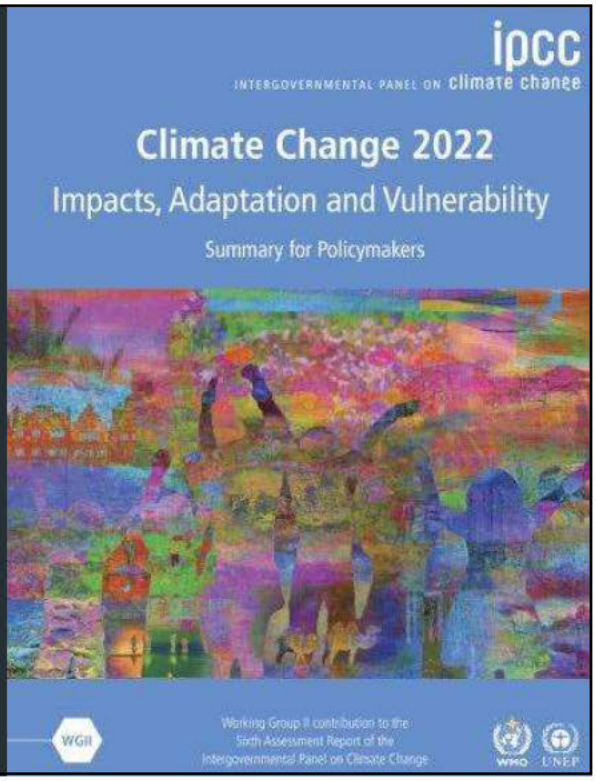
John M. Doherty, Ph.D.
Science and Policy Analyst,
Environmental Law Institute
[redacted]

QUIZ TIME!

1. What is the IPCC?

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

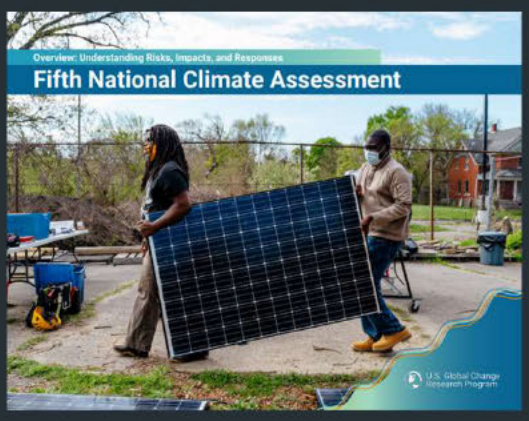
- The IPCC is the world's leading authority for assessing the science related to climate change. It consists of members from 195 countries, including the United States.
- IPCC prepares comprehensive Assessment Reports about:
  - Physical science (Working Group I)
  - Climate impacts and risk (Working Group II)
  - Potential solutions (Working Group III)



QUIZ TIME!

1. What is the IPCC?
2. What is the NCA?

THE NATIONAL CLIMATE ASSESSMENT



The National Climate Assessment is the U.S. government's preeminent report on climate change in the United States.

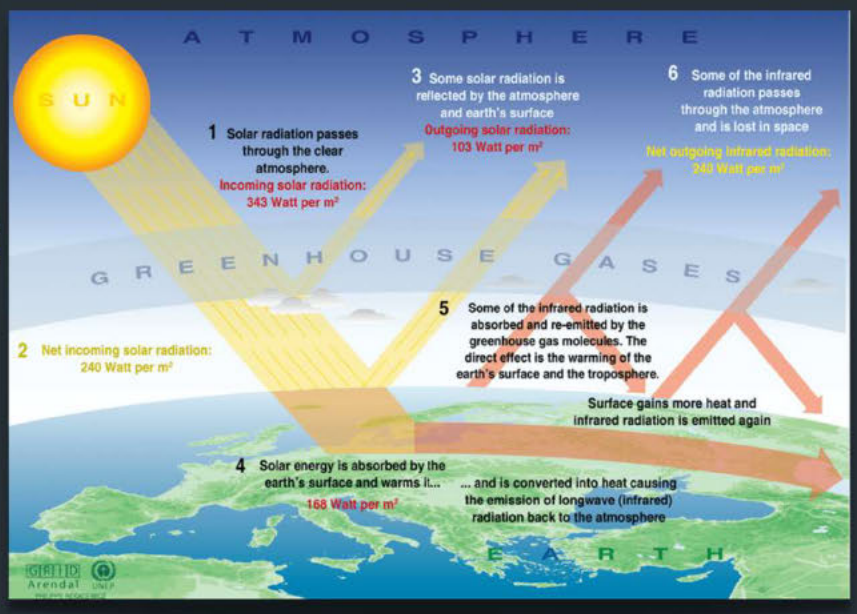
It is a congressionally mandated report that is coordinated by the U.S. Global Change Research Program, which is comprised of 15 scientific agencies.

The NCA is policy-neutral but policy-relevant

QUIZ TIME!

1. What is the IPCC?
2. What is the NCA?
3. What is the greenhouse effect?

ENERGY BALANCE AND THE GREENHOUSE EFFECT

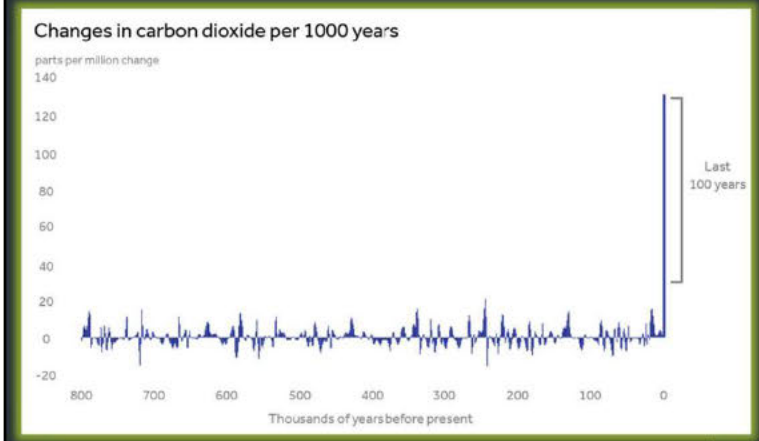


Source: IPCC (1996) Working Group 1 contribution, Science of Climate Change, Second Assessment Report

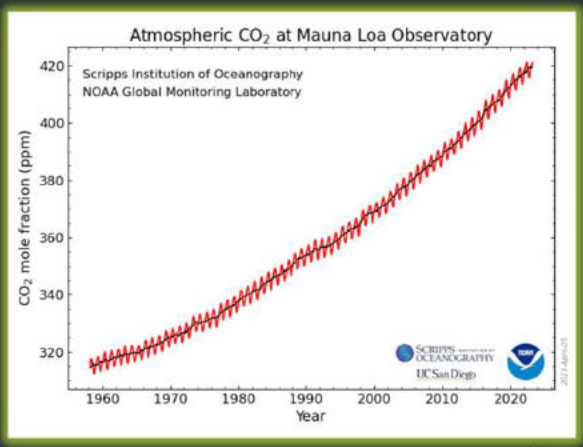
INCREASING ATMOSPHERIC CO_2

Changes in Atmospheric Carbon Dioxide over Time

Dramatic rate of increase of CO_2 occurred at the start of the industrial revolution



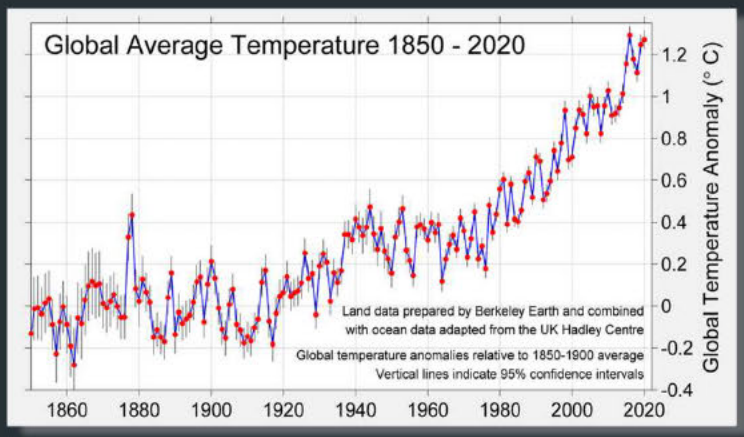
Source: Benjamin Strauss, The Carbon Skyscraper, Climate Central (2021)



Source: NOAA, Global Monitoring Laboratory (2022)

GLOBAL AVERAGE TEMPERATURE

The most obvious signal of climate change is global mean surface temperature



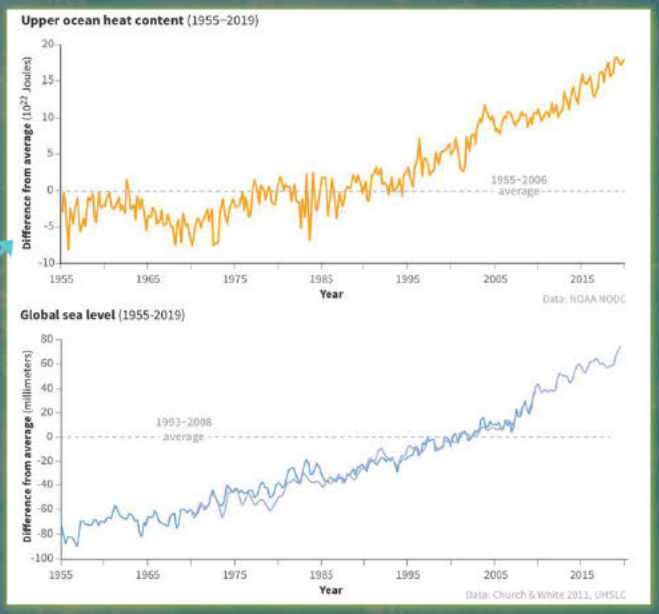
Demonstrates a detectable increase in global mean surface temperature

Source: Berkeley Earth

OTHER CLIMATE SIGNALS (DETECTION)

A clear **warming trend** since the industrial era is indicated by other **climate signals**, including:

- Ocean heat content
- Sea level rise

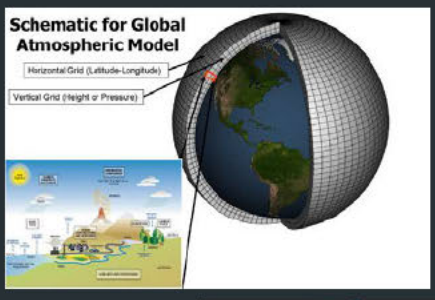


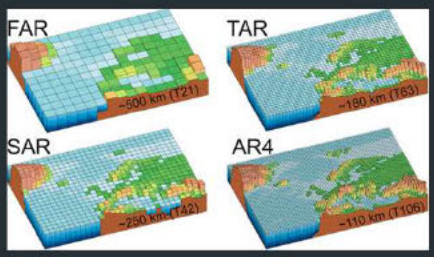
Source: Nat'l Acad. of Sci. & The Royal Soc'y, Climate Change: Evidence & Causes Update 2020, at 4 (2020)

IDENTIFYING HUMAN INFLUENCE

We don't have a physical replicate of the planet, but we do have **climate models**

Climate models are **computer simulations** of the physical, chemical, and biological aspects of Earth's climate system run on three-dimensional grids

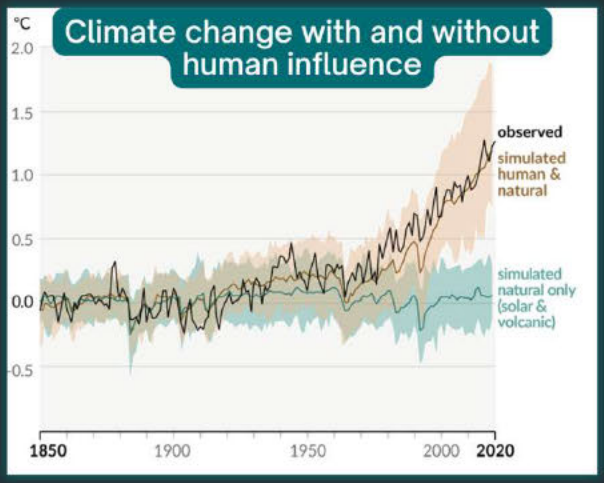




Source: IPCC (2007); NOAA

IDENTIFYING HUMAN INFLUENCE

Changes in global surface temperature relative to 1850-1900



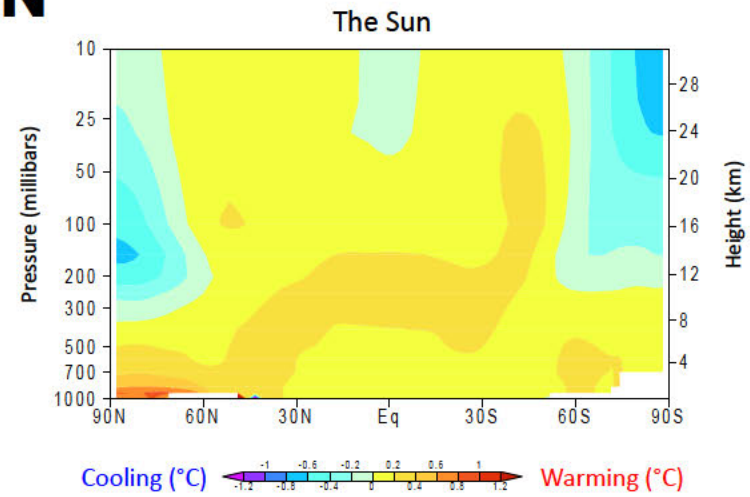
Observations and models show that the observed warming trend **cannot be due to causes other than human activity, notably greenhouse gas emissions**

Source: IPCC, Climate Change 2021: The Physical Science Basis, Summary for Policymakers (2021) (Figure SPM.1 (b)).

QUIZ TIME!

1. What is the IPCC?
2. What is the NCA?
3. What is the greenhouse effect?
4. What can be learned from looking at temperature across the height of the atmosphere (hint: recall Dr. Santer's "fingerprinting" talk)

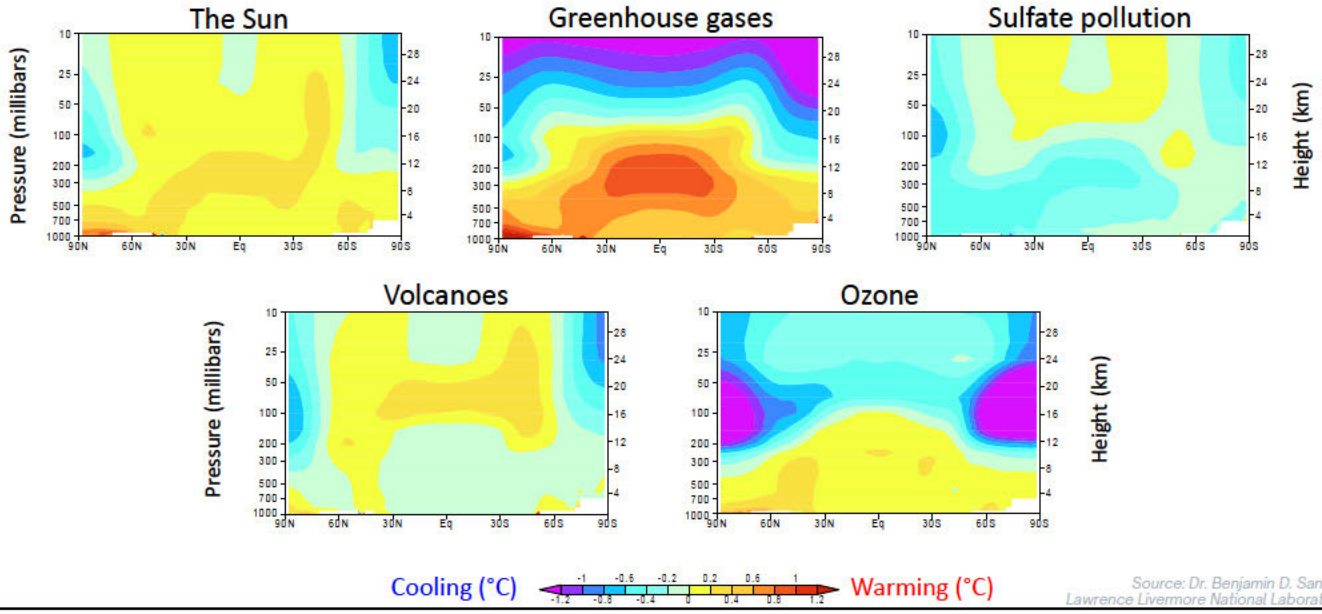
TEMPERATURE "FINGERPRINTING" – THE SUN



Source: Dr. Benjamin D. Santer, Lawrence Livermore National Laboratory

1 EARTH'S ENERGY BALANCE

OTHER TEMPERATURE "FINGERPRINTS"

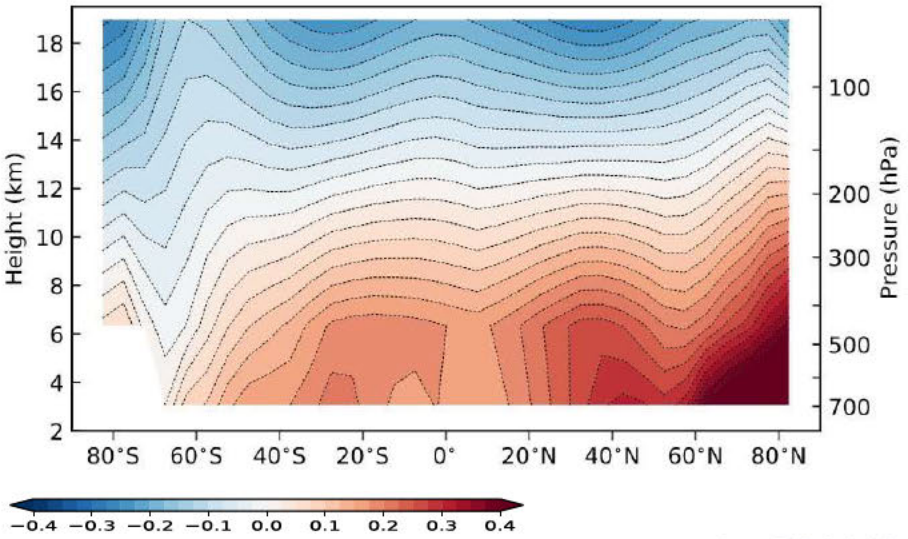


Source: Dr. Benjamin D. Santer, Lawrence Livermore National Laboratory

1 EARTH'S ENERGY BALANCE

SATELLITE MEASUREMENTS

Satellite observations of temperature trend (°C per decade from 1979-2020)



Source: Dr. Benjamin D. Santer, Lawrence Livermore National Laboratory

NOT ONLY TEMPERATURE!

Identification of human-induced changes in atmospheric moisture content

B. D. Santer*[,2], C. Mears[1], F. J. Wentz[1], K. E. Taylor[2], P. J. Gleckler[2], T. M. L. Wigley[3], T. P. Barnett[4], J. S. Boyle[2], W. Brüggemann[5], N. P. Gillett[6], S. A. Klein[2], G. A. Meehl[3], T. Nozawa[3], D. W. Pierce[4], P. A. Stott[7], W. M. Washington[3], and M. F. Wehner[2]

Identifying external influences on global precipitation

Kate Marvel[1] and Céline Bonfils

Attribution of observed surface humidity changes to human influence

Katharine M. Willett[1,2], Nathan P. Gillett[3], Philip D. Jones[1] & Peter W. Thorne[1]

Detection of a direct carbon dioxide effect in continental river runoff records

N. Gedney[1], P. M. Cox[2], R. A. Betts[3], O. Boucher[3], C. Huntingford[4] & P. A. Stott[5]

Human contribution to more-intense precipitation extremes

Seung-Ki Min[1], Xuebin Zhang[2], Francis W. Zwiers[2] & Gabriele C. Hegerl[3]

Detection of human influence on sea-level pressure

Nathan P. Gillett*, Francis W. Zwiers†, Andrew J. Weaver* & Peter A. Stott‡

Human-Induced Arctic Moistening

Seung-Ki Min, Xuebin Zhang, Francis Zwiers*

Detectability of the impacts of ozone-depleting substances and greenhouse gases upon stratospheric ozone accounting for nonlinearities in historical forcings

Justin Randers[1], Susan Solomon[2], Benjamin D. Santer[3], Douglas E. Kinnison[4], and Michael J. Mills[4]

The fingerprint of human-induced changes in the ocean's salinity and temperature fields

David W. Pierce,[1] Peter J. Gleckler,[2] Tim P. Barnett,[1] Benjamin D. Santer,[2] and Paul J. Durack[2]

Human influence on Arctic sea ice detectable from early 1990s onwards

Seung-Ki Min,[1] Xuebin Zhang,[1] Francis W. Zwiers,[1] and Tom Agnew[1]

Changes in the geopotential height at 500 hPa under the influence of external climatic forcings

Nikolaos Christidis[1] and Peter A. Stott[1]

[1]Met Office Hadley Centre, Exeter, UK

Detection of human influence on twentieth-century precipitation trends

Xuebin Zhang[1], Francis W. Zwiers[1], Gabriele C. Hegerl[2], F. Hugo Lambert[2], Nathan P. Gillett[3], Susan Solomon[4], Peter A. Stott[5] & Tony Noguera[1]

Human influence on joint changes in temperature, rainfall and continental aridity

Céline J. W. Bonfils[1,2,3], Benjamin D. Santer[3], John C. Fyfe[1,4], Kate Marvel[1,4], Thomas J. Phillips[1] and Susan R. H. Zimmerman[1,5]

Climate Change Detection and Attribution: Beyond Mean Temperature Signals

Source: Dr. Benjamin D. Santer, Lawrence Livermore National Laboratory

QUIZ TIME!

1. What is the IPCC?
2. What is the NCA?
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5. What are the three factors of climate risk?

2 CLIMATE RISK

CONCEPTUAL FRAMEWORK OF CLIMATE RISK

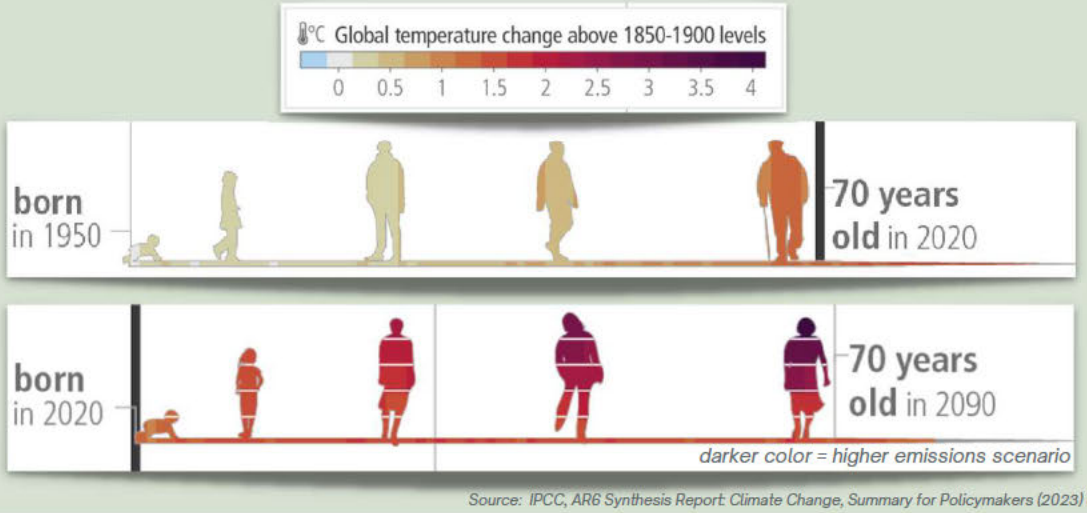
Risks result from the interaction of **hazards** with people and ecosystems that are **exposed** and **vulnerable** and that respond in different ways.

Adapted from IPCC (2022)

2 CLIMATE RISK

DIFFERENT GENERATIONAL IMPACTS

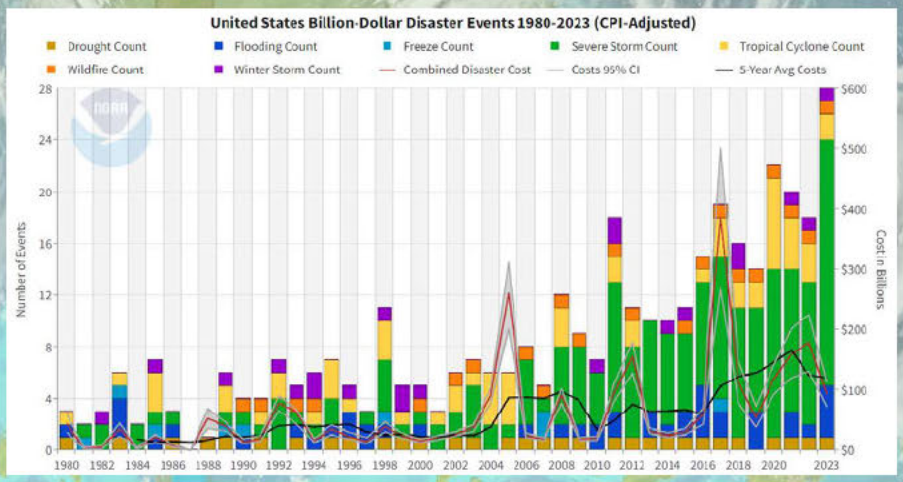
Climate extremes will get worse over time, so young people and future generations will suffer disproportionately from impacts



Source: IPCC, AR6 Synthesis Report: Climate Change, Summary for Policymakers (2023) (Figure SPM.1 (c))

2 CLIMATE RISK

INCREASING ECONOMIC IMPACTS



Source: NOAA, Climate.gov (2024)

QUIZ TIME!

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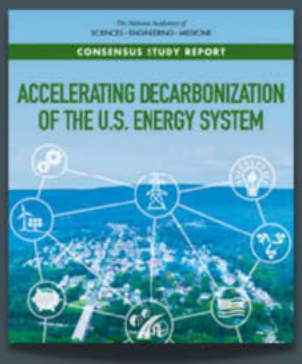
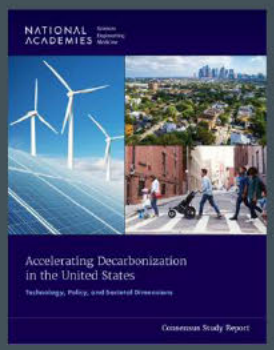
5. What are the three factors of climate risk?

6. What is the name of the major international agreement that instructs the global community to limit warming in an effort to reduce climate risk?

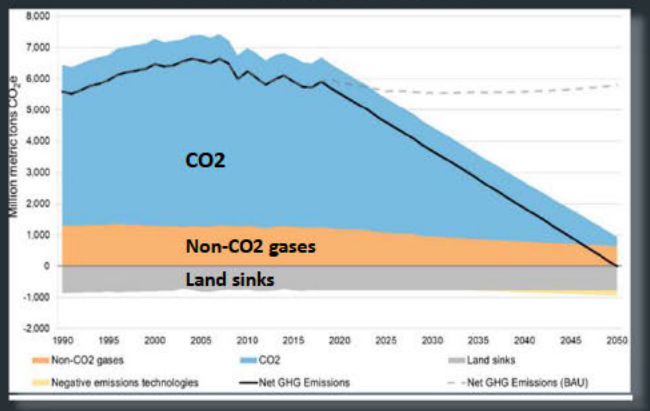
3 POTENTIAL SOLUTIONS

NET ZERO EMISSIONS BY 2050 IS POSSIBLE…





Path to net-zero greenhouse gas (GHG) emissions by 2050, by gas



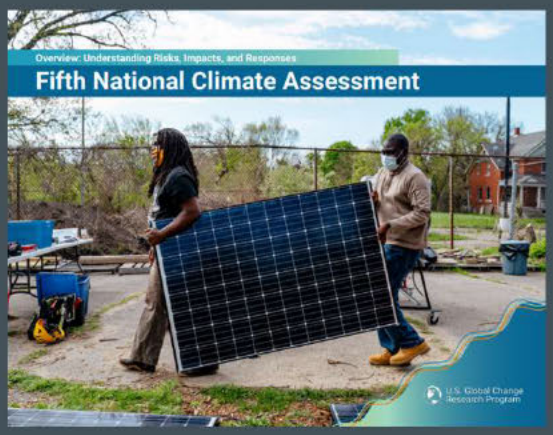
One pathway to net-zero emissions by 2050:

- Deep reduction in carbon dioxide emissions
- Moderate declines in non-carbon dioxide greenhouse gas emissions
- Expansion of land carbon sinks
- Expansion of negative emissions technologies

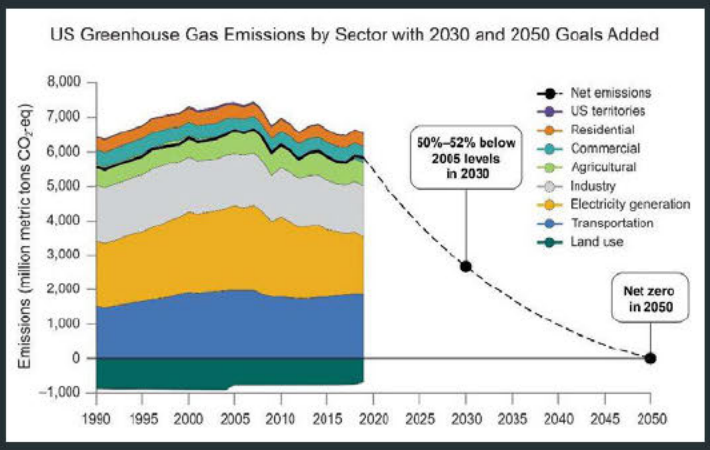
Source: Nat'l Acad. of Sci. Eng'g and Med, Accelerating Decarbonization of the U.S. Energy System 58 (2021)

3 POTENTIAL SOLUTIONS

…BUT WE HAVE A WAYS TO GO



Total Emissions by Sector



Source: U.S. Global Change Research Program (USGCRP), Fifth National Climate Assessment, Chapter 32 (2023) (Figure 32.1)

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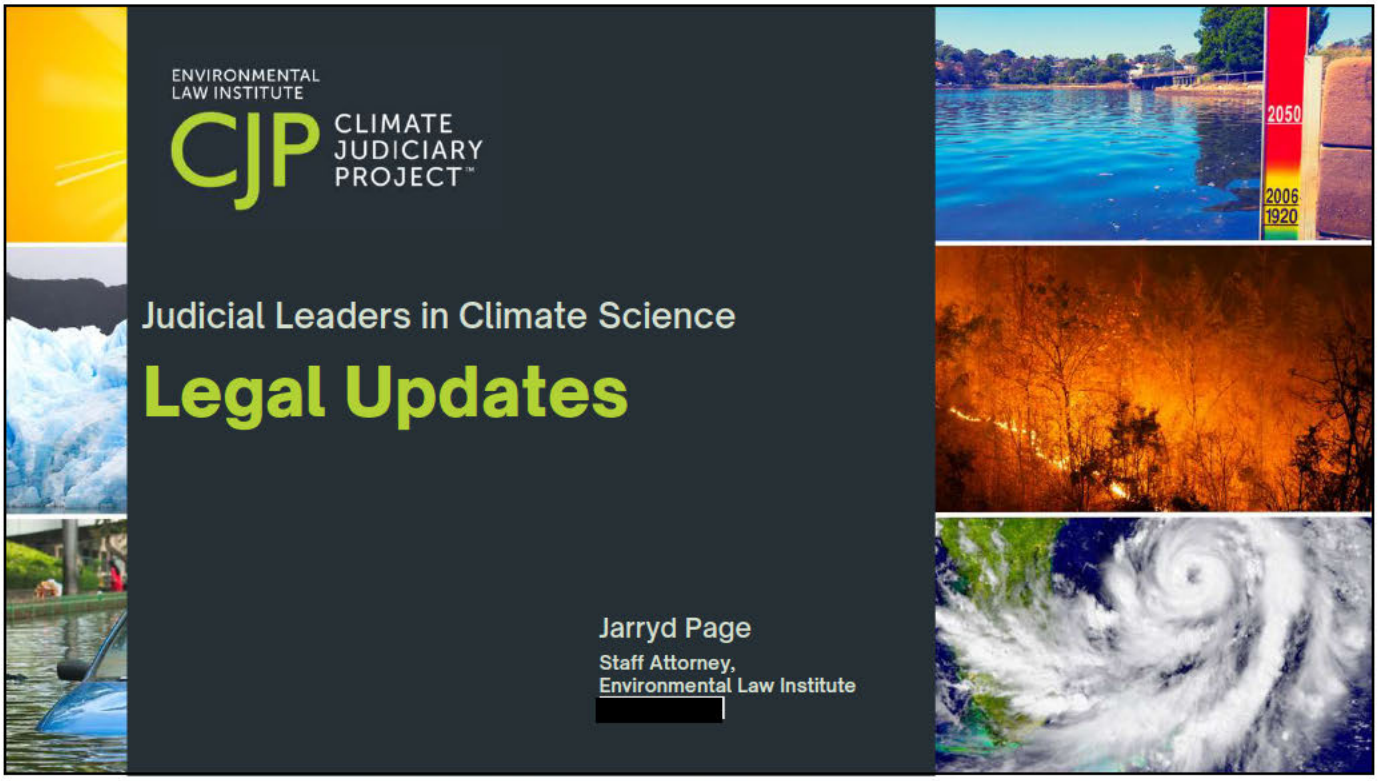


A LOT HAS HAPPENED SINCE MARCH!

1. INTERESTING TIDBITS
2. UPDATES SINCE RENO

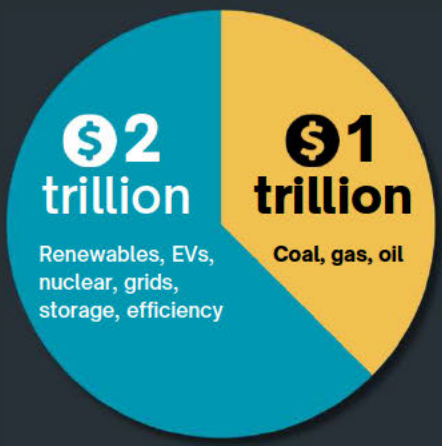
1 INTERESTING TIDBITS

JLCS EVENTS SINCE MARCH

1 INTERESTING TIDBITS

ENERGY LANDSCAPE

Supply > Demand in California



Global Energy Investment in 2024

1 INTERESTING TIDBITS

RECORD HEAT QUIZ

World Records Hottest Day Ever—Here Are The U.S. Cities Breaking Heat Records This Summer

New heat records were set in dozens of U.S. cities last week — and more records are expected to fall as heat advisories remain in the West Coast.

Forbes / Aug 1

https://www.forbes.com/sites/brianbushard/2024/07/23/world-records-hottest-day-ever-here-are-the-us-cities-breaking-heat-records-this-summer/

- How many states tied or broke heat records from May 24–July 20?
- How many JLCS states?
- Bonus: How many times for Reno, NV?

2

UPDATES SINCE RENO

2 UPDATES SINCE RENO

CLIMATE LITIGATION DATABASE

COLUMBIA LAW SCHOOL SABIN CENTER FOR CLIMATE CHANGE LAW

http://climatecasechart.com/

2 UPDATES SINCE RENO

TRENDS IN CLIMATE LITIGATION

TREND	EXAMPLES
Suits by state and local governments against energy companies	• California • Chicago, Illinois • County of Multnomah, Oregon
Suits under state constitutions	• Montana (*Held v. State of Montana*) • Hawai'i (*Navahine F. v. Hawai'i Dep't of Transp.*)
Challenges to renewable energy projects and programs	• natural resource management and land use • wildlife impacts • Bipartisan Infrastructure Law and Inflation Reduction Act
Challenges to federal climate regulations	• SEC rule • U.S. EPA emissions regulations for power plants • U.S. EPA, NHTSA vehicle emissions rules

2 UPDATES SINCE RENO

STATE AND LOCAL GOVERNMENT VS. FOSSIL FUEL COMPANIES

Filings

- Bucks County, PA
- Puerto Rico

Decisions

- Oregon
- New York
- Connecticut
- Colorado
- Maryland
- Delaware

From last time. . .

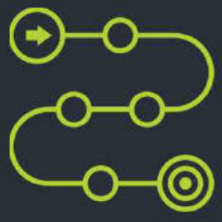
Feb. 28, 2024 — Sunoco, et al., petitions U.S. Supreme Court in City and County of Honolulu case.

Now the latest. . .

June 10, 2024 — U.S. Supreme Court calls for the views of the U.S. Solicitor General in that case.

2 UPDATES SINCE RENO

SUITS UNDER STATE CONSTITUTIONS



Montana Supreme Court

oral argument in *Held v. Montana*

> "All persons are born free and have certain inalienable rights. They include the right to a clean and healthful environment."
> —Art. II, Sec. 3

> "The state and each person shall maintain and improve a clean and healthful environment in Montana for present and future generations."
> —Art. IX, Sec. 1, Cl. 1

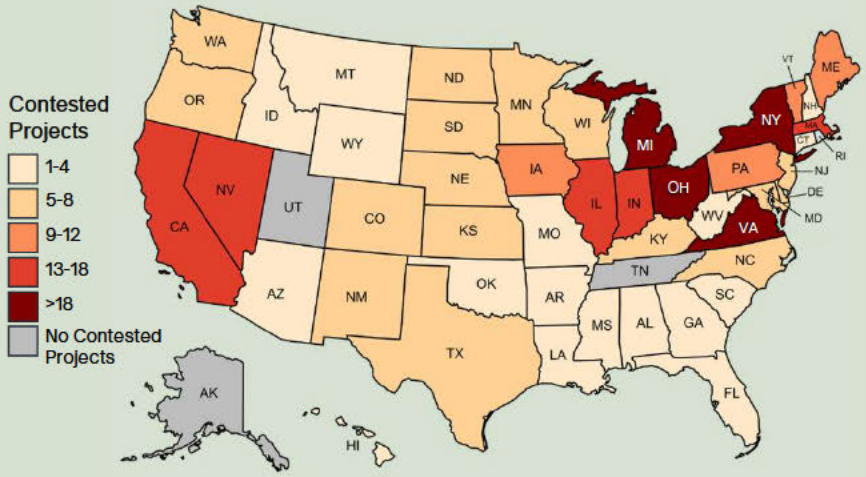
Hawaii First Circuit Court

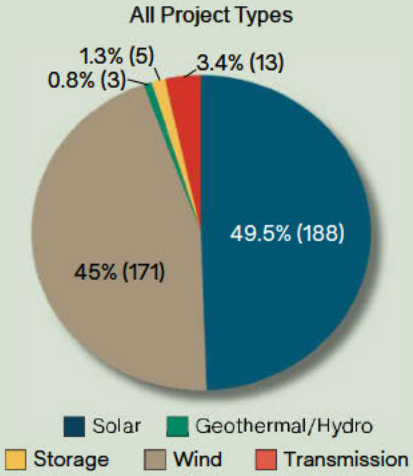
approved settlement in *Navahine F. v. Hawaii Department of Transportation*

- HDOT GHG Reduction Plan by May 2025
- 5-year targets to reduce emissions in transportation (sea, air too)
- Requires science-based methodology "to assess and report the total, long-term [greenhouse gas] emission and [vehicle miles traveled] impacts of each infrastructure project."
- Court supervised through 2045

2 UPDATES SINCE RENO

ENERGY PROJECT CHALLENGES





Based on data from Sabin Center for Climate Change Law, Opposition to Renewable Energy Facilities in the United States: June 2024 Edition.

KEYNOTE – GREETING AND WOODS HOLE WORK

DIVIDER 5

Dr. Peter de Menocal

JUDICIAL LEADERSHIP

DIVIDER 6

Hon. Clemens Landau

CLIMATE SCIENCE IN THE FIELD

DIVIDER 7

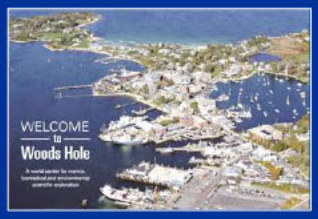
Dr. Sarah Das

Climate Science in the Field

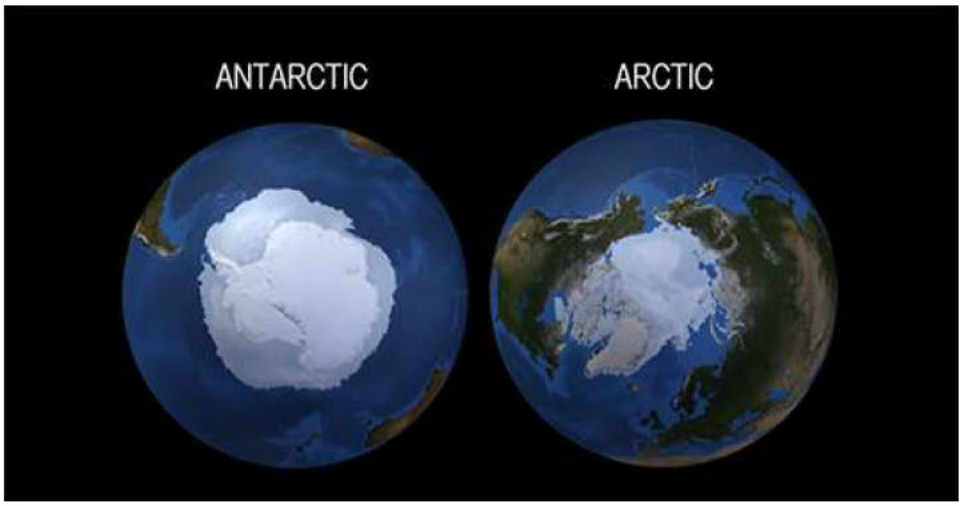
Dr. Sarah Das

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

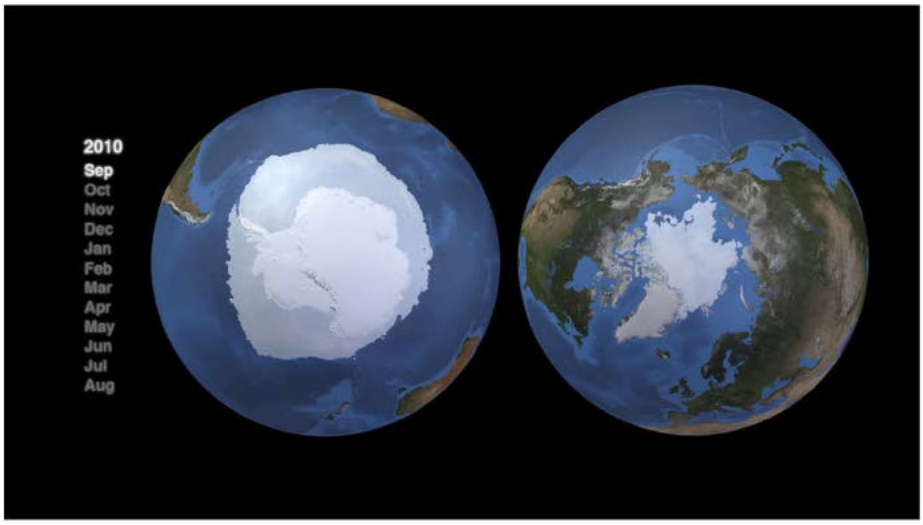
THE NATIONAL JUDICIAL COLLEGE



Polar Ice Sheets

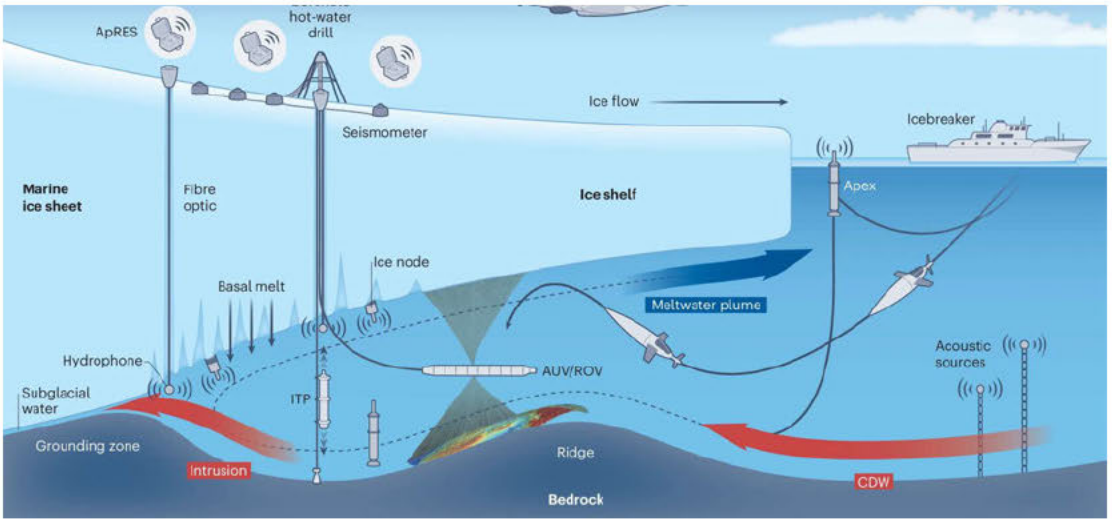


Polar Ice Sheets



Credit: NASA

Observing and understanding change



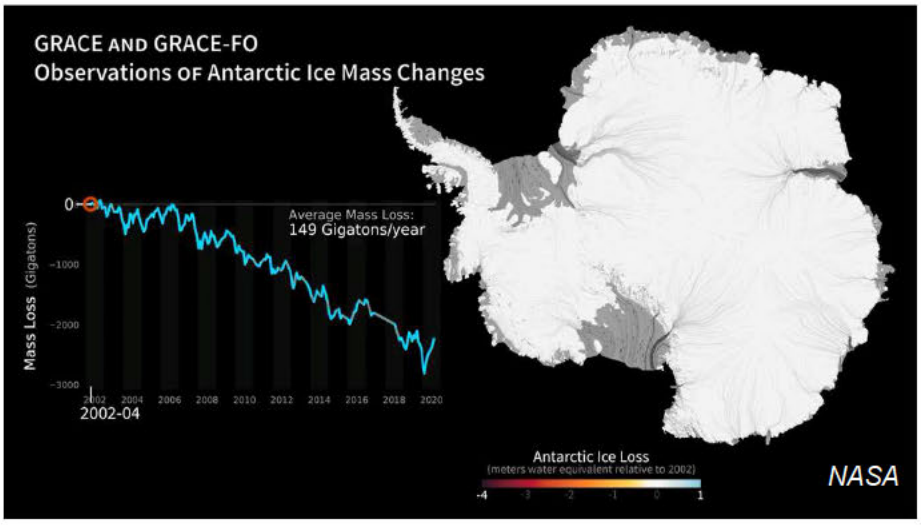
Observing and understanding change

Fay Fuller, Mt Ranier 1890

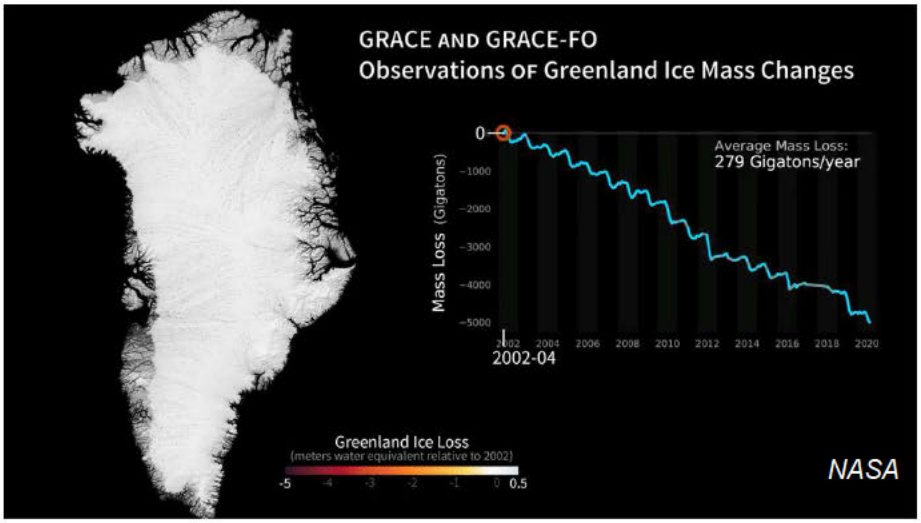
Dr. Sarah Das, Greenland & Antarctica, 1995-present

Working (and living) on an ice sheet

Antarctic Ice Sheet: observed mass loss 2002-2022

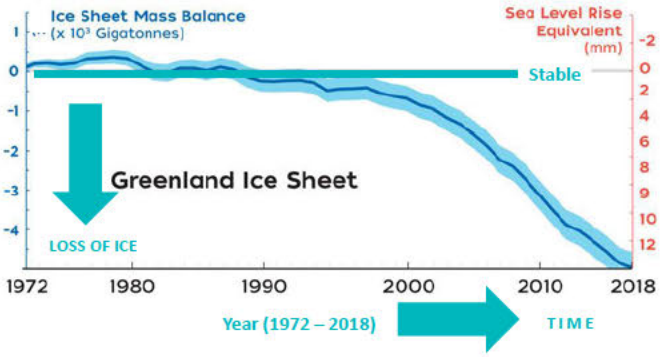


Greenland Ice Sheet: Observed mass loss 2002-2022

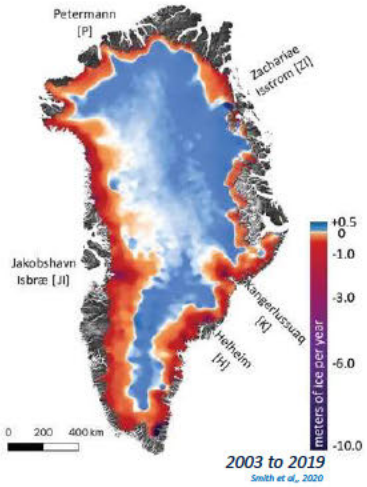


Greenland Ice Sheet mass loss

Mass loss **In time...**



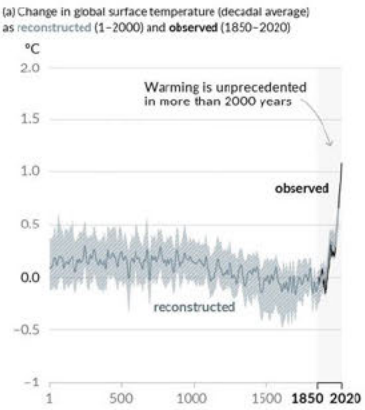
Mass loss **in space...**



A changing climate

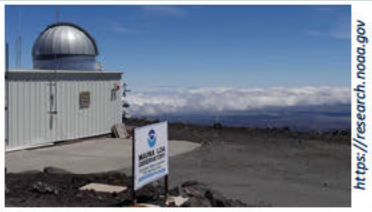
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Changes in global surface temperature relative to 1850–1900



IPCC AR6 WGI SPM (2022)

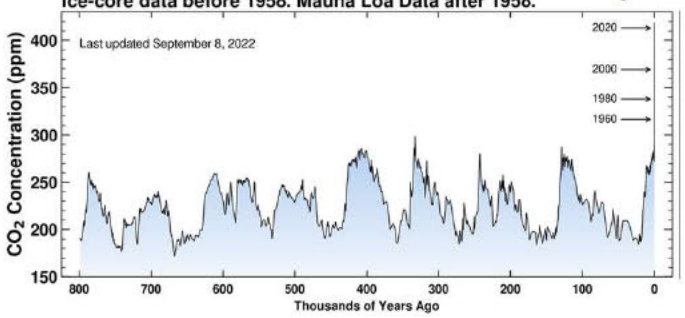
Evidence: Paleoclimate data



https://research.noaa.gov

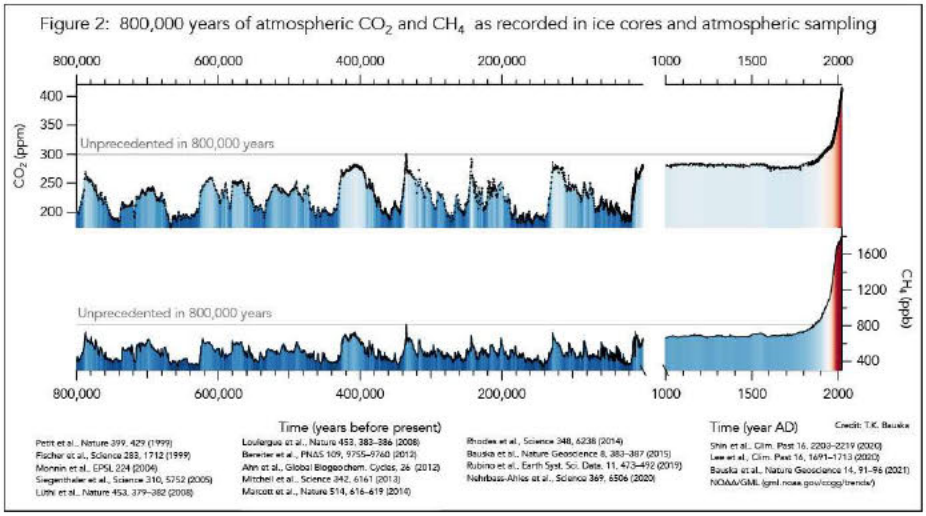
https://icecores.org/about-ice-cores

Ice-core data before 1958. Mauna Loa Data after 1958.



https://keelingcurve.ucsd.edu/

CO_2 ,CH4 and more …



British Antarctic Survey

Climate Variability & Past Change

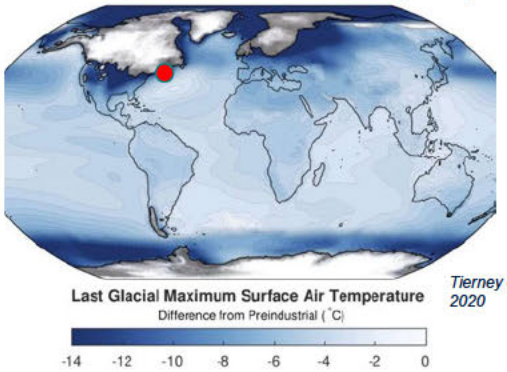
Paleoclimatology Datasets

Paleoclimatology data extend the weather and climate information archive by hundreds to millions of years. The data include geophysical or biological measurement time series as well as proxy or reconstructed climate variables such as temperature and precipitation.

NOAA

What's in a few degrees? Cooler:

Last Glacial Maximum: Δ5°**C** globally



Tierney et al., 2020

After LGM, **maximum warming rate was 1.5°C/1000 yrs**
Since 1850-present surface has **warmed 1.1°C**

20,000 years ago
GLACIER ICE

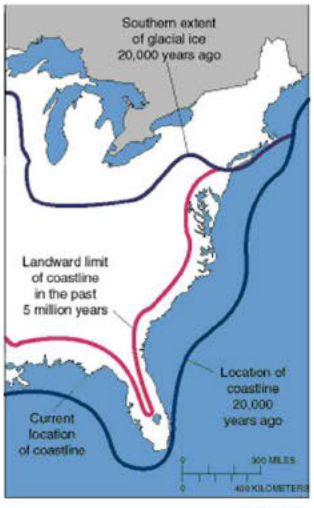
10,000 years ago
BOREAL FOREST
WETLANDS

Today
BEACH
COASTLINE

What's in a few degrees? Warmer:

"What's past is prologue"

Mid Pliocene
~ 3 million years ago
Atmospheric CO_2
400 ppmv
Global Temperature
+2.5C° to +4°C
Sea Level
+10m to +20 m higher



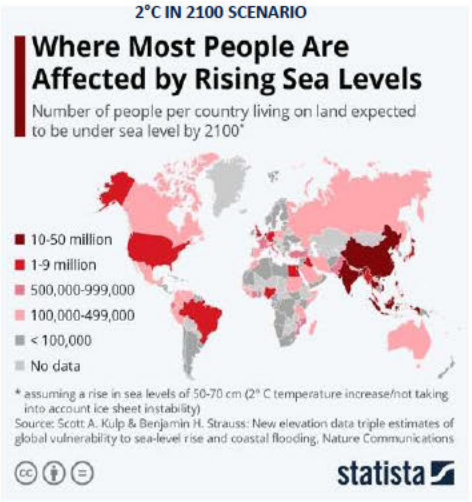
USGS

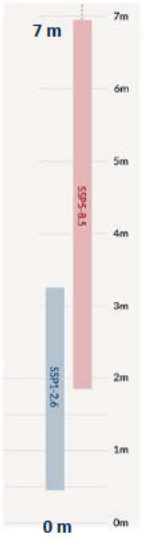
Rovere et al, 2015

Global Impacts of sea level rise

- **230 M people** live less than **1 m below current high tide lines**
- **190 M people** live below projected high tide lines for **2100 under low carbon emissions**
- **630 M people** live below projected high tide lines for **2100 under high carbon emissions**

Kulp & Strauss, 2019

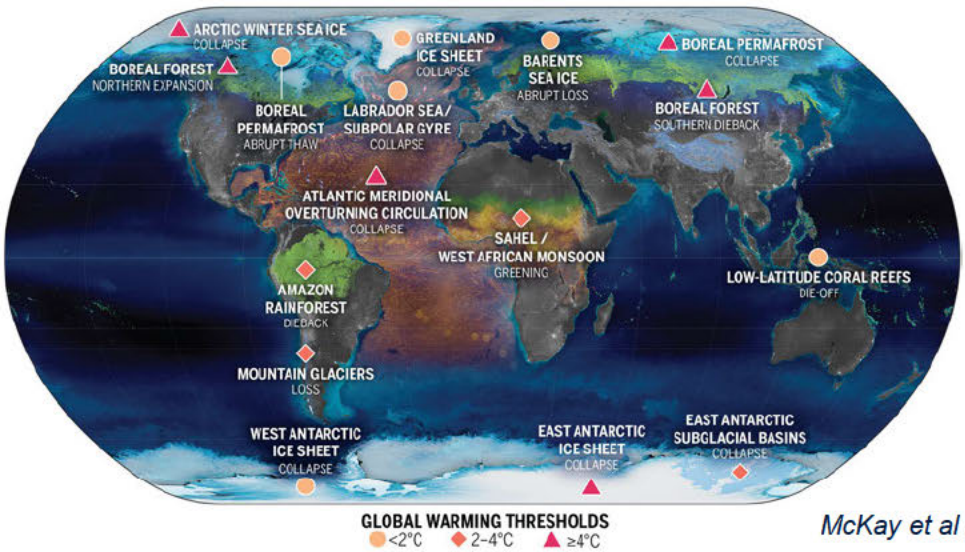




And by 2300

2021 AR6 WR1 SPM

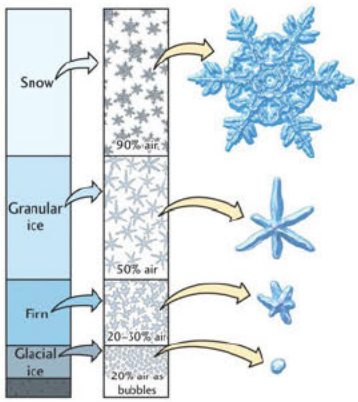
Warming levels & Tipping Points

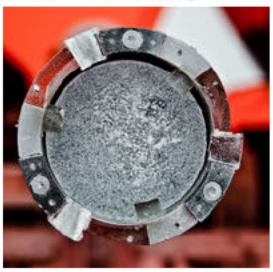


McKay et al 2022

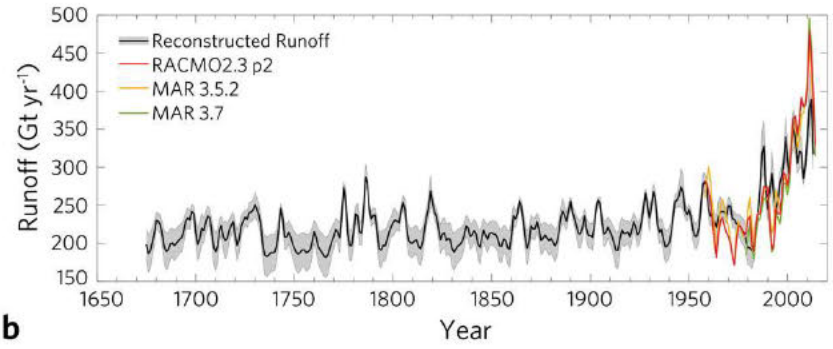
Polar Ice Sheets: Ice core records

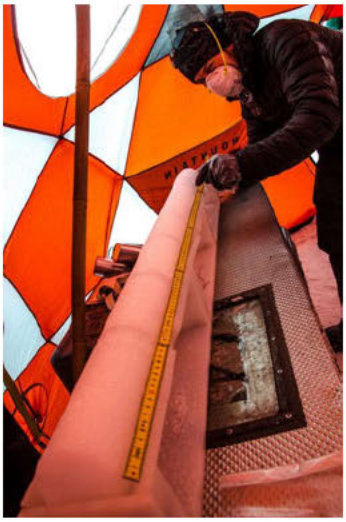
Glacier variability and proxy development (decades – millenia)





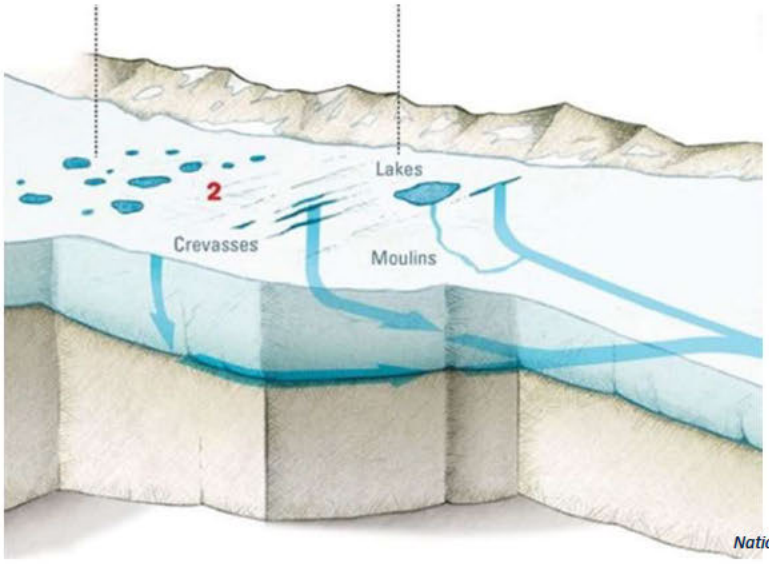
Greenland ice sheet change since pre-Industrial period





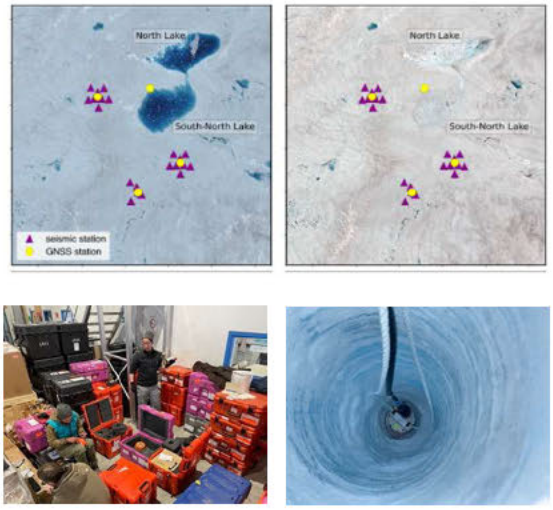
Trusel, Das et al., Nature 2018

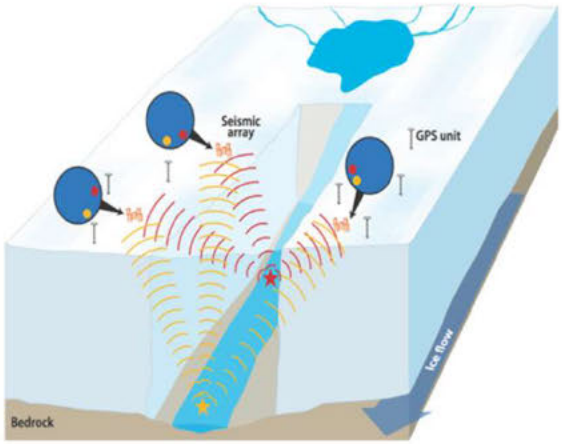
Polar ice sheets: Ice dynamics



National Geographic graphic

Ice flow, surface hydrology and subglacial hydrology






Thank you!

CLIMATE SCIENCE AND PRACTICAL APPLICATION IN THE COURTROOM (PART 1)

DIVIDER 8

Hon. Stacy Boulware-Eurie
Dr. Yvonne Stedham
Professor Kelly Tait

IMPACTS OVERVIEW

DIVIDER 9

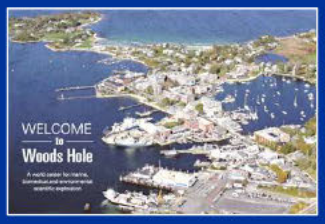
Dr. Christopher Schwalm

Impacts Overview

Dr. Christopher R. Schwalm

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE

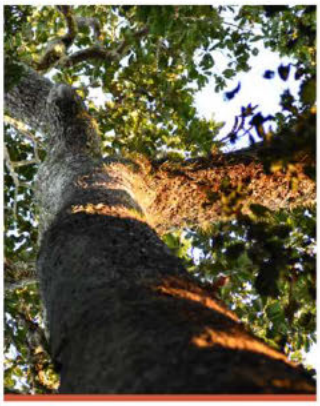


On Climate Change…

Everything you wanted to know about climate change (but were afraid to ask)

September 17, 2024
Christopher R Schwalm
Senior Scientist, Director of Climate Risk
Woodwell Climate Research Center

Woodwell Climate Research Center



Woodwell Climate Research Center

WORKING IN CONCERT FOR OUTSIZED IMPACT

We work with partners, stakeholders, and government officials in over 20 countries across six continents—from the Arctic to the Amazon. We engage throughout the research process to ensure that our insights can be integrated into real-world decision-making. Founded in 1985, our "impact through engagement" approach has delivered outsized results for almost 40 years. Woodwell researchers have:

- Testified frequently before the U.S. Congress, including at one of the first hearings on climate change in 1986
- Helped create the United Nations Framework Convention on Climate Change
- Shared the Nobel Prize with the Intergovernmental Panel on Climate Change for our groundbreaking research in 2007
- Worked last year with more than 50 congressional offices on both sides of the aisle to shape federal climate legislation
- Woodwell President Dr. John Holdren hired to serve as President Obama's science advisor in 2009
- Woodwell President Dr. Phil Duffy hired to serve as President Biden's Senior Climate Adviser in 2021

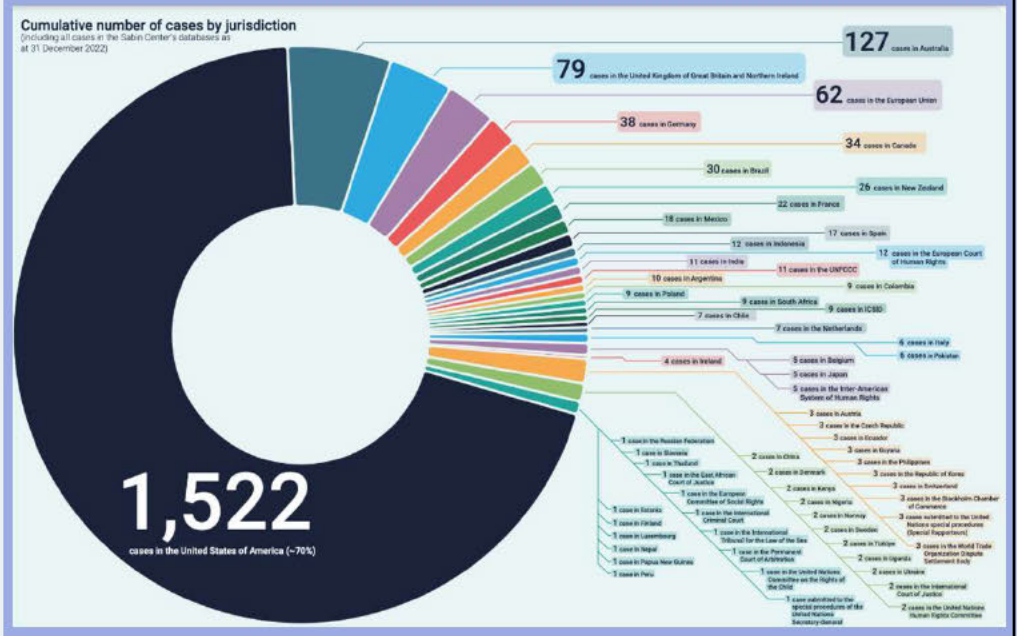
BY THE NUMBERS

PRINCIPAL INVESTIGATORS	19
TOTAL STAFF	120+
CORE PARTNERS	30+
SCIENTIFIC PUBLICATIONS	120+/yr
MEDIA MENTIONS	6,500+/yr

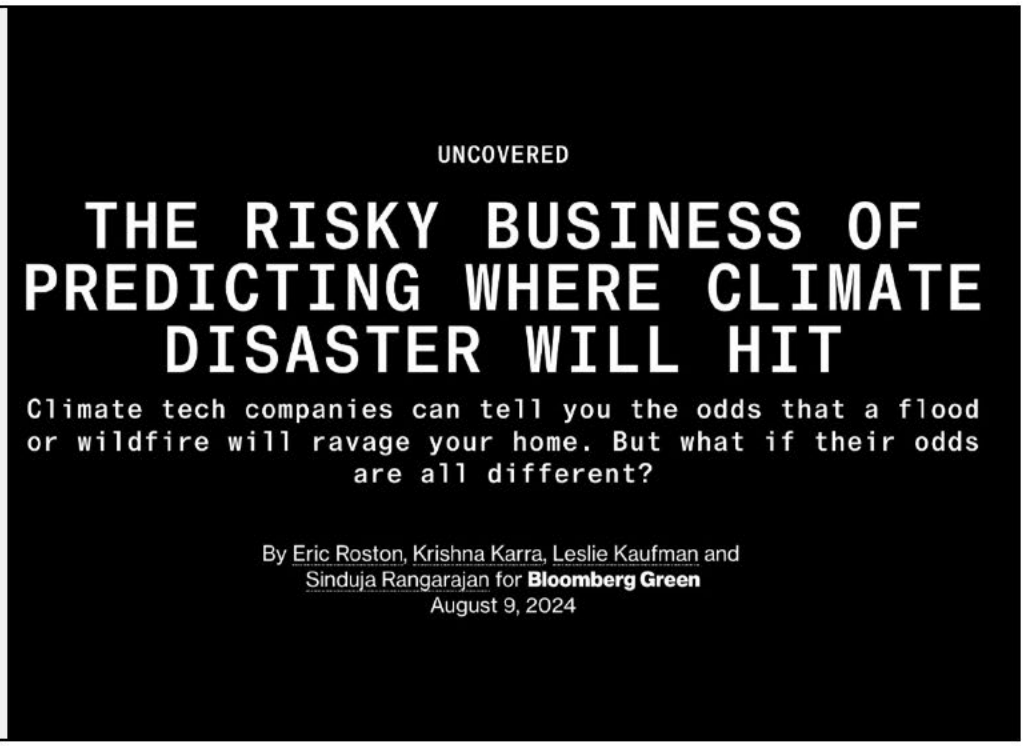
SELECTED PARTNERS

WELLINGTON MANAGEMENT®
esri ICLEI
COPPA
IPAM Amazônia · GeoHazards International
McKinsey & Company
Probable Futures
The Center for Climate and Security
NISKANEN CENTER
indigo
Alaska Institute for Justice

Climate litigation



Climate analytics



UNCOVERED

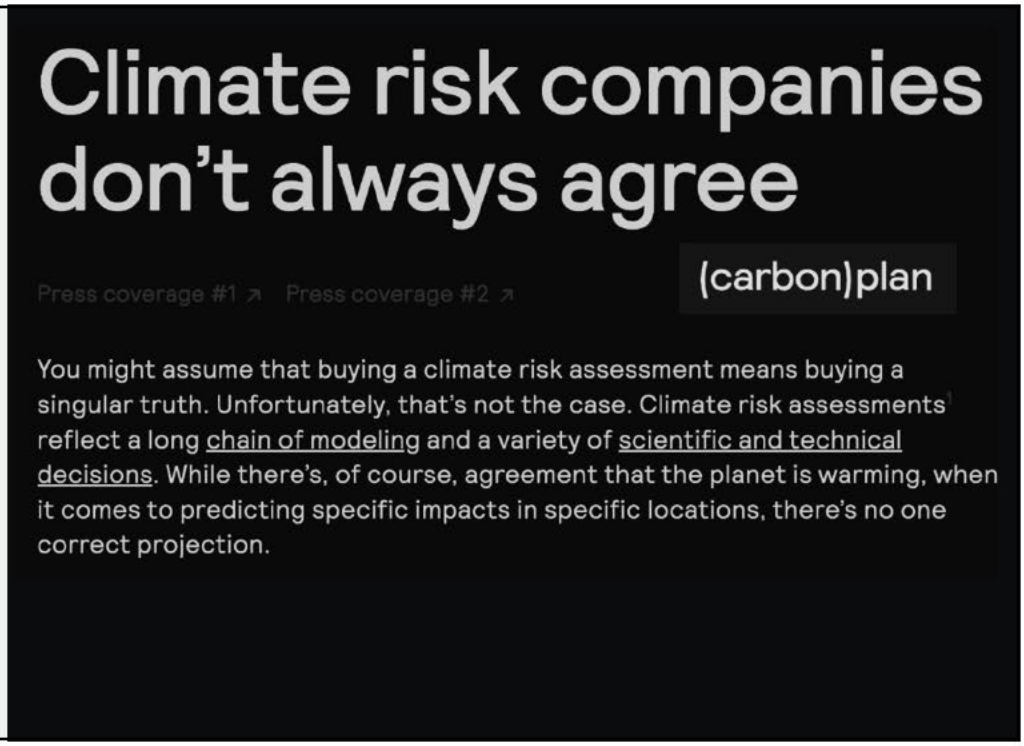
THE RISKY BUSINESS OF PREDICTING WHERE CLIMATE DISASTER WILL HIT

Climate tech companies can tell you the odds that a flood or wildfire will ravage your home. But what if their odds are all different?

By Eric Roston, Krishna Karra, Leslie Kaufman and Sinduja Rangarajan for **Bloomberg Green**
August 9, 2024

2024 Bloomberg Green

Climate analytics



Climate risk companies don't always agree

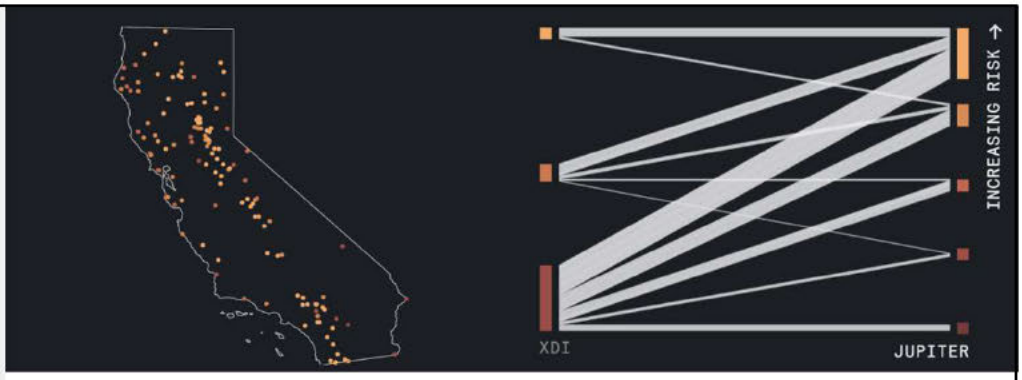
(carbon)plan

Press coverage #1 ↗ Press coverage #2 ↗

You might assume that buying a climate risk assessment means buying a singular truth. Unfortunately, that's not the case. Climate risk assessments reflect a long chain of modeling and a variety of scientific and technical decisions. While there's, of course, agreement that the planet is warming, when it comes to predicting specific impacts in specific locations, there's no one correct projection.

2024 Aug 09 CarbonPlan, 501(c)(3) registered in California

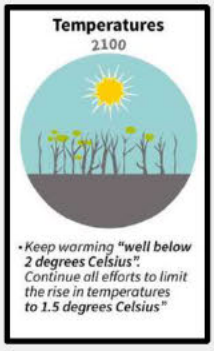
Climate analytics

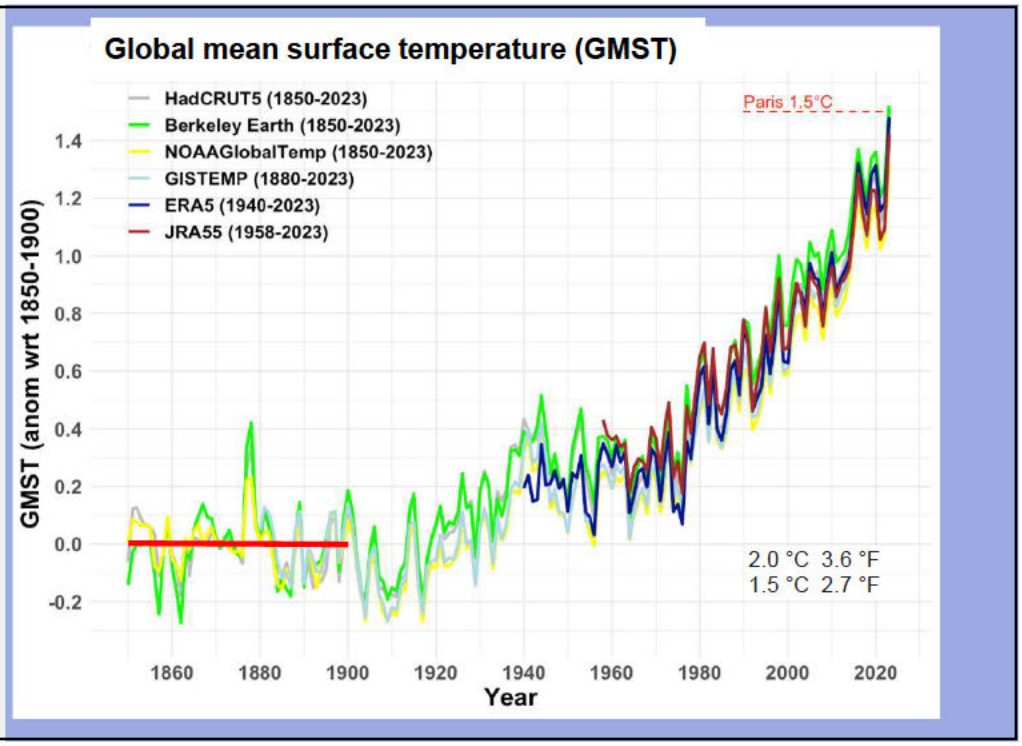


Divergent risk: Fire risk scores for 128 California locations in California from two climate analytics companies, XDI and Jupiter. Risk scores (historial, ca. 1995) are ordinal: XDI uses a three-tier scale and Jupiter a five-tier scale. The slopegraph compares the company risk scores for each location. Thicker lines indicate more locations with the given relationship. Any time lines cross it means the relative ranking differs. For future risk scenarios (not shown) XDI used RCP8.5 (CMIP5); Jupiter used SSP5-8.5 (CMIP6).
See: https://carbonplan.org/research/climate-risk-comparison

2024 Aug 09 CarbonPlan, 501(c)(3) registered in California

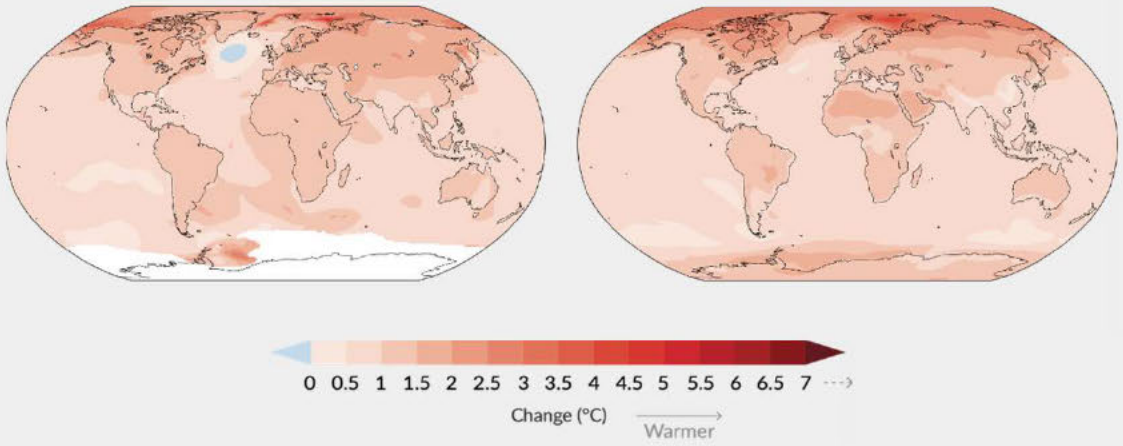
About climate impacts





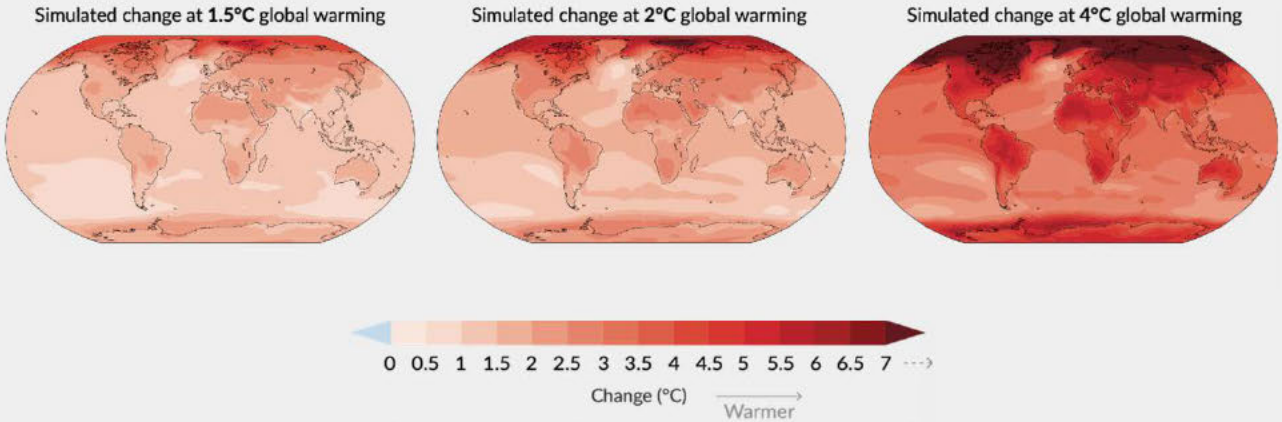
IPCC AR6
Figure SPM.5
Validation

Annual mean temperature change (°C) at 1°C global warming



IPCC AR6
Figure SPM.5
Projection

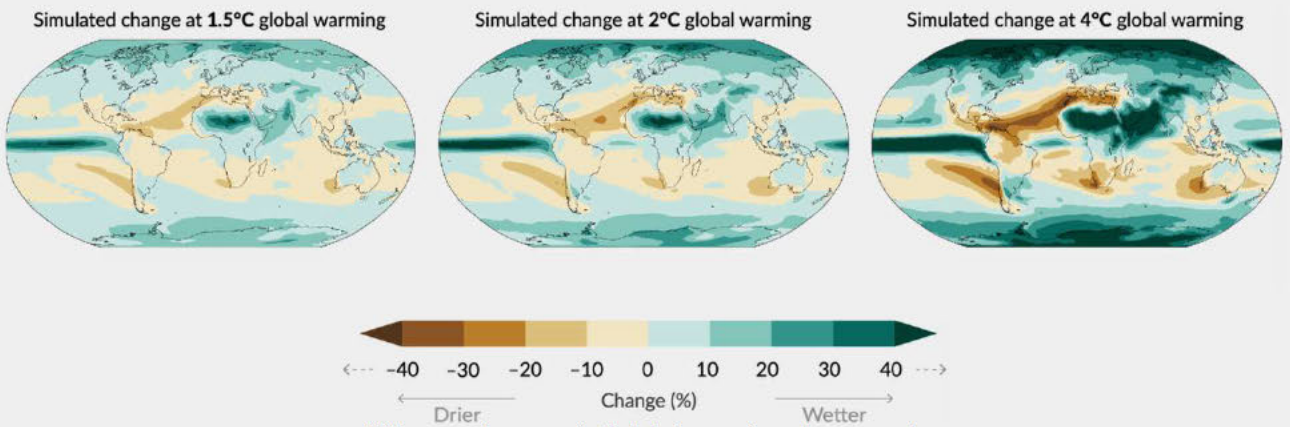
Annual mean temperature change (°C) relative to 1850-1900



With every increment of global warming, changes get larger in regional mean temperature and precipitation

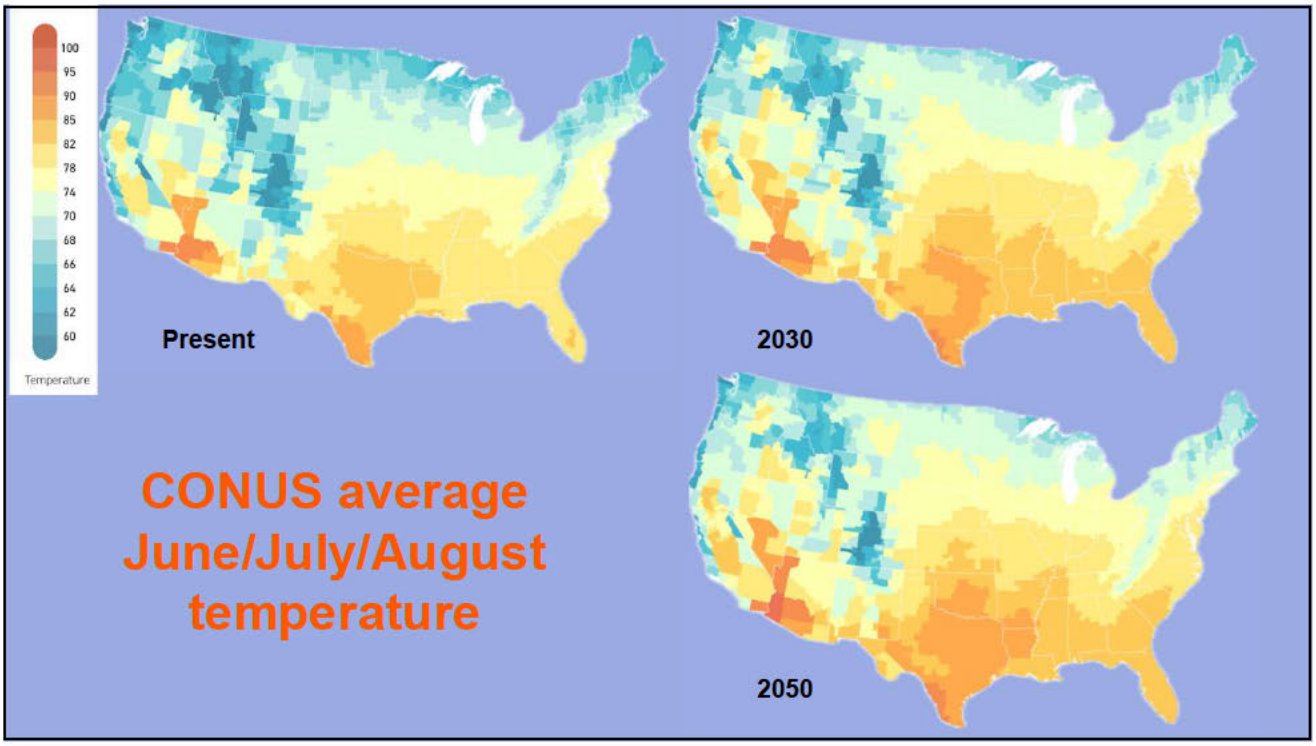
IPCC AR6
Figure SPM.5
Projection

Annual mean precipitation change (%) relative to 1850-1900

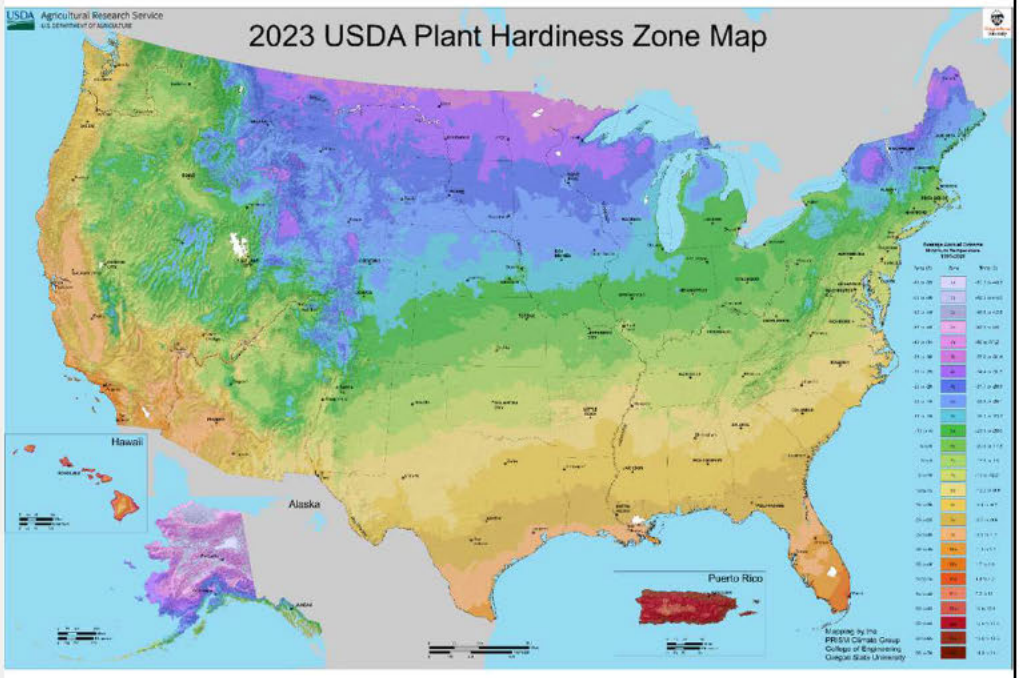


With every increment of global warming, changes get larger in regional mean temperature and precipitation

SIXTH ASSESSMENT REPORT Working Group I – The Physical Science Basis © IPCC 2022 ipcc

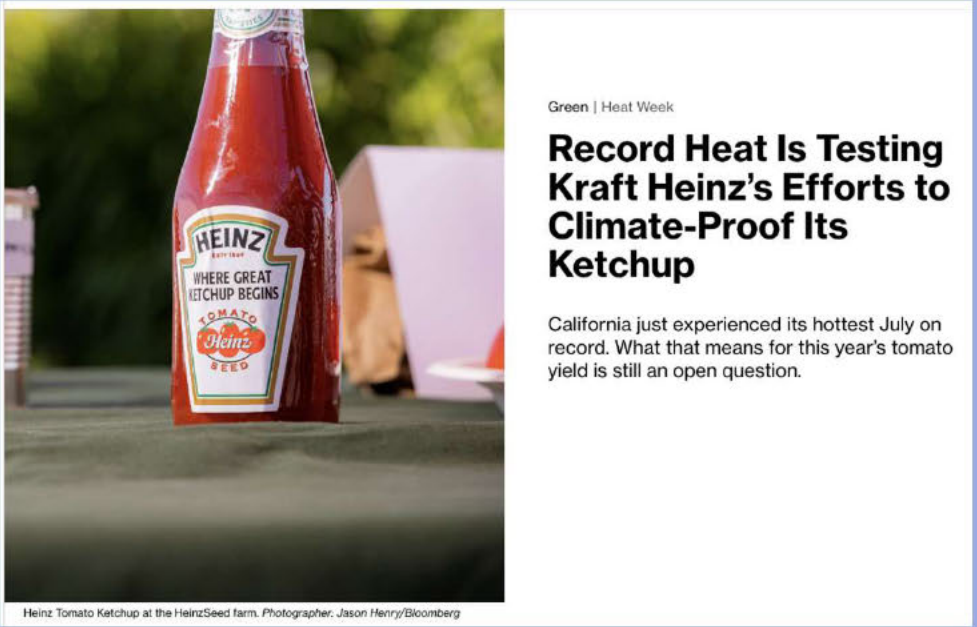


About climate impacts



2023 USDA update of 2012 zone map, which was an update of 1990 map. A loss of stability?
Source: USDA

About climate impacts



California, where all of the tomatoes for Heinz ketchup sold in the US are grown, just experienced its hottest July ever. Source: Bloomberg

About climate impacts

Since the beginning of August, 60 blood drives across the US have been cancelled due to extreme weather and heat
Source: Guardian, 20 Aug 2024

Climate crisis threatens medical blood supply in US amid extreme weather

Turnout at blood drives affected as summers get hotter and extreme weather causes cancellations, Red Cross warns

A person donates blood during a Children's Hospital Los Angeles blood donation drive in 2022. Photograph: Patrick T Fallon/AFP/Getty Images

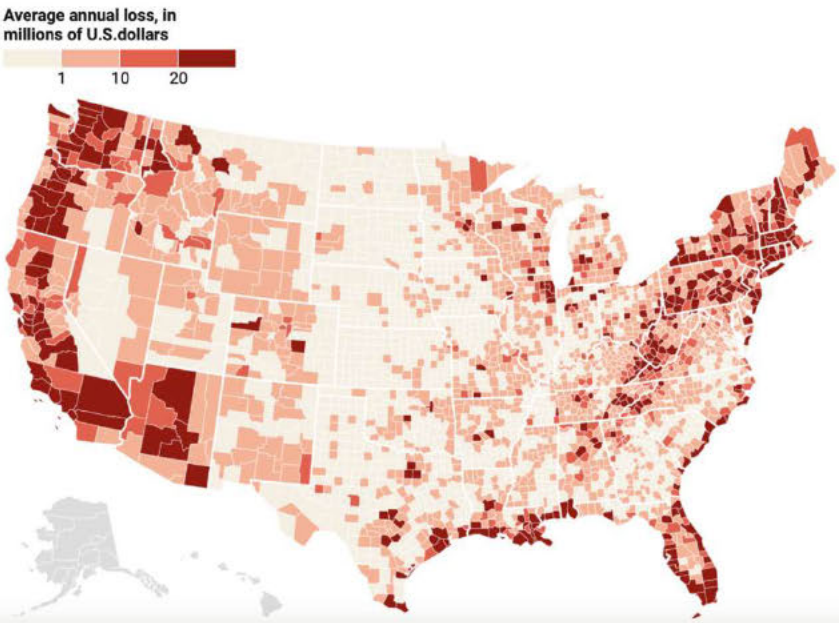
The climate crisis is threatening the medical blood supply in the US, with this summer's record heat contributing to an emergency blood shortage, the American Red Cross has warned.

About climate impacts

Flooding now
Flood risk is mainly concentrated on low income and white communities

Where flood costs tend to be highest today

US flood risk in 2020, reflected in the annual average loss due to flooding by county, shows the highest damage along the coasts, Appalachia and in the Northeast.

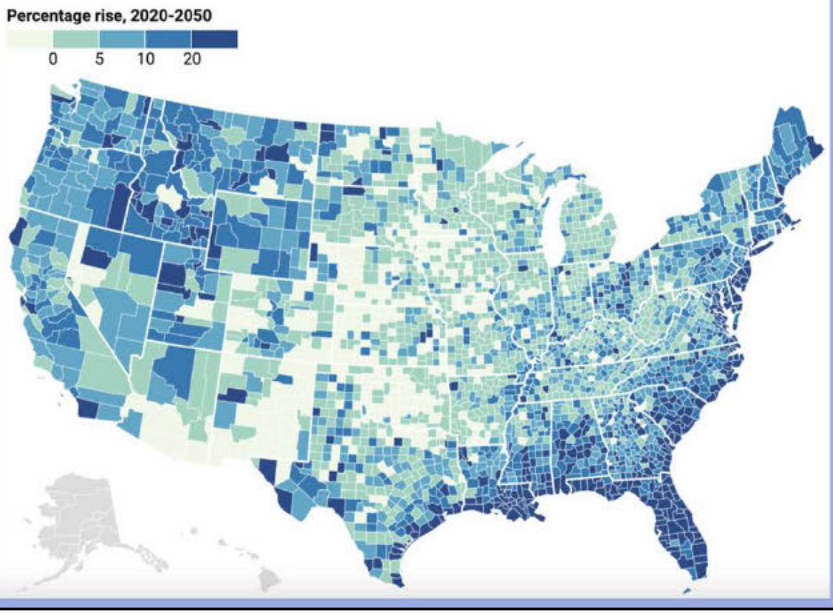


About climate impacts

Flooding later
Urban and rural areas alike from Texas through Florida to Virginia contain predominantly black communities projected to see at least a 20% increase in flood risk over the next 30 years.

Where flood risk is projected to rise fastest in the US

A new analysis projects changes in flood risk between 2020 and 2050 by zooming in on every neighborhood across the U.S. The map shows county-level data on the average annual loss due to flood damage.

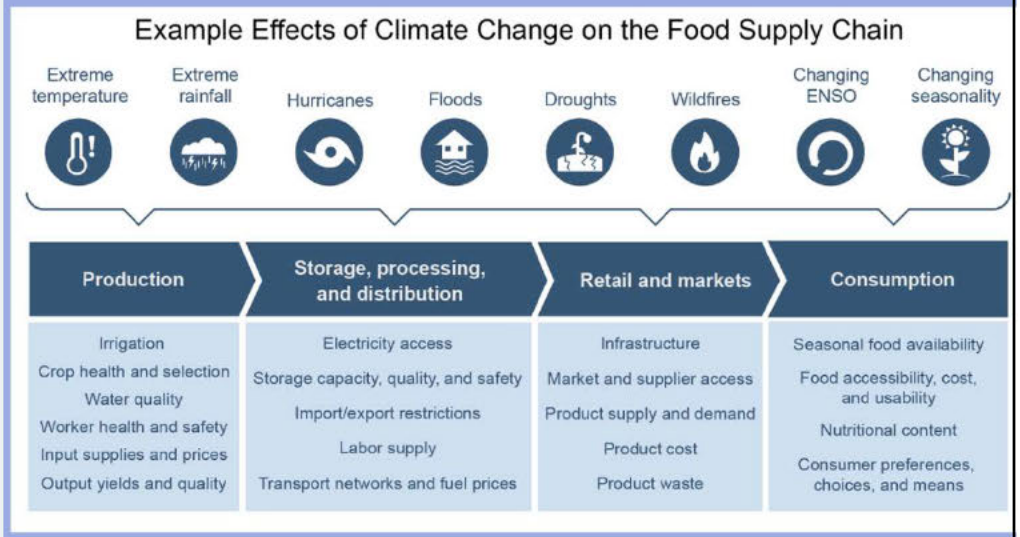


About climate impacts

2030 economic impact of future sea-level rise using value at risk in US$ million per year. Source: [Abadie et al. 2020]

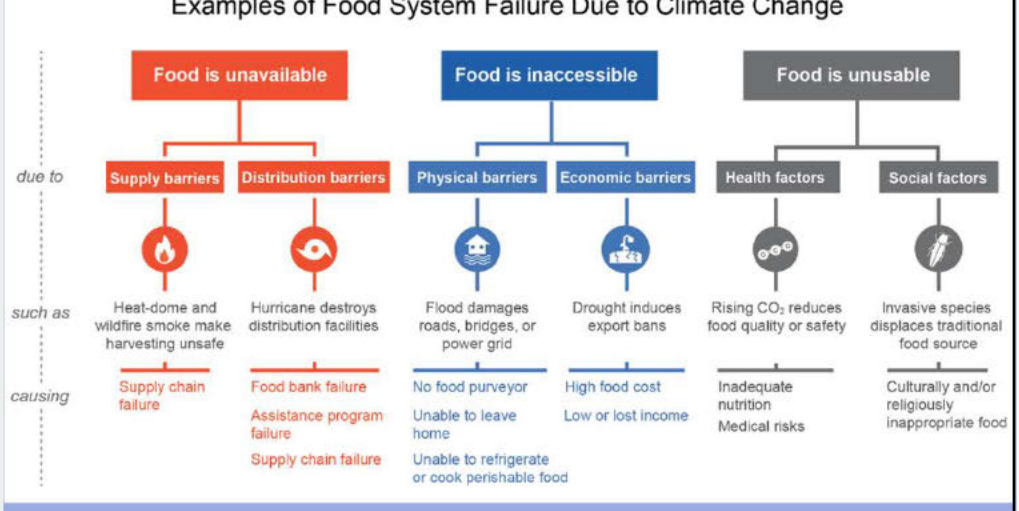
Rank	City	Value at Risk	
1	Guangzhou Guangdong	198	
2	New Orleans	145	13x increase in 2100
3	Mumbai	67	
4	Osaka-Kobe	59	
5	Tokyo	46	
6	Nagoya	40	
7	Calcutta	31	
8	Tianjin	25	
9	Alexandria	21	
10	Guayaquil	20	
11	Fukuoka-Kitakyushu	17	
12	Vancouver	15	
13	New York	12	26x increase in 2100
14	Bangkok	12	
15	Jakarta	12	
16	Zhanjiang	12	
17	Shenzhen	12	
18	Boston	11	
19	Xiamen	8	
20	Hiroshima	8	
21	Abidjan	7	
22	Miami	6	
23	Taipei	5	
24	Houston	5	
25	Surat	5	
26	Chennai	5	
27	Ho Chi Minh City	4	
28	Los Angeles	4	
29	Hai Phong	4	
30	Dhaka	3	

About climate impacts



Climate change has cascading and compounding effects on all stages of the food supply chain.
Source: NCA5

About climate impacts



Climate change is expected to increase risks to food security in multiple ways.
Source: NCA5

A likely climate future

Toward a world of more extreme extremes

Future Rainfall and Storm Surge Events in Chelsea, MA

Future return period of historical (2001-2020) event

	2041-2060	2071-2090
1-in-100 year 1% annual chance 7.99 inches	1-in-34 year 2.9x as likely 10.63 inches	1-in-26 year 3.8x as likely 12.42 inches

How to Interpret: In the year 2071-2090, what is today considered a 1-in-100 year rainfall event will become a 1-in-26 year storm, indicating it is almost 4x as likely to occur. 10.63 inches of rain will fall, as compared to the present 7.99 inches.

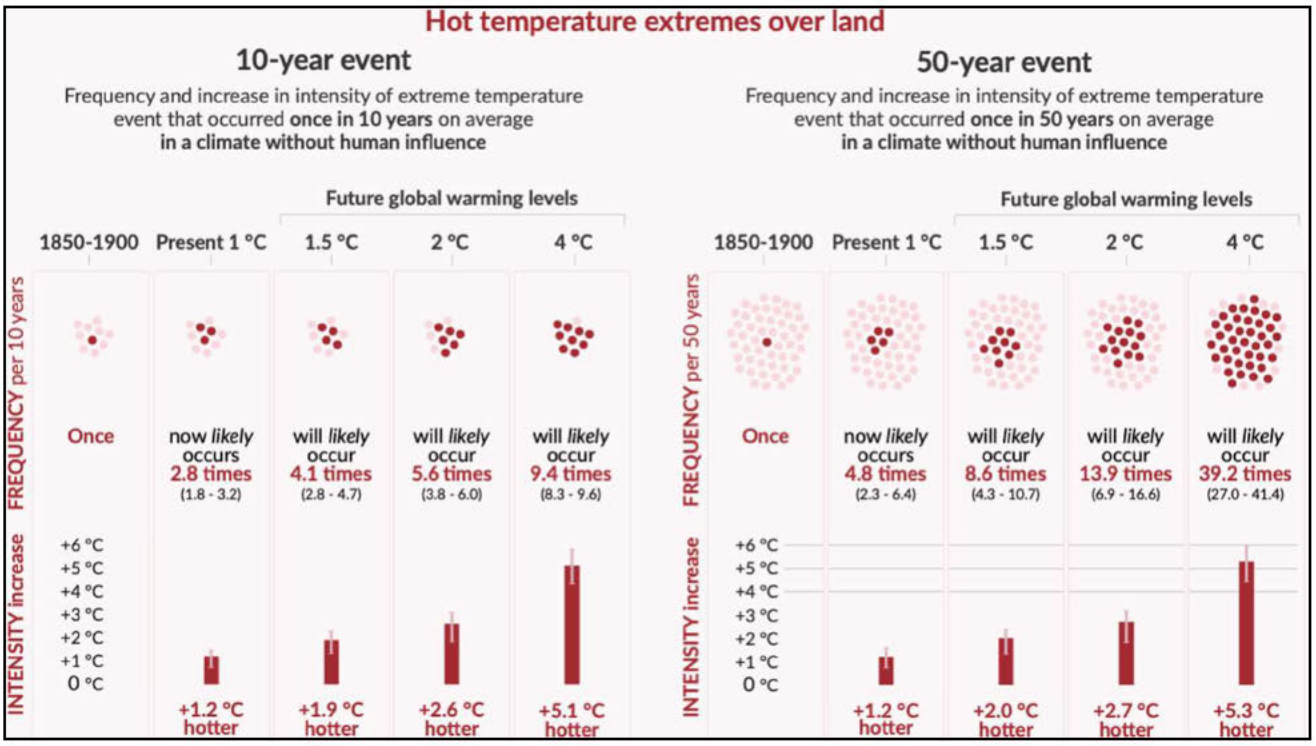
Rainfall

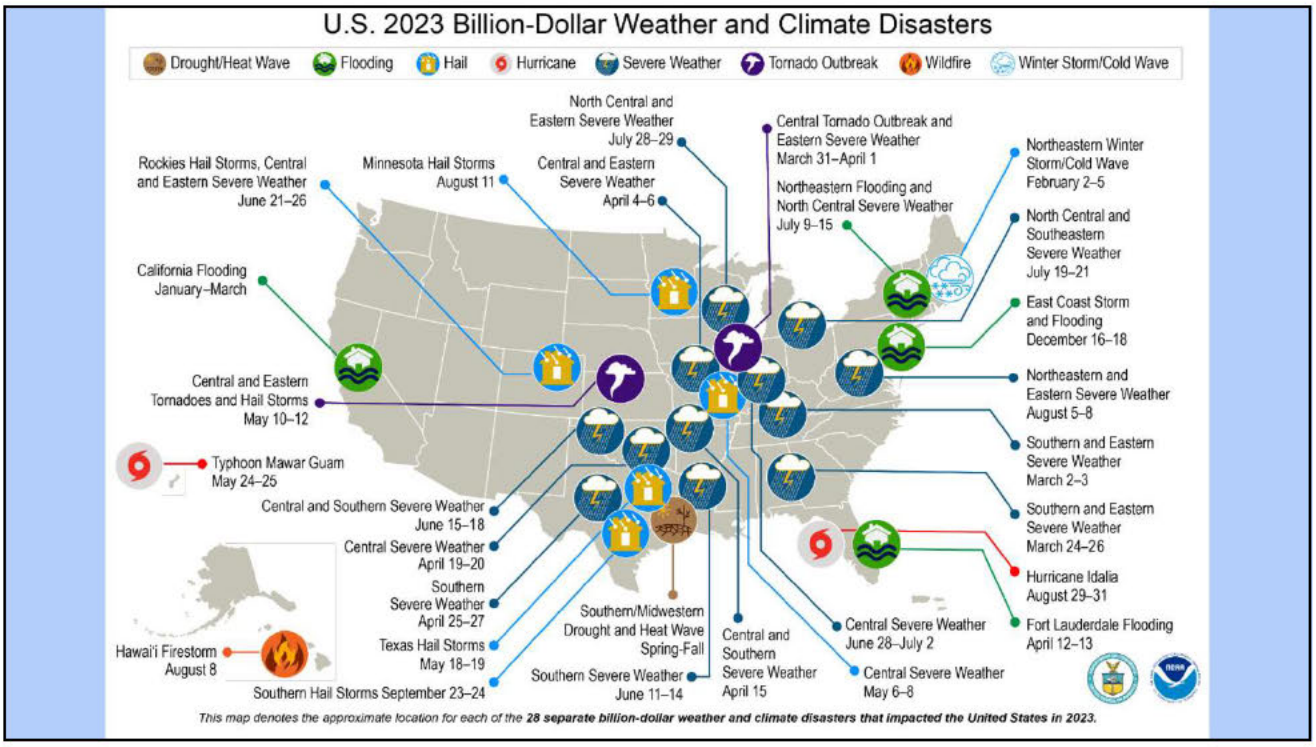
	2041-2060	2071-2090
1-in-100 year 1% annual chance 10.04 feet	1-in-28 year 3.6x as likely 10.96 feet	1-in-12 months 100x as likely 14.04 feet

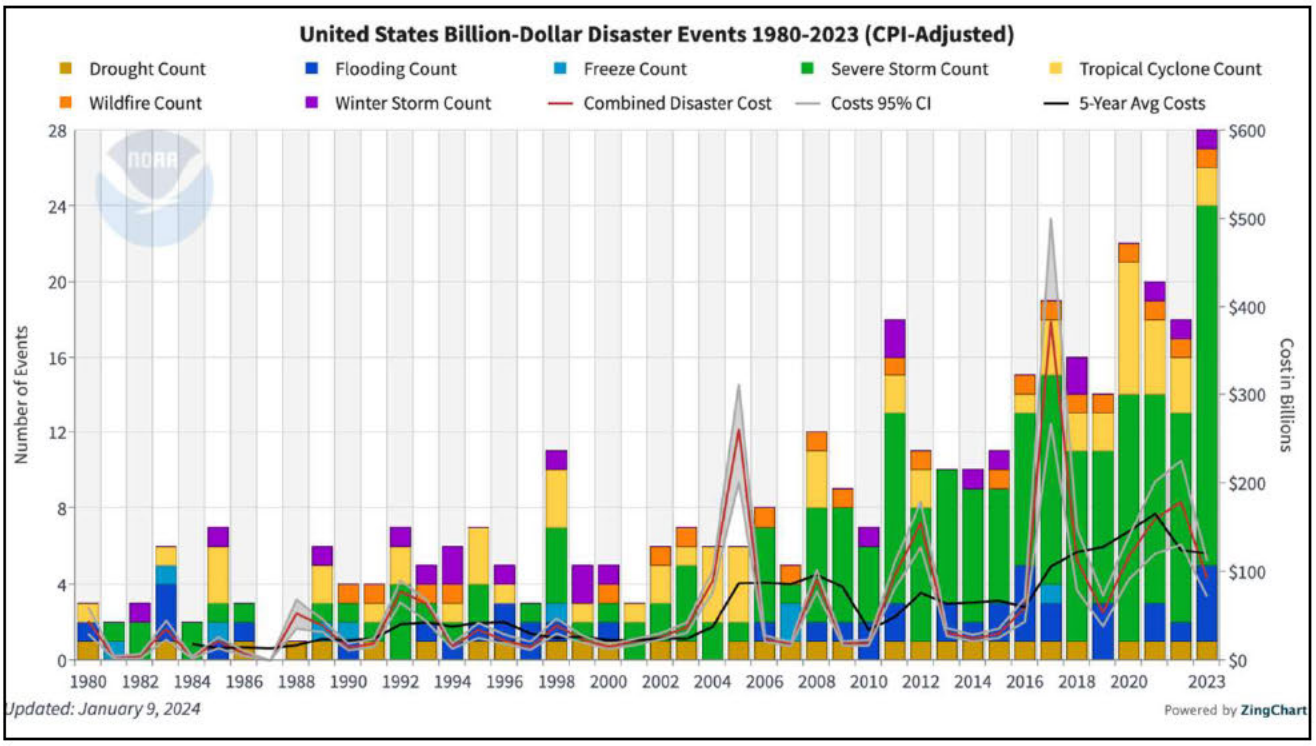
Storm Surge

A present-day 1-in-100 year storm surge event will likely occur every year by 2080.

Hot temperature extremes over land




U.S. 2023 Billion-Dollar Weather and Climate Disasters
Drought/Heat Wave
Flooding
Hail
Hurricane
Severe Weather
Tornado Outbreak
Wildfire
Winter Storm/Cold Wave
Rockies Hail Storms, Central and Eastern Severe Weather June 21–26
Minnesota Hail Storms August 11
North Central and Eastern Severe Weather July 28–29
Central and Eastern Severe Weather April 4–6
Central Tornado Outbreak and Eastern Severe Weather March 31–April 1
Northeastern Flooding and North Central Severe Weather July 9–15
Northeastern Winter Storm/Cold Wave February 2–5
North Central and Southeastern Severe Weather July 19–21
East Coast Storm and Flooding December 16–18
California Flooding January–March
Central and Eastern Tornadoes and Hail Storms May 10–12
Northeastern and Eastern Severe Weather August 5–8
Southern and Eastern Severe Weather March 2–3
Typhoon Mawar Guam May 24–25
Central and Southern Severe Weather June 15–18
Southern and Eastern Severe Weather March 24–26
Central Severe Weather April 19–20
Hurricane Idalia August 29–31
Southern Severe Weather April 25–27
Southern/Midwestern Drought and Heat Wave Spring-Fall
Fort Lauderdale Flooding April 12–13
Hawai'i Firestorm August 8
Texas Hail Storms May 18–19
Central and Southern Severe Weather April 15
Central Severe Weather June 28–July 2
Southern Hail Storms September 23–24
Southern Severe Weather June 11–14
Central Severe Weather May 6–8
This map denotes the approximate location for each of the 28 separate billion-dollar weather and climate disasters that impacted the United States in 2023.


United States Billion-Dollar Disaster Events 1980-2023 (CPI-Adjusted)
Drought Count
Flooding Count
Freeze Count
Severe Storm Count
Tropical Cyclone Count
Wildfire Count
Winter Storm Count
Combined Disaster Cost
Costs 95% CI
5-Year Avg Costs
Number of Events
Cost in Billions
0
4
8
12
16
20
24
28
$0
$100
$200
$300
$400
$500
$600
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2023
Updated: January 9, 2024
Powered by ZingChart

Finance

Swiss Re says natural catastrophe insured losses hit $50 bln in H1

By Simon Jessop, Alessandro Parodi and Laura Lenkiewicz

August 9, 2023 5:48 PM GMT+2 · Updated 2 months ago

REUTERS

Why insurance companies are pulling out of California and Florida, and how to fix some of the underlying problems

Published: June 7, 2023 2.24pm CEST

THE CONVERSATION

Third consecutive year of weather-event insurance claims exceeding $100bn: Bloomberg Intelligence

Reinsurance News

23rd August 2023 - Author: Akankshita Mukhopadhyay

In a recently released insurance sector report, Bloomberg Intelligence has forecasted that 2023 is poised to mark the third consecutive year in which insured losses stemming from natural catastrophes will surpass $100 billion, primarily due to a surge in weather-related claims.

FITCH WIRE

Global Reinsurers Pull Back from Natural Catastrophe Cover

Thu 24 Aug, 2023 - 5:09 AM ET

Fitch Ratings-Chicago/Frankfurt/London-24 August 2023: Global reinsurers are cutting back on the cover they provide against medium-sized natural catastrophe risks due to investor pressure after several years of large catastrophe losses and improved profitability in other parts of the market, Fitch Ratings says.

The New York Times

CALCULATOR

As Natural Disasters Get Worse, So Do Home Insurance Premiums

U.S. insurers paid out $99 billion in weather-related claims in 2022, according to a recent study. So they're passing along more of the cost.

A likely climate future

UN environment programme

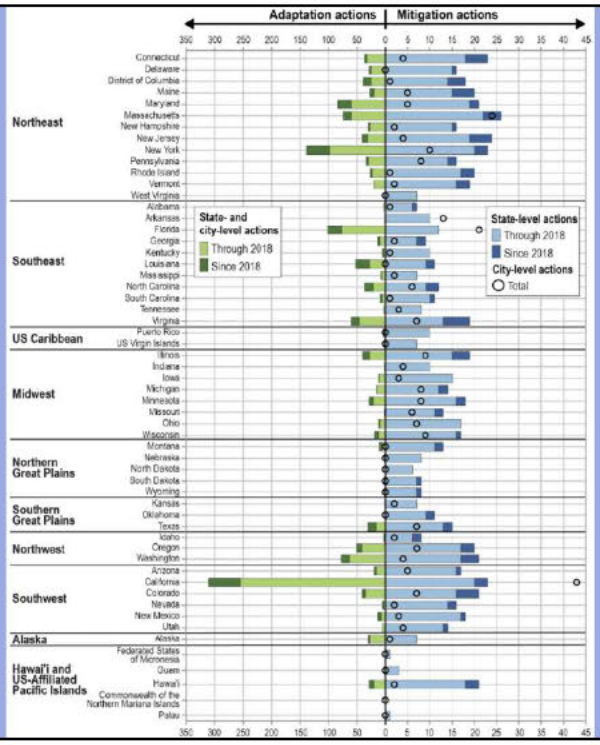
Emissions Gap Report 2023

If current policies are continued, global warming is estimated to be limited to 3°C. Delivering on all unconditional and conditional pledges by 2030 lowers this estimate to 2.5°C, with the additional fulfilment of all net-zero pledges bringing it to 2°C

- A continuation of the level of climate change mitigation efforts implied by current policies is estimated to limit global warming to 3°C (range: 1.9–3.8°C) throughout the century with a 66 per cent chance. Warming is expected to increase further after 2100 as CO_2 emissions are not yet projected to reach net-zero levels.
- A continuation of the unconditional NDC scenario lowers this estimate to 2.9°C (range: 2–3.7°C), whereas the additional achievement and continuation of conditional NDCs lowers this by around 0.4°C to 2.5°C (range: 1.9–3.6°C).
- In the most optimistic scenario where all conditional NDCs and net-zero pledges, including those made as part of long-term low-emissions development strategies, are assumed to be fully achieved, global warming is projected to be limited to 2°C (range: 1.8–2.5°C) with 66 per cent chance over the course of the century. However, as noted previously, net-zero pledges remain highly uncertain.

Adaptation and mitigation actions

Cities and states are acting on climate change, with a substantial increase in new activities underway since 2018. Source: NCA5



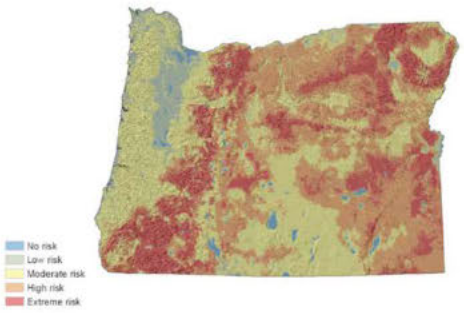
About climate impacts

2022 State Sen. Jeff Golden, D-Ashland, championed the bill as a way to prepare the state for hotter, drier summers and more fire risk that come along with climate change.

Swamped by public outcry, Oregon withdraws controversial wildfire risk map

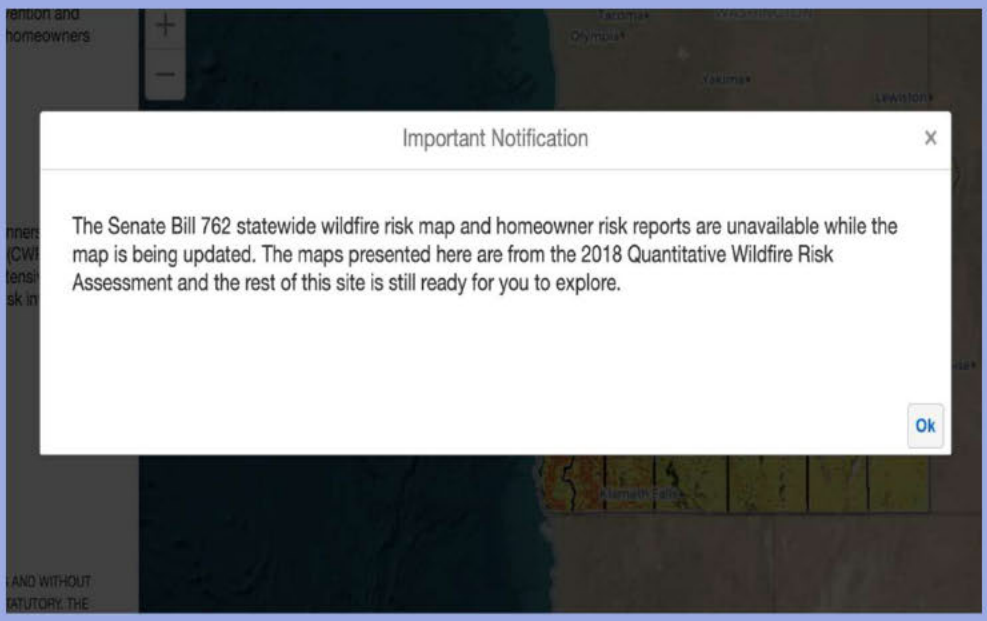
By Cassandra Profita (OPB)
Aug. 6, 2022 12:54 a.m.

Oregon Department of Forestry has been inundated with complaints after releasing a map of wildfire risk on every tax lot in the state.



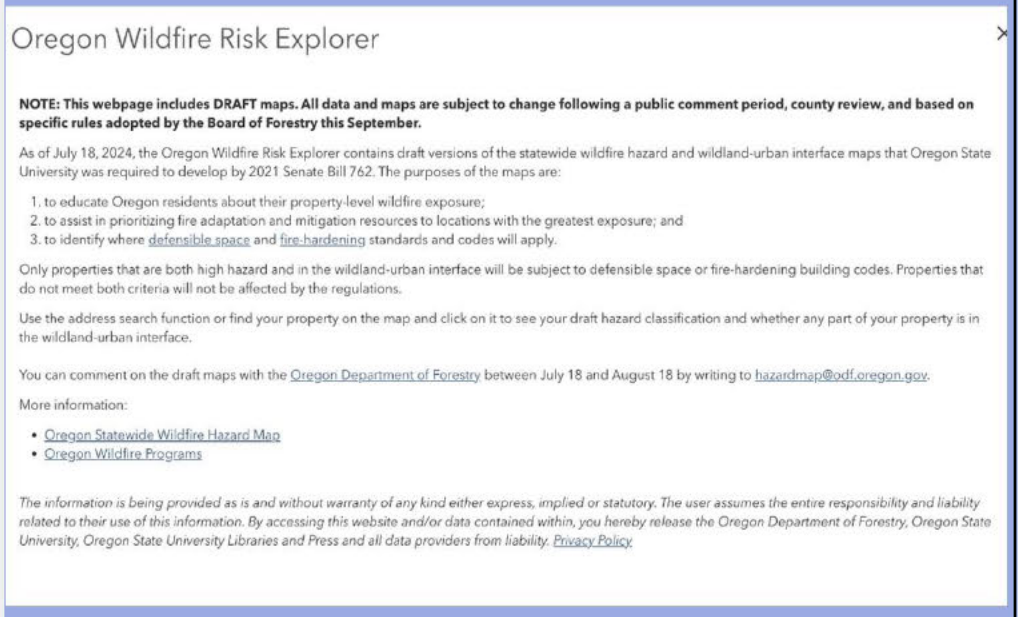
The Oregon Wildfire Risk Explorer map, created by Oregon State University as part of a new wildfire policy directed by Senate Bill 762, outlines wildfire risk at the property ownership level across the state.
Oregon Wildfire Risk Explorer

About climate impacts



2023 SB 762

About climate impacts



2024 SB 762


Thank you
Woodwell
Climate
Research
Center

SEA-LEVEL RISE AND COMMUNITY RESPONSE

DIVIDER 10

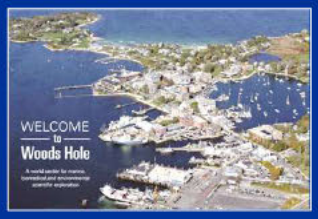
Ms. Shannon Hulst

Sea-Level Rise and Community Response

Shannon Hulst, CFM

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE

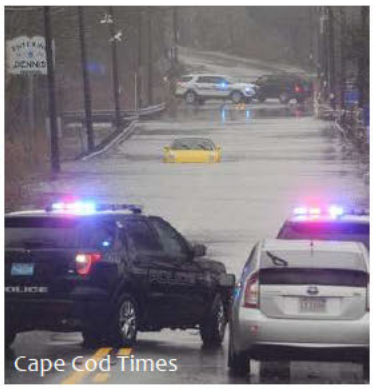


Outline

- Overview of flooding and erosion and how they relate to climate change
- Response Timeframes
  - In-event
  - Post-event
  - Long term

How flooding and erosion relate to climate change

First Responders

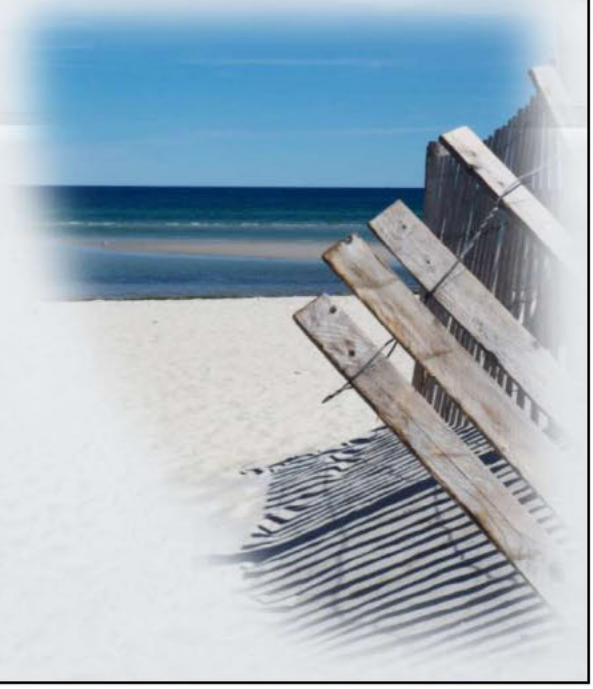


Public Works

MyCoast

Storm Team Documentation

Short-Term Response



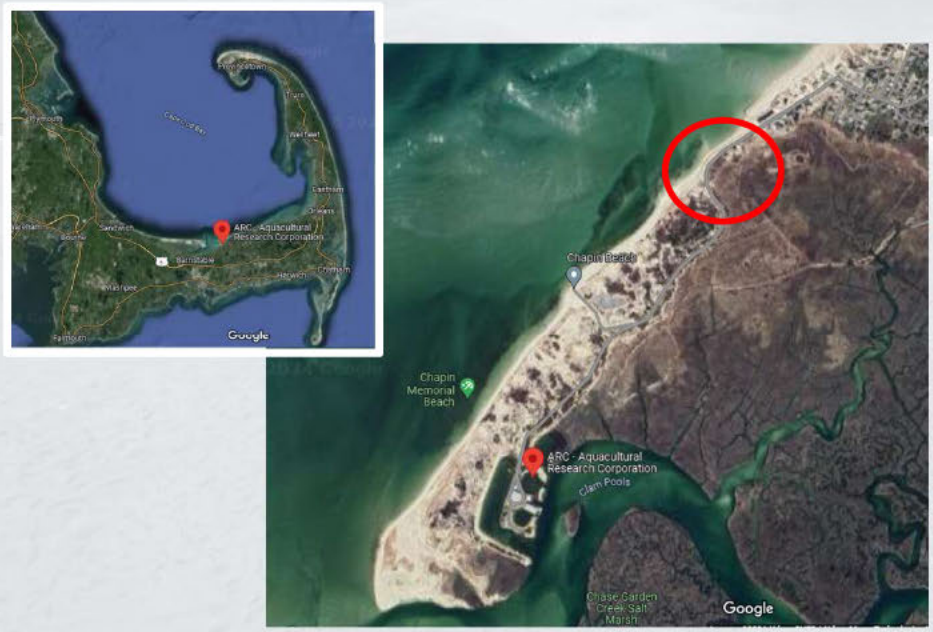
Sea Grant

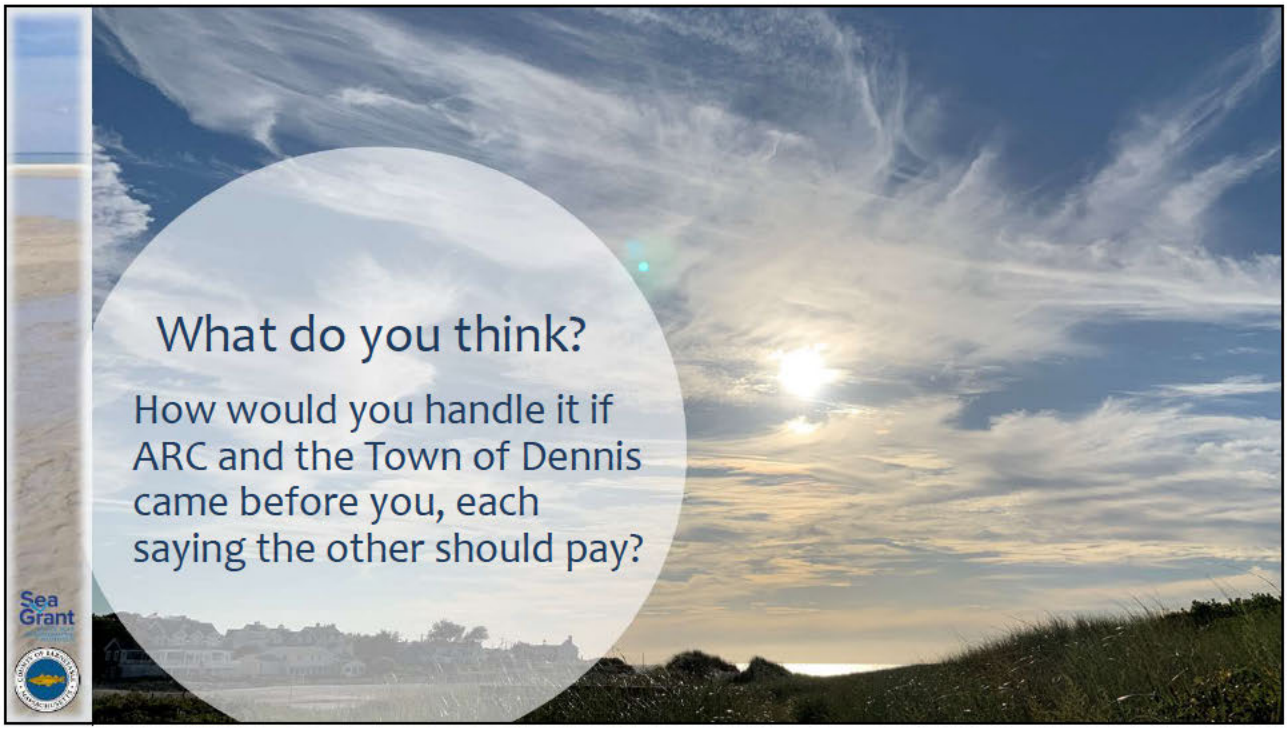
Aquaculture Research Corporation

Dennis, MA

Aquaculture Research Corporation

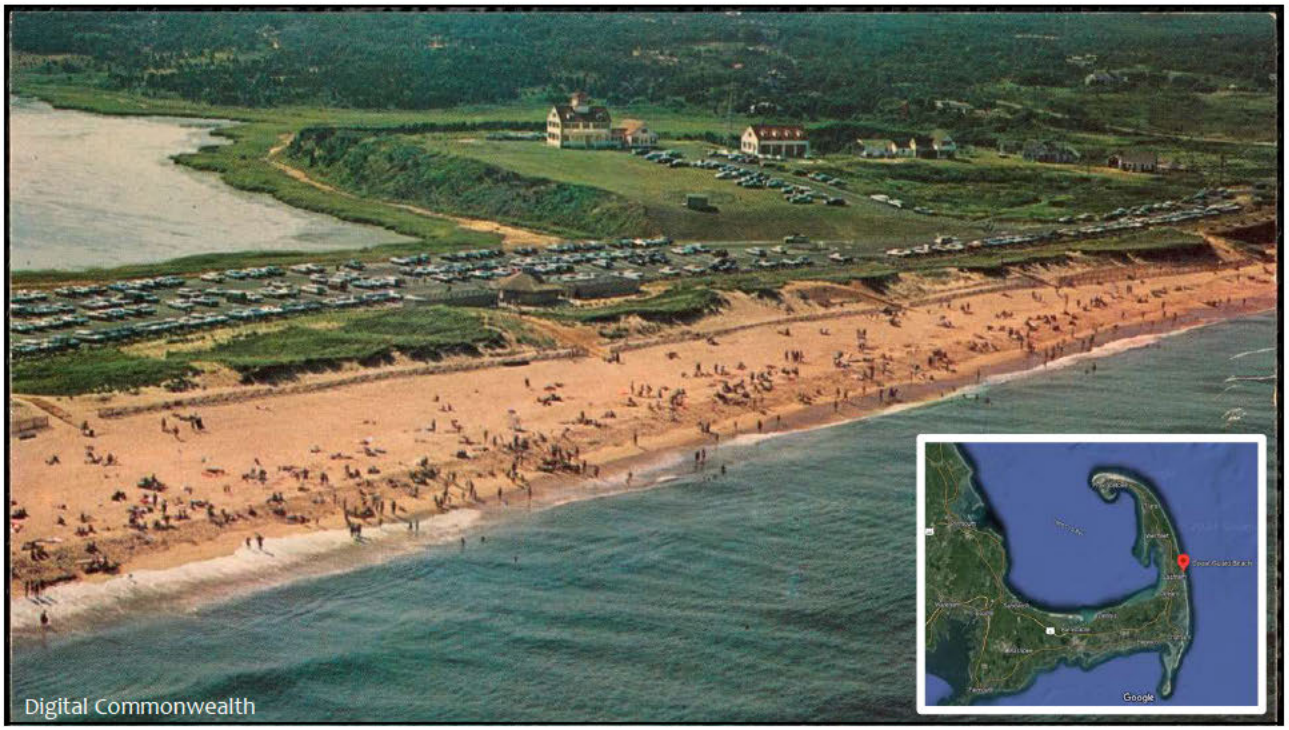
Dennis, MA




What do you think?
How would you handle it if ARC and the Town of Dennis came before you, each saying the other should pay?
Sea Grant

Coast Guard Beach

Eastham, MA




Coast Guard Beach, Cape Cod National Seashore
Spencer Kennard
www.capecodphotos.com


AREA
CLOSED
No Beach
Access


Coast Guard Beach
Coast Guard Beach
Google


WARNING
www.mycapecodblog.com


Do you remember?
How does sea level rise contribute to erosion?
Sea Grant


Town Neck Beach
Sandwich, MA

Cape Cod Commission Chronology Viewer


What do you think?
Is anyone familiar with Harvey Cedars vs. Karan?
Sea Grant

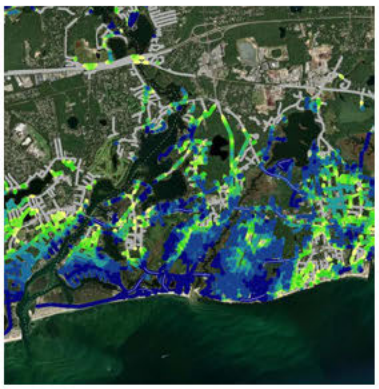

Long-Term Response
Sea Grant

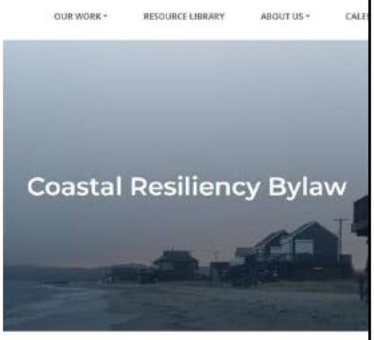

Photo: Ptownie
Low Probability
High Consequence


Town Level Planning
RESILIENT WOODS HOLE
PRIVATE-PUBLIC INVESTMENT TO ENSURE THE FUTURE
Coastal Resiliency Information
Welcome to the Coastal Resiliency Webpage
TOWN PROJECTS
TOWN STUDIES
TOWN PLANS
COMMUNITY ENGAGEMENT
RESOURCES FOR HOMEOWNERS
Hyannis Harbor Plan
Flood Map
Flooding Photos (October 2022)
Sea Grant
Municipal Vulnerability Preparedness (MVP) program
Learn more about our Climate MVP program that supports cities and towns as they build resilience to climate change.
WELLFLEET
2022 Hazard Mitigation Plan

Regional Planning

CAPE COD COMMISSION





Regulations

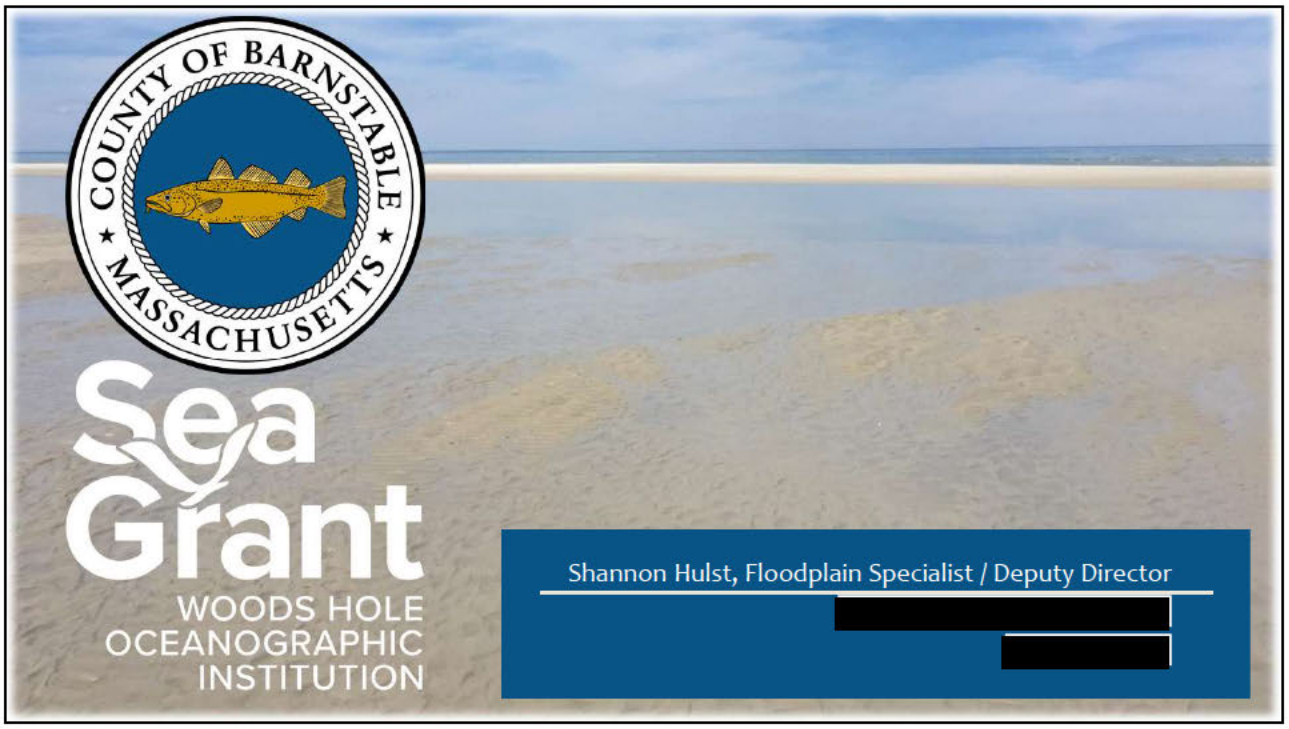
- Where to build
- How high to build
- What materials to use below flood levels
- Acceptable uses below flood levels

Sea Grant

Outreach, Trainings, Technical Assistance

- Town Staff
- Engineers & Surveyors
- Homebuilders & Remodelers
- Realtors
- Homeowners
- Public

Sea Grant


COUNTY OF BARNSTABLE
MASSACHUSETTS
Sea Grant
WOODS HOLE OCEANOGRAPHIC INSTITUTION
Shannon Hulst, Floodplain Specialist / Deputy Director
[redacted]
[redacted]

HEALTH IMPACTS

DIVIDER 11

Jesse E. Bell, Ph.D.

OBJECTIVES:

After this session, you will be able to:

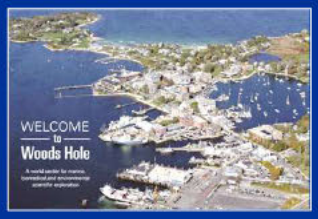
1. Describe the pathways of health impacts from climate change and the mechanisms of those impacts;
2. Describe the implications of social determinants of health on the outcomes associated with climate change; and
3. Explain the impact of climate change on health risks for different populations.

Health Impacts

Jesse E. Bell, Ph.D.

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE



Health Impacts of Climate Change

Jesse E. Bell, PhD
Claire M. Hubbard Professor of Water, Climate and Health
Executive Director of Water, Climate and Health Program at UNMC
Director of Water, Climate and Health at Daugherty Water for Food Global Institute
Professor - UNL School of Natural Resources
Department of Environmental, Agricultural, and Occupational Health
College of Public Health
University of Nebraska Medical Center

THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE at the University of Nebraska

University of Nebraska System

COLLEGE OF AGRICULTURAL SCIENCES AND NATURAL RESOURCES

University of Nebraska Medical Center

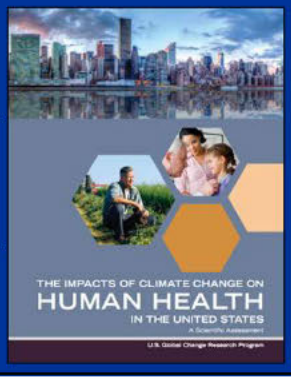
Learning Objectives

- Describe the pathways of health impacts from climate change and the mechanisms of those impacts.
- Describe the implications of social determinants of health on the outcomes associated with climate change.
- Explain the impact of climate change on health risks for different populations.

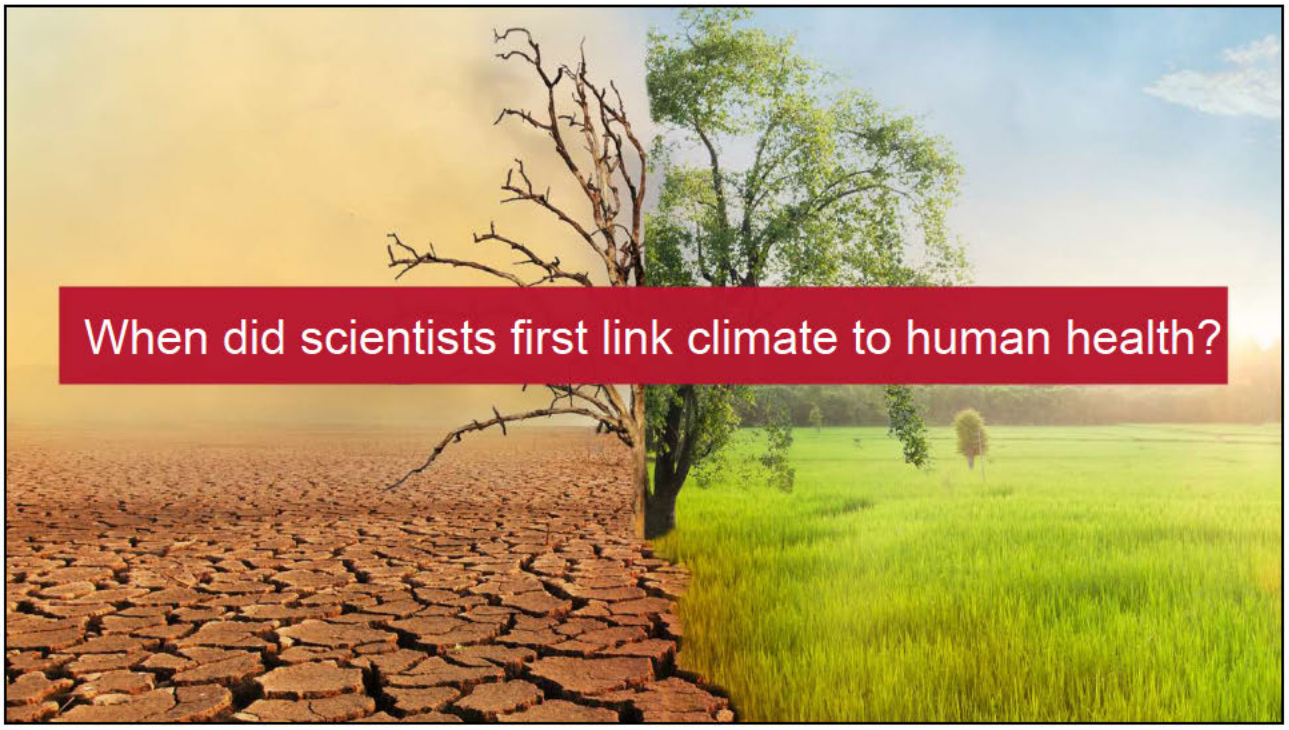
Executive Summary

Climate change is a significant threat to the health of the American people.

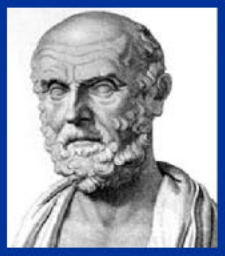
Every American is vulnerable to the health impacts associated with climate change



health2016.globalchange.gov



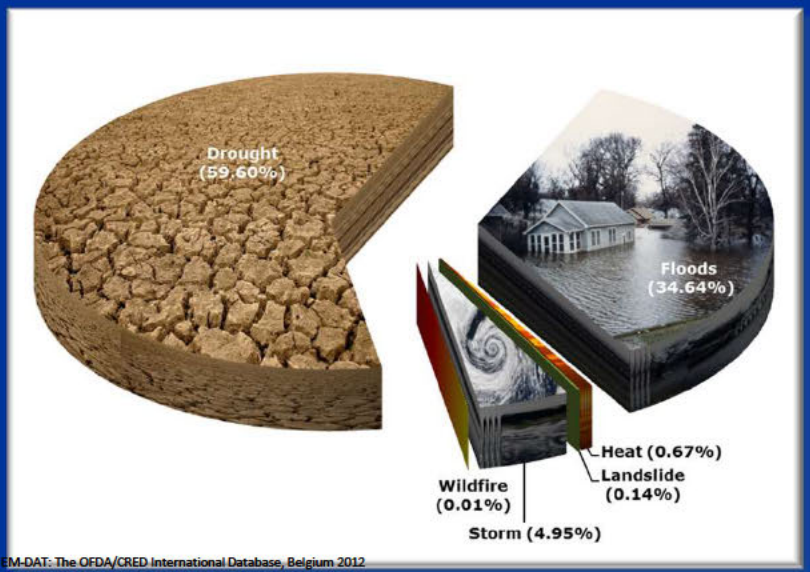
A Long History of Climate & Health



Hippocrates wrote about epidemics in 400 B.C.E. and noted the change in weather

1814 Dr. James Tilton, Surgeon General of the Army, directed all hospital surgeons to keep weather records

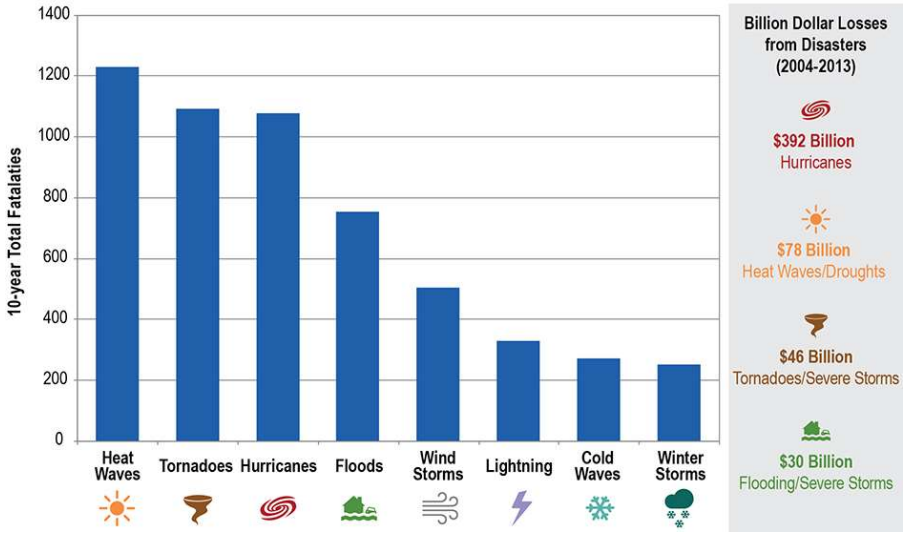
Percentage of disaster-deaths worldwide according to each category of climate-related hazard, (1900-2013)



Source: Adapted from EM-DAT: The OFDA/CRED International Database, Belgium 2012
Keim, ME Extreme Weather Events: the role of public health

Costs of Extreme Events

Estimated Deaths and Billion Dollar Losses
from Extreme Events in the U.S., 2004–2013



Climate is Affecting Your Health

Direct

Affecting Health Directly →
- Extreme Heat
- Air Pollution
- Extreme Weather

Indirect

Spreading Disease →
- Diseases Spread by Insects, Ticks, and Rodents
- Contaminated Water
- Contaminated Food

Destroying & Disrupting Food Supplies →
- Hunger and Malnutrition

Disrupting Well-Being →
- Mental Health Problems
- Conflict and Displacement

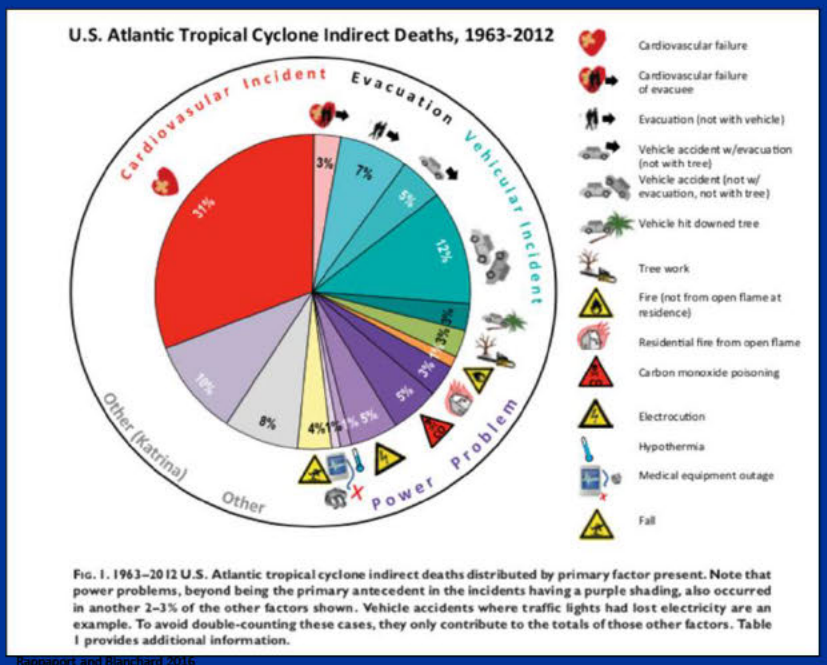
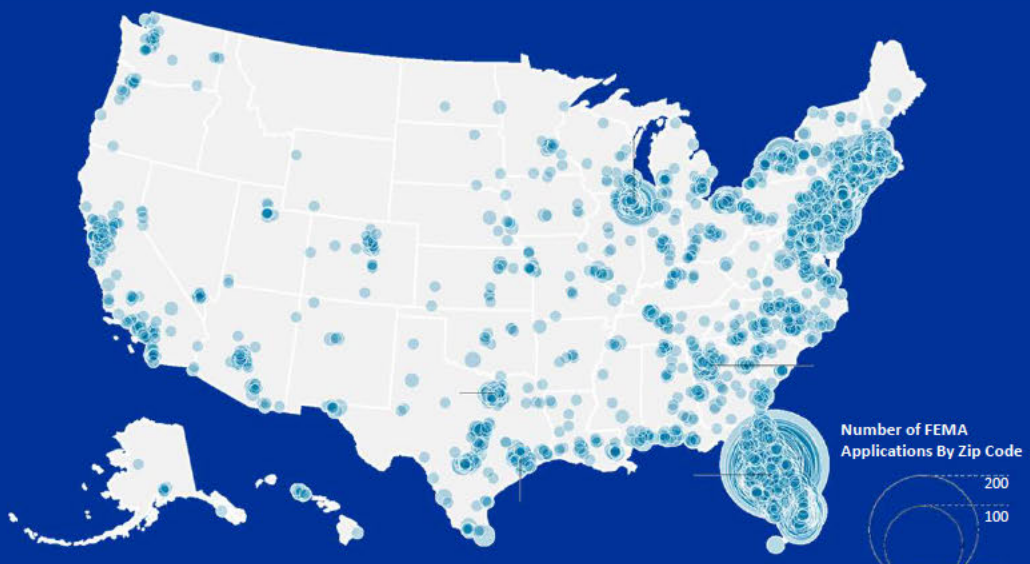


FIG. 1. 1963–2012 U.S. Atlantic tropical cyclone indirect deaths distributed by primary factor present. Note that power problems, beyond being the primary antecedent in the incidents having a purple shading, also occurred in another 2–3% of the other factors shown. Vehicle accidents where traffic lights had lost electricity are an example. To avoid double-counting these cases, they only contribute to the totals of those other factors. Table 1 provides additional information.

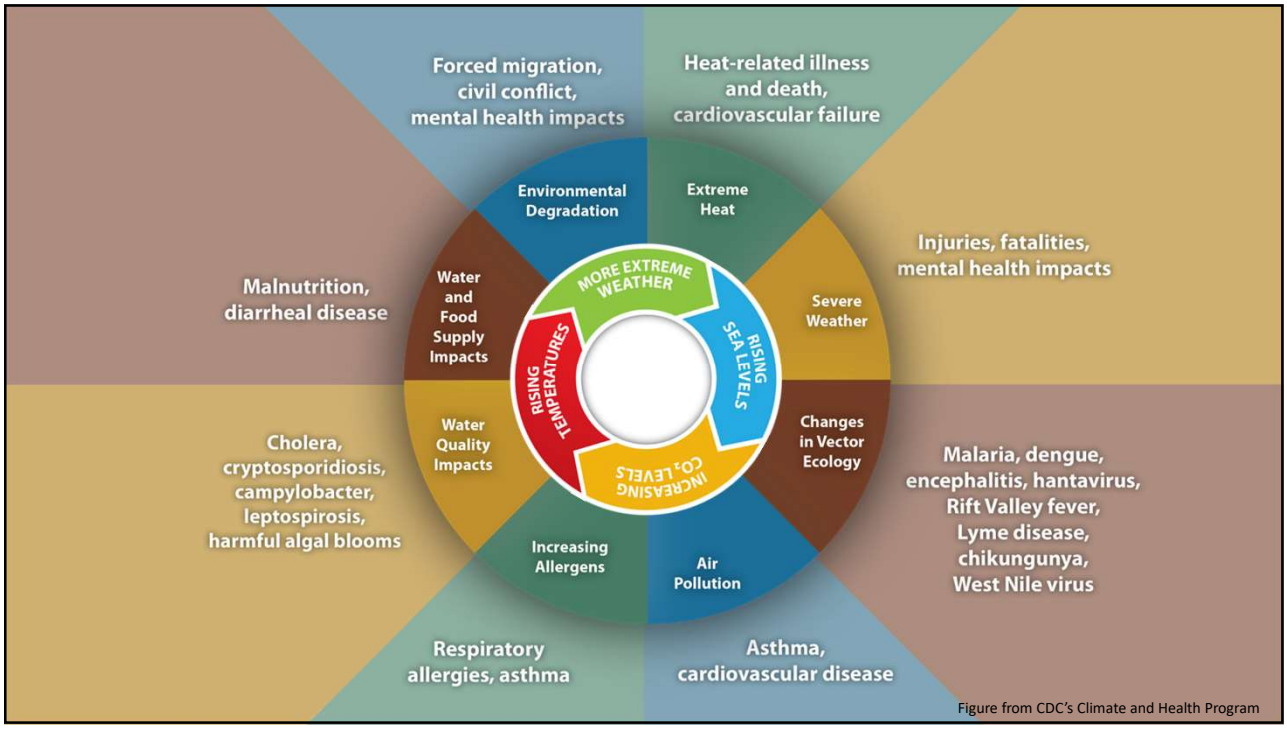
Rappaport and Blanchard 2016

Estimate of People Displaced by Hurricane Maria

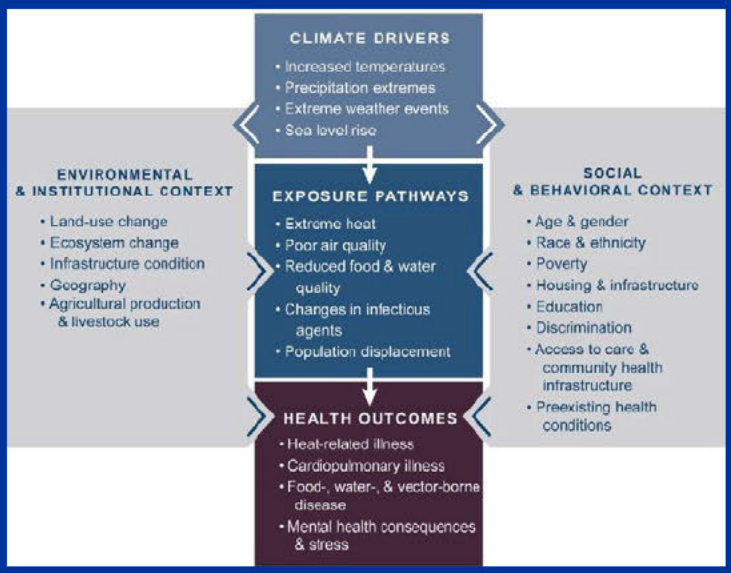


Source: CNN analysis, Federal Emergency Management Agency

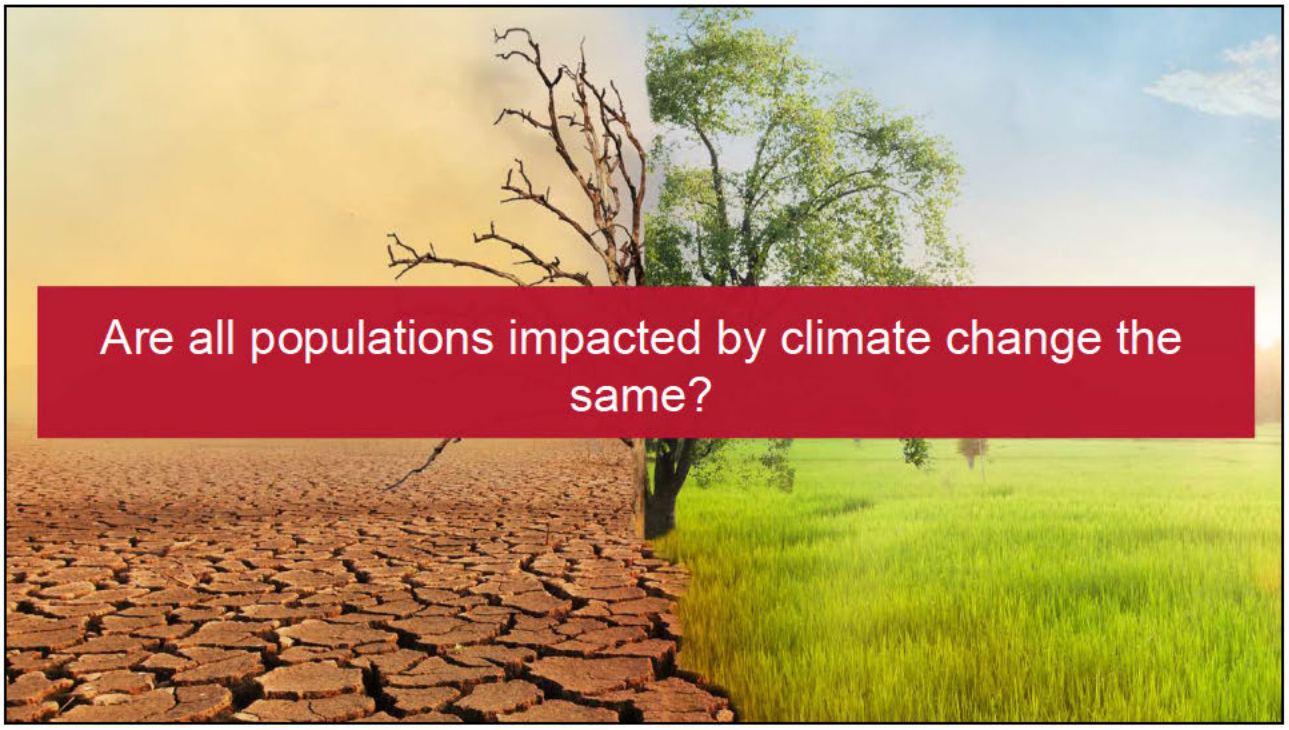

What are some pathways for climate change to impact health?


Forced migration, civil conflict, mental health impacts
Heat-related illness and death, cardiovascular failure
Injuries, fatalities, mental health impacts
Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus
Asthma, cardiovascular disease
Respiratory allergies, asthma
Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms
Malnutrition, diarrheal disease
Environmental Degradation
Extreme Heat
Severe Weather
Changes in Vector Ecology
Air Pollution
Increasing Allergens
Water Quality Impacts
Water and Food Supply Impacts
MORE EXTREME WEATHER
RISING SEA LEVELS
INCREASING CO2 LEVELS
RISING TEMPERATURES
Figure from CDC's Climate and Health Program

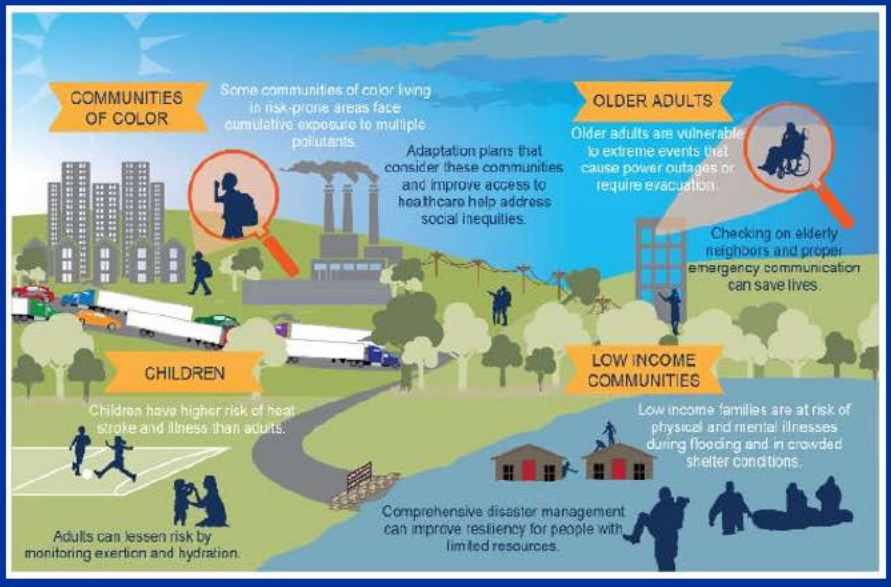
Climate Change and Health



How we prepare and respond influences the outcomes

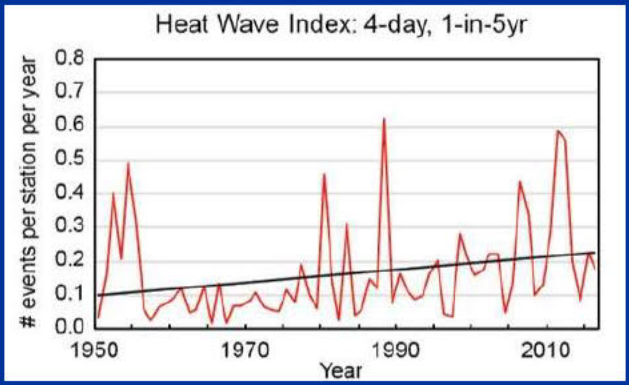


Populations of Concern



Extreme Heat

Extreme Heat

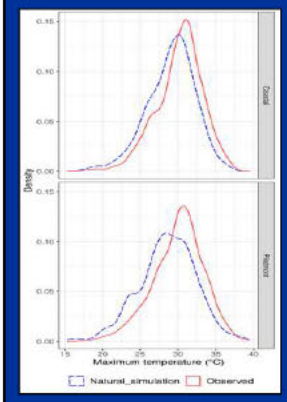


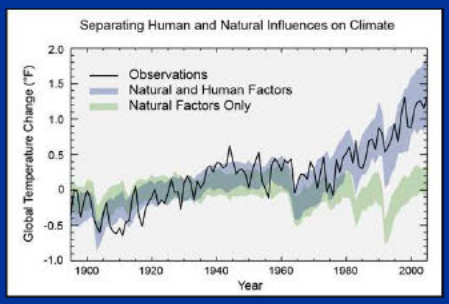
Increased temperatures, higher humidity, longer and more frequent heat waves

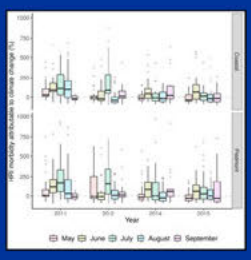
Heat stroke, dehydration, and heat-related illness

At-risk populations: Outdoor workers, student athletes, people in cities, people without air conditioning, people with chronic diseases, pregnant women, older adults, and young children

The Impacts Are Now



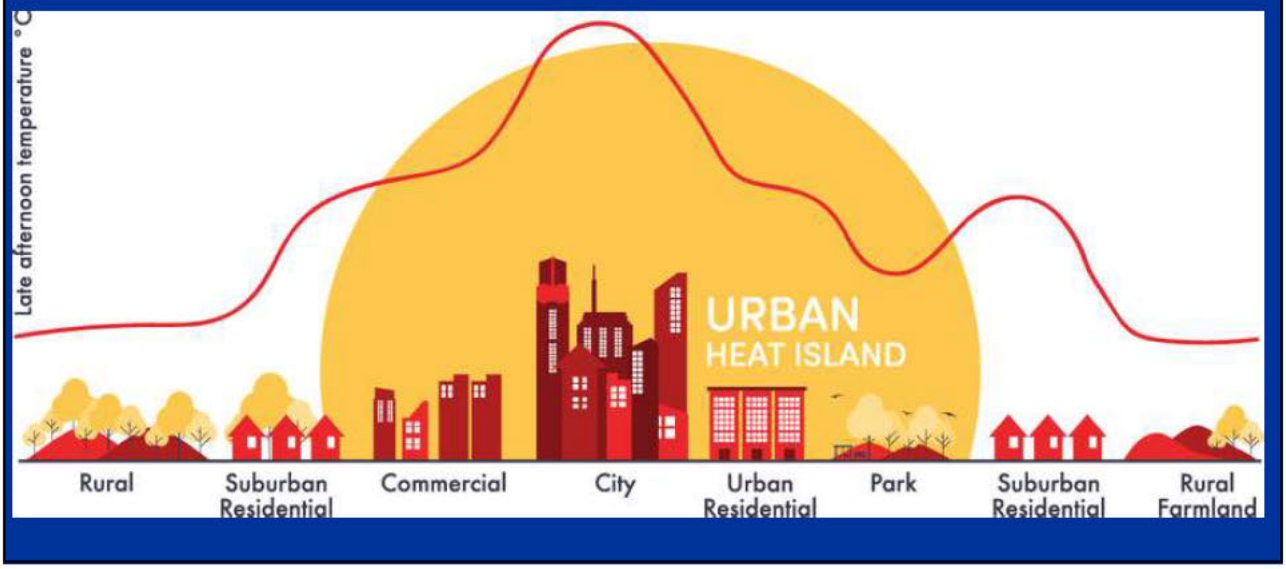


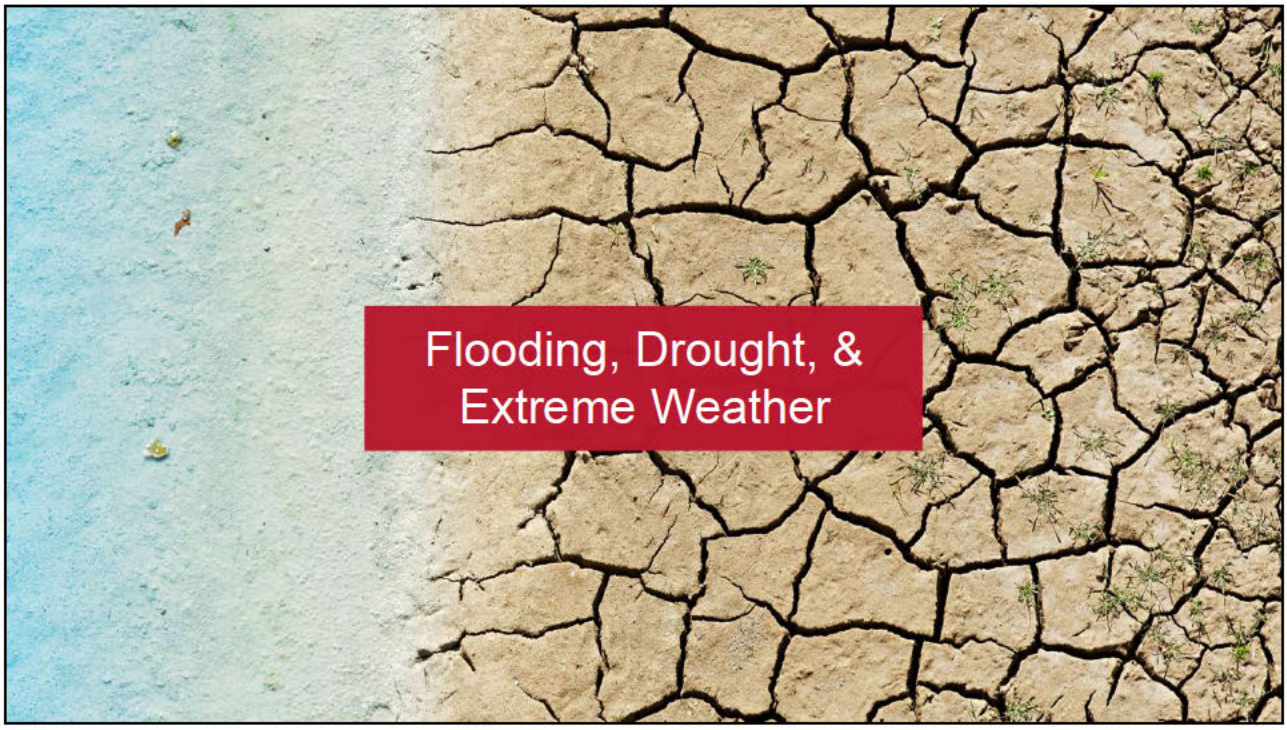


Puvvula et al. 2022

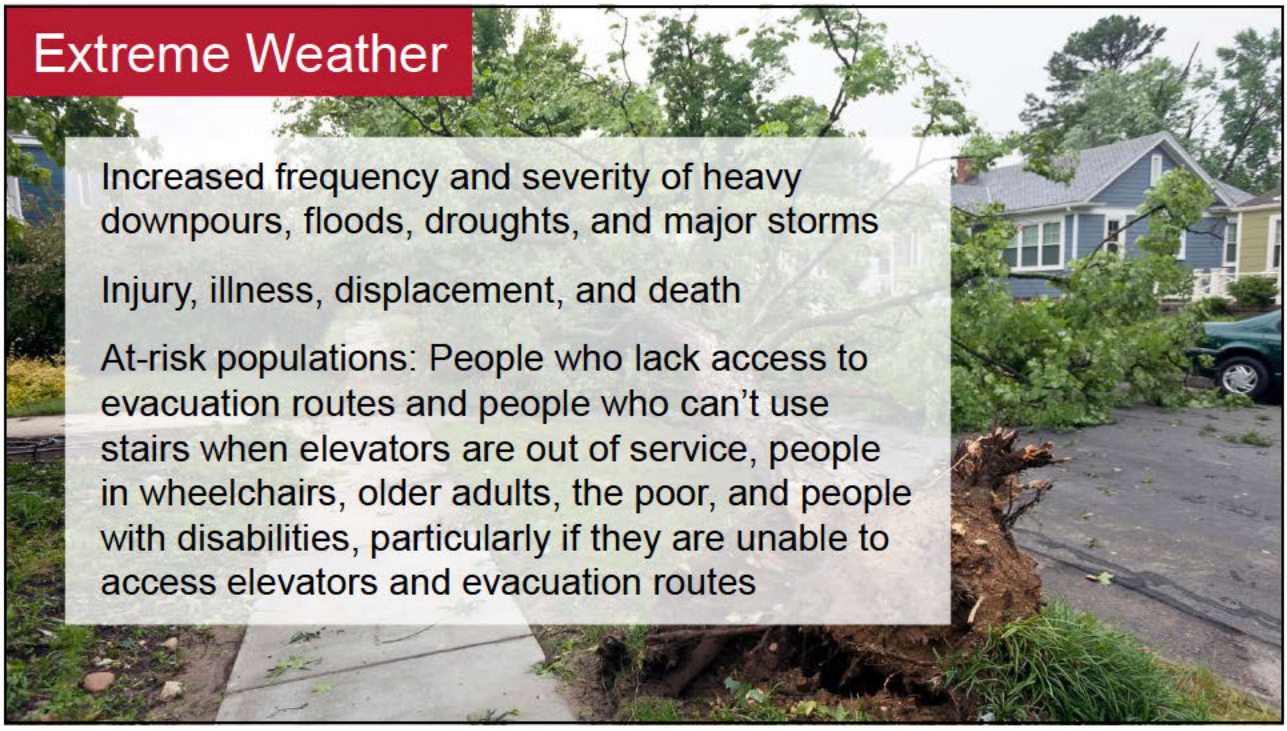
In North Carolina, 13.4% and 16.4% of emergency room visits for heat-related illness from 2011-2016 occurred because of anthropogenic climate change.

WCHP Research: Urban Heat Island





Extreme Weather

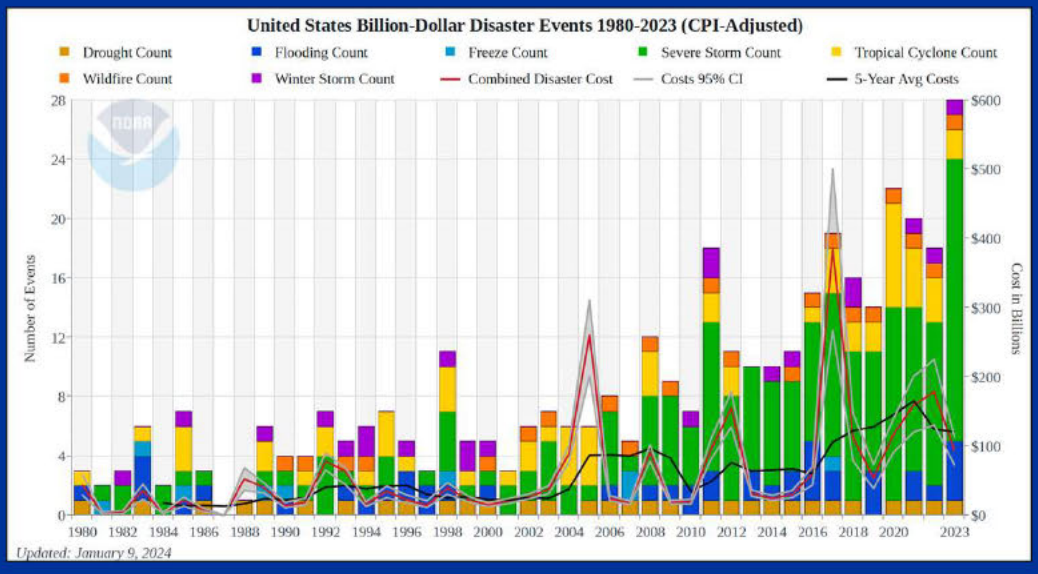


Increased frequency and severity of heavy downpours, floods, droughts, and major storms

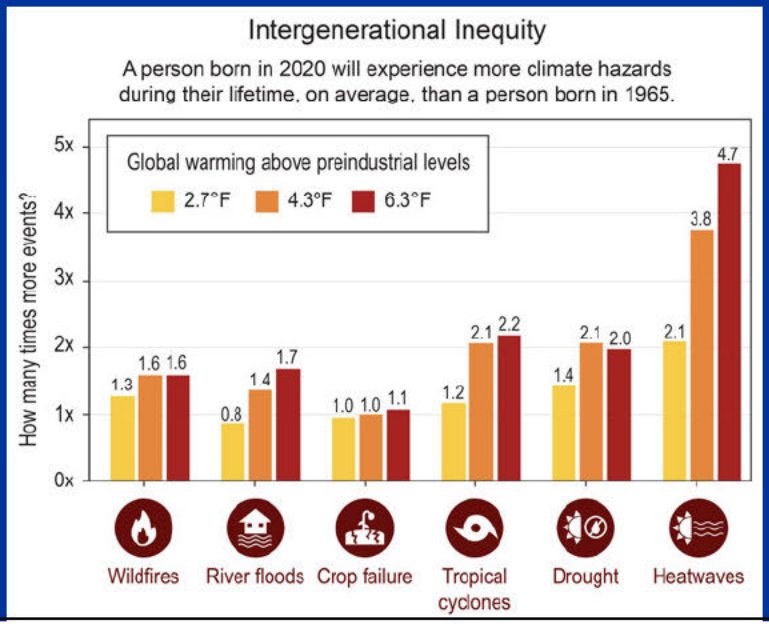
Injury, illness, displacement, and death

At-risk populations: People who lack access to evacuation routes and people who can't use stairs when elevators are out of service, people in wheelchairs, older adults, the poor, and people with disabilities, particularly if they are unable to access elevators and evacuation routes

Billion Dollar Disasters are Increasing



Living in a Changed Climate



Missouri River and North Central Flooding

March 2019

$10.8 billion dollars of economic loss

3 deaths

Hundreds displaced

Costliest inland flooding event in U.S. history

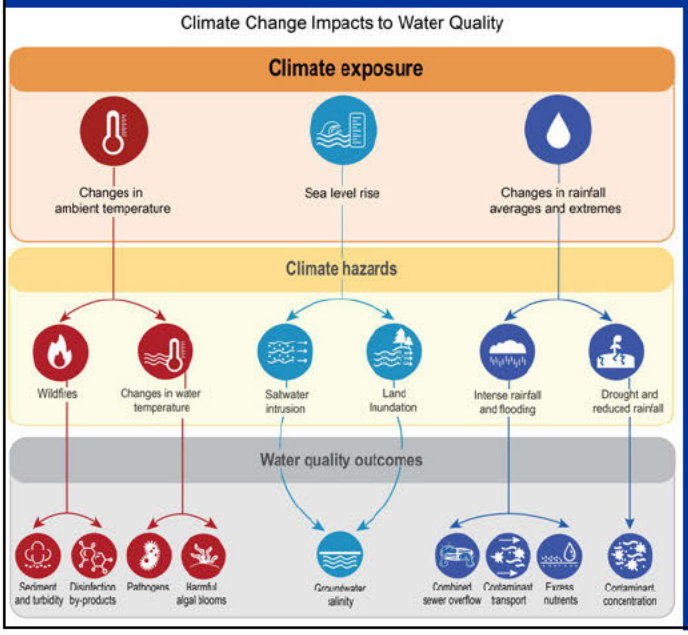
At least 2 hospitals sustained damage

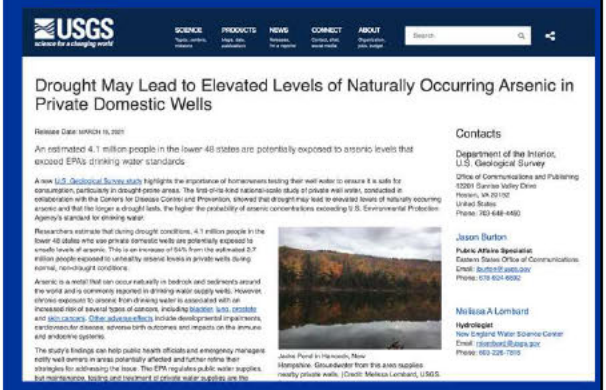
At least a dozen long term care facilities were evacuated

Lack of access to care

- Flooded roads
- Damaged infrastructure

Compromised Quality & Quantity of Water





USGS

Drought May Lead to Elevated Levels of Naturally Occurring Arsenic in Private Domestic Wells

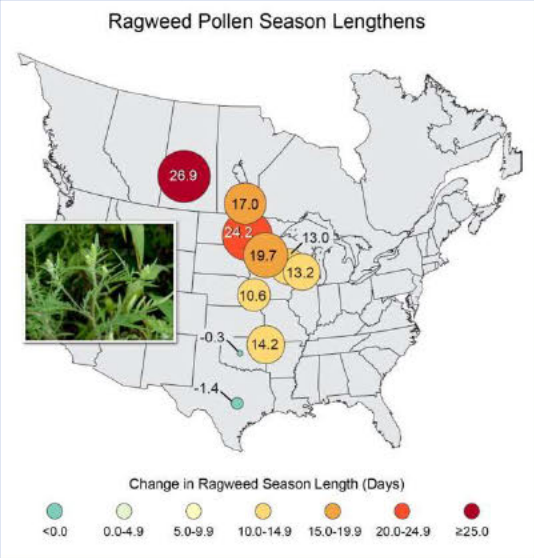
Contacts

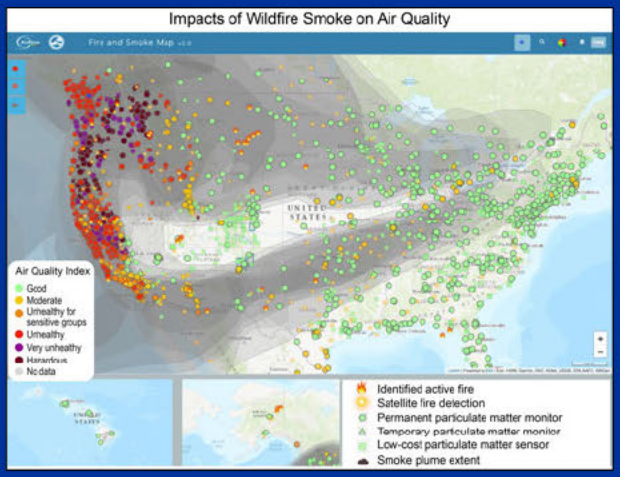
Department of the Interior, U.S. Geological Survey

Air Quality

- Increased wildfires, smog, pollen, and mold
- Asthma, respiratory, and allergy issues
- At-risk populations: People with heart and respiratory conditions such as heart disease, asthma, or chronic lung disease

Changes in Air Quality with Climate Change



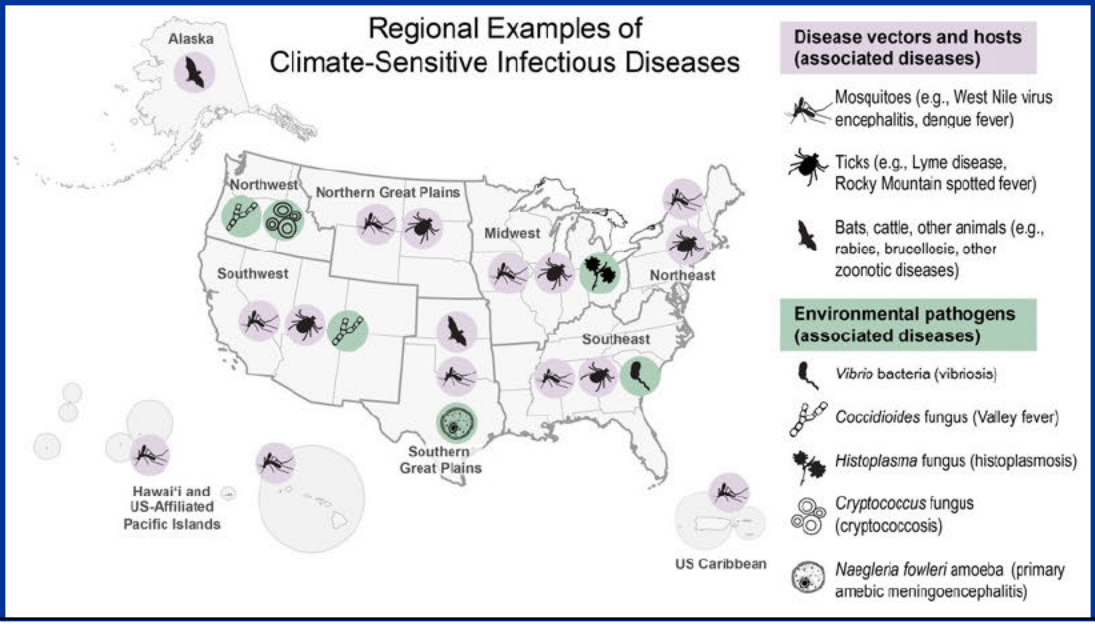


Puvvula et al. 2022 Environ Epi

Spreading Disease: INSECTS, TICKS, AND RODENTS

- Higher temperatures, changes in rain patterns, and disrupted ecosystems
- Lyme disease, West Nile disease, etc.
- At-risk populations: People who spend more time outdoors in places where these insects and other disease-carriers live

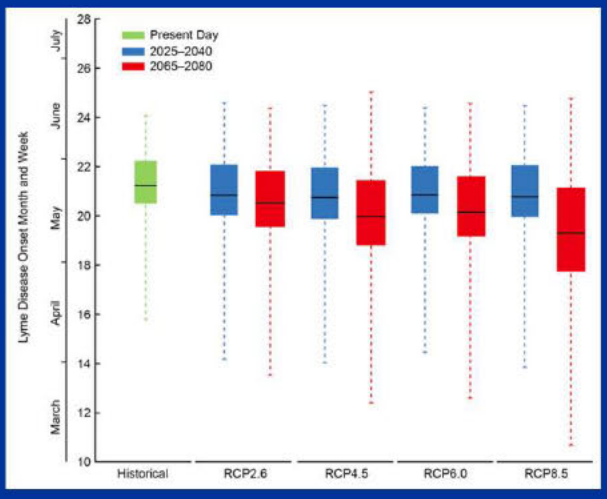
U.S. Infectious Diseases are Sensitive to Climate



Lyme Disease Could Come Earlier with Climate Change

Spread of Lyme disease factors

- Climate
- Ecological
- Social



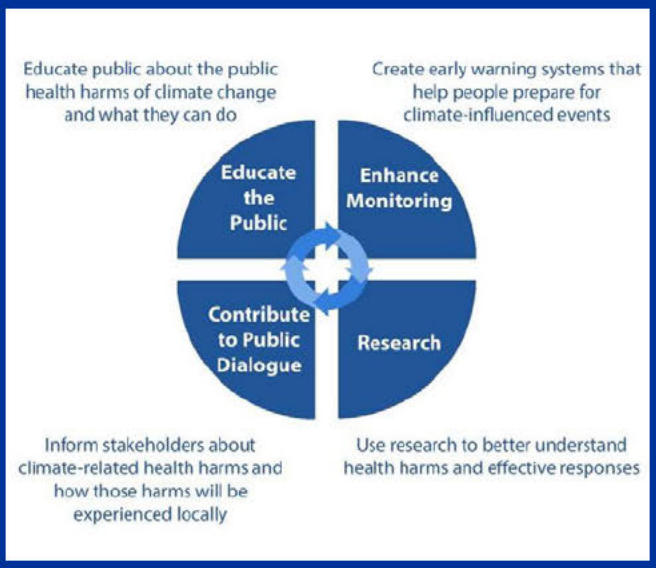
Source: Beard, C.B., R.J. Eisen, C.M. Barker, J.F. Garofalo, M. Hahn, M. Hayden, A.J. Monaghan, N.H. Ogden, and P.J. Schramm, 2016: Ch. 5: Vectorborne Diseases. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. U.S. Global Change Research Program, Washington, DC, 129–156.

Mental Health

- Increased frequency and severity of extreme weather events
- Stress, depression, anxiety, PTSD, and suicidal thoughts
- At-risk populations: Children, older adults, pregnant and postpartum women, people with mental illnesses, the poor, homeless people, first responders, and people who rely on the environment for their livelihood

Opportunities for Engagement

There's Much We Can Do



Public health spending is estimated to be between 1.5% and 3% of all U.S. health spending.

"Do no harm"

- Hospitals can lead America's effort to transform the energy system
  - Transitioning to renewable energy can improve the health of our communities
  - Hospitals account for 10% of US carbon emissions
- Better research before, during, and after a disaster to understand impacts and vulnerabilities

"Do no harm" cont.

- Climate-resilient health systems
  - Conducting vulnerability and adaptation assessments
  - Reduce vulnerabilities and build capacity to address climate disasters
    - 1/3 of excess deaths from Hurricane Maria were from delayed or interrupted health service (Kishore et al. 2018)
  - Disaster Risk Management Plans that address local climate threats
  - Understanding economic burden
- Educating and training the next generation of health professionals
  - Invest in continuing education

Closing Thoughts

- Climate Change is a Significant Health Threat
- All people are vulnerable… some more than others
- Costs are increasing
- Multiple relationships between climate and health
- Lots to be gained by combining expertise
- Multiple opportunities to address this issue
- **Lack of preparedness, planning, and understanding can increase the severity of a disaster**

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ATTRIBUTION SCIENCE AND THE LAW

DIVIDER 12

Dr. John Doherty
Mr. Jarryd Page

Attribution Science and the Law

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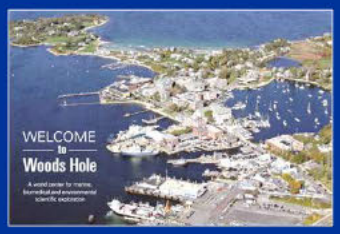
Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE



ROADMAP

1. WHAT IS EVENT ATTRIBUTION SCIENCE?
2. EXTREME HEAT EVENTS
3. WILDFIRE
4. CONFIDENCE
5. FUTURE DIRECTIONS

WHAT IS EVENT ATTRIBUTION SCIENCE?

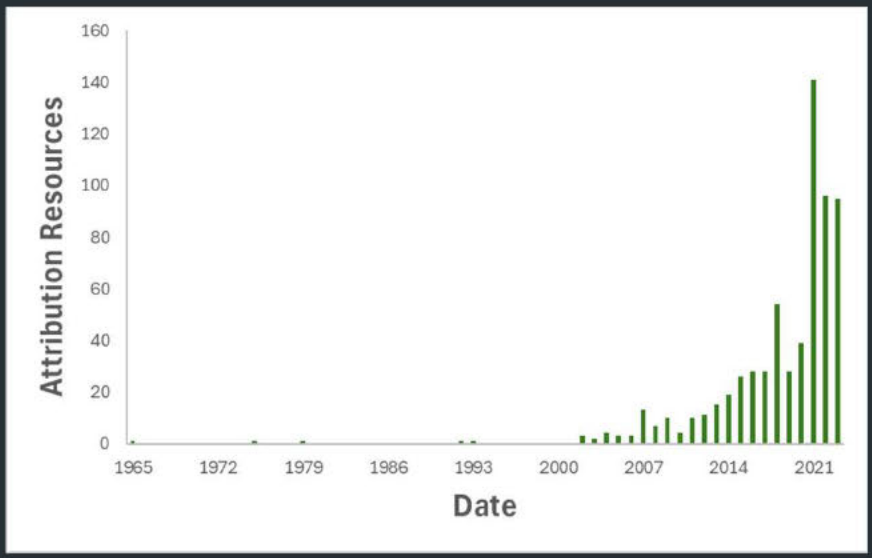
1 WHAT IS EVENT ATTRIBUTION SCIENCE?

ATTRIBUTION SCIENCE

Source: climateattribution.org

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

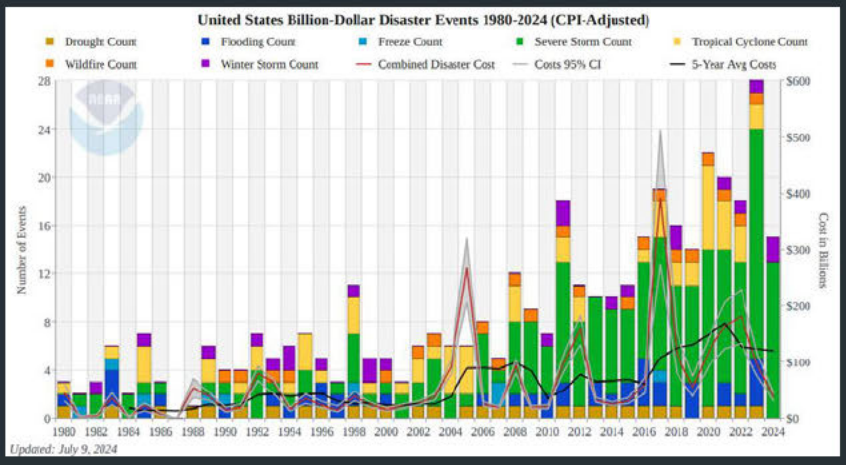
THE NUMBER OF SCIENTIFIC PUBLICATIONS IN ATTRIBUTION RESEARCH HAS SKYROCKETED IN RECENT YEARS



Data: climateattribution.org

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

EXTREME WEATHER EVENTS ARE BECOMING MORE IMPACTFUL



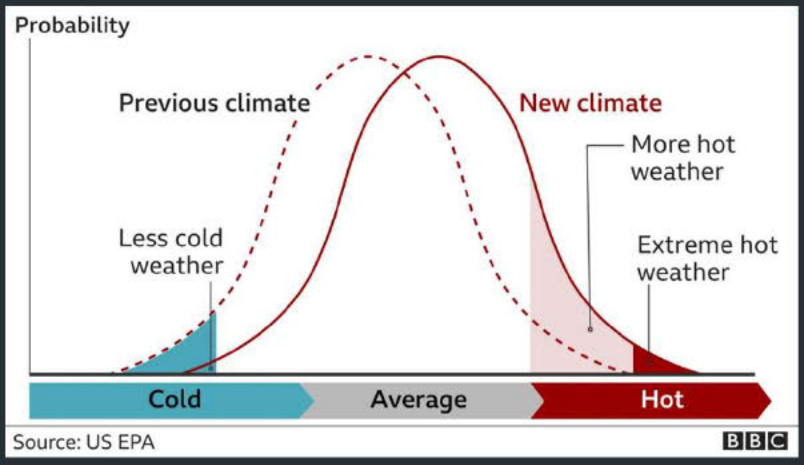
Source: NOAA NCEI, https://www.ncei.noaa.gov/access/billions/time-series/US/cost

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

EVENT ATTRIBUTION SCIENCE PROVIDES THE LINK BETWEEN CLIMATE AND WEATHER

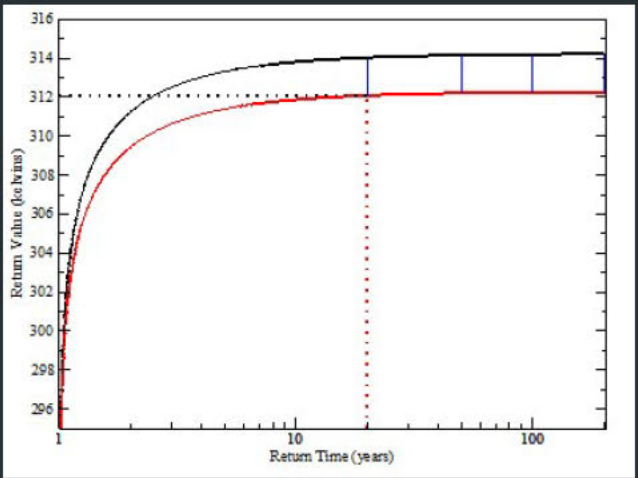
1 WHAT IS EVENT ATTRIBUTION SCIENCE?

NOT ALL CHANGES ARE EXTREME!



1 WHAT IS EVENT ATTRIBUTION SCIENCE?

A "1-IN-X-YEAR" EVENT



An example from Washington, DC - 3 day average daily maximum air temperature

Extreme weather events are frequently discussed in terms of their **return time**, the inverse of their probability of occurring (1/P)

Return time for certain climate variables **with and without climate change** can be calculated using climate models

Source: Michael Wehner et al., *Early 21st century anthropogenic changes in extremely hot days as simulated by the C20C+ detection and attribution multi-model ensemble*, 20 Weather and Climate Extremes 1, 6. (2018)

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

WHAT CAN ATTRIBUTION SCIENCE TEACH US?

LIKELIHOOD

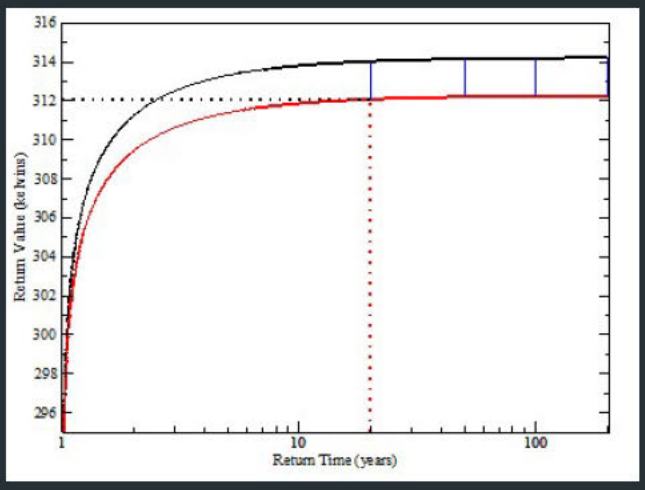
Did climate change play a role in the likelihood of this event occurring? If yes, to what extent?

INTENSITY

Did climate change play a role in the intensity of this event? If yes, to what extent?

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

INFLUENCE ON LIKELIHOOD



Source: Michael Wehner et al., *Early 21st century anthropogenic changes in extremely hot days as simulated by the C20C+ detection and attribution multi-model ensemble*, 20 Weather and Climate Extremes 1, 6. (2018)

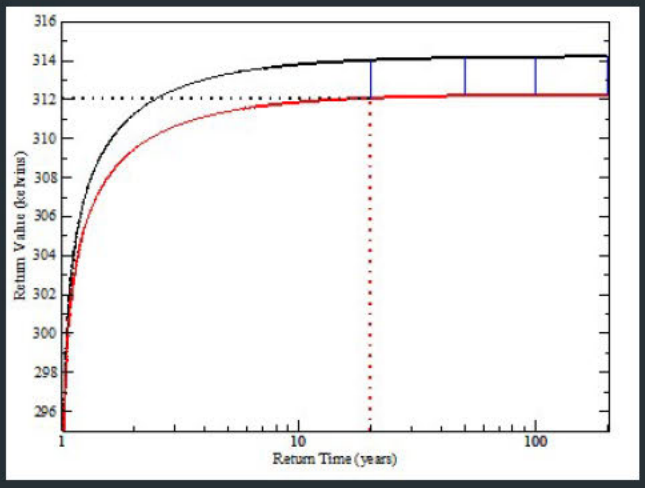
How often should we expect the maximum temperature to be 312 K (~102 °F) in a world **without climate change**?

How often should we expect that same maximum temperature in a world **with climate change**?

1/20 years (5%) -> 1/2 years (50%), so the likelihood has increased by **about ten times**

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

INFLUENCE ON INTENSITY



Source: Michael Wehner et al., *Early 21st century anthropogenic changes in extremely hot days as simulated by the C20C+ detection and attribution multi-model ensemble*, 20 Weather and Climate Extremes 1, 6. (2018)

How much **more intense** is the 1-in-20-year temperature event?

314 K = ~105.5 °F
312 K = ~102 °F

The 1-in-20-year temperature event is **about 3.5 °F more intense** because of climate change

1 WHAT IS EVENT ATTRIBUTION SCIENCE?

THE SCIENCE/LAW INTERSECTION


Heatwave in Oregon
County of Multnomah v. Exxon Mobil Corp.


Hurricane(s) in Puerto Rico
Municipalities of Puerto Rico v. Exxon Mobil Corp.

Did climate change play a role in this event?

These lawsuits raise additional questions about source attribution and damages calculations

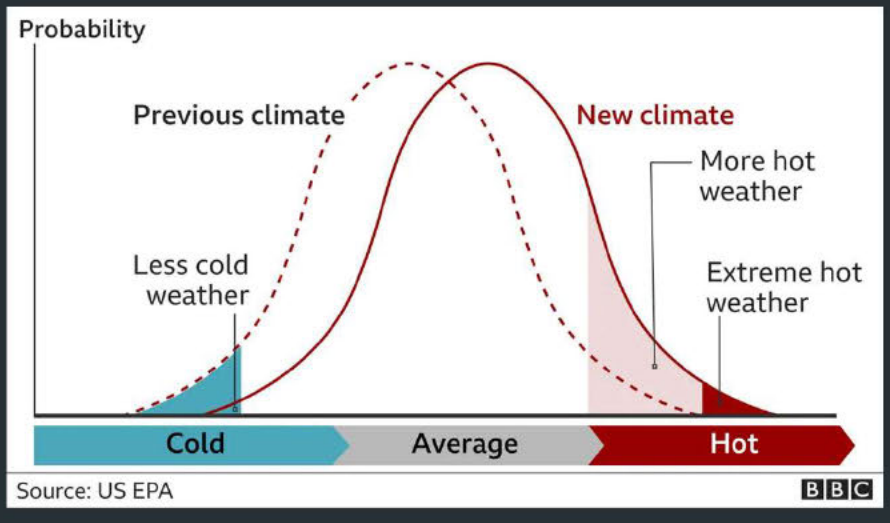
1 WHAT IS EVENT ATTRIBUTION SCIENCE?

OTHER TYPES OF ATTRIBUTION

Climate connections are built on an evidentiary spectrum, depending on the claims alleged and relief requested

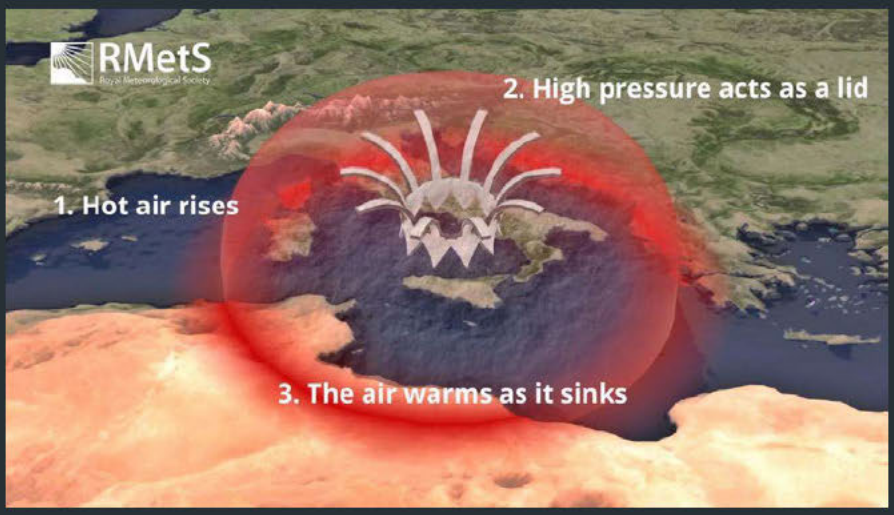
2 EXTREME HEAT

CHANGING DISTRIBUTION



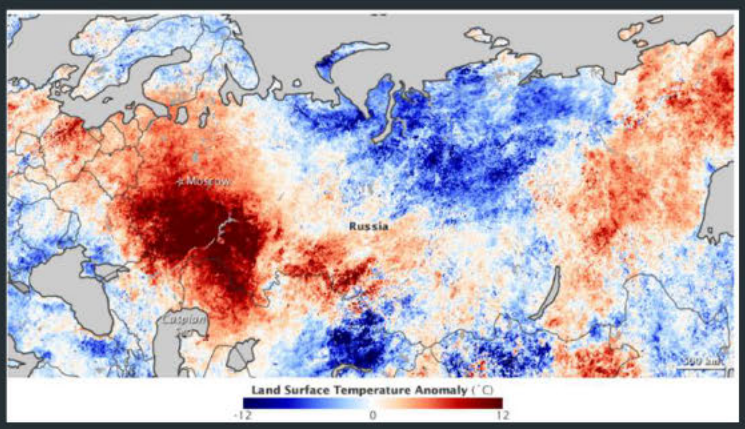
2 EXTREME HEAT

BUT THERE'S MORE...



2 EXTREME HEAT

THE 2010 RUSSIAN HEATWAVE



Source: July 20–27 2010 temperature anomaly rel. 2000–2008, NASA Earth Observatory. https://earthobservatory.nasa.gov/images/45069/heatwave-in-russia

Parts of Russia reached **108 °F**

It was the **most extreme heatwave** of the instrumental record (since 1880) and lasted for **more than a month**

Also drove downstream impacts like **fires** and **declining air quality**

55,000 deaths, **25% decline** in annual crop production, and **$15 billion USD** (1% of GDP) damages

2 EXTREME HEAT

DID CLIMATE CHANGE PLAY A ROLE?

ONE QUESTION:
COULD AN EVENT OF THIS MAGNITUDE BE POSSIBLE WITHOUT CLIMATE CHANGE?

"...Such an intense event **could be produced through natural variability alone**. Analysis of observations indicate that this heat wave was **mainly due to internal atmospheric dynamical processes** that produced and maintained a strong and long-lived blocking event, and that similar atmospheric patterns have occurred with prior heat waves in this region."

- Dole et al. (2011). *Geophysical Research Letters*

Was there a basis for anticipating the 2010 Russian heat wave?

Randall Dole,[1] Martin Hoerling,[1] Judith Perlwitz,[2] Jon Eischeid,[2] Philip Pegion,[2] Tao Zhang,[2] Xiao-Wei Quan,[2] Taiyi Xu,[2] and Donald Murray[2]

Received 23 December 2010; revised 25 January 2011; accepted 2 February 2011; published 19 March 2011.

2 EXTREME HEAT

DID CLIMATE CHANGE PLAY A ROLE?

ANOTHER QUESTION:
HOW LIKELY WOULD THIS EVENT HAVE BEEN WITHOUT CLIMATE CHANGE?

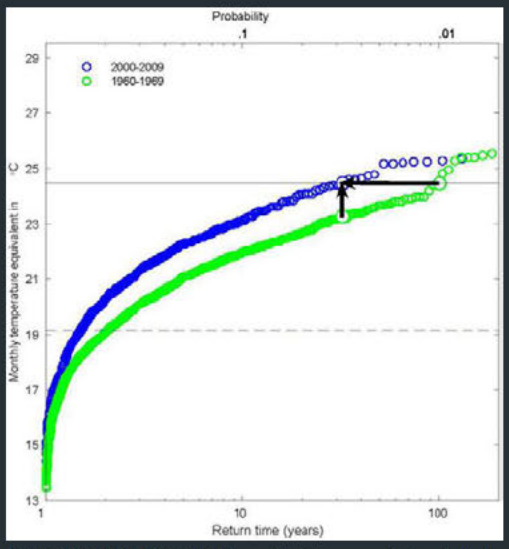
2 EXTREME HEAT

DID CLIMATE CHANGE PLAY A ROLE?

Scientists simulated the temperature distribution for **1960-1969 (green)** and **2000-2009 (blue)** coincident with the **circulation patterns** that made the heatwave persist

The event had a **99-year return time** in the 1960s, but a **33-year return time** in the 2000-2009

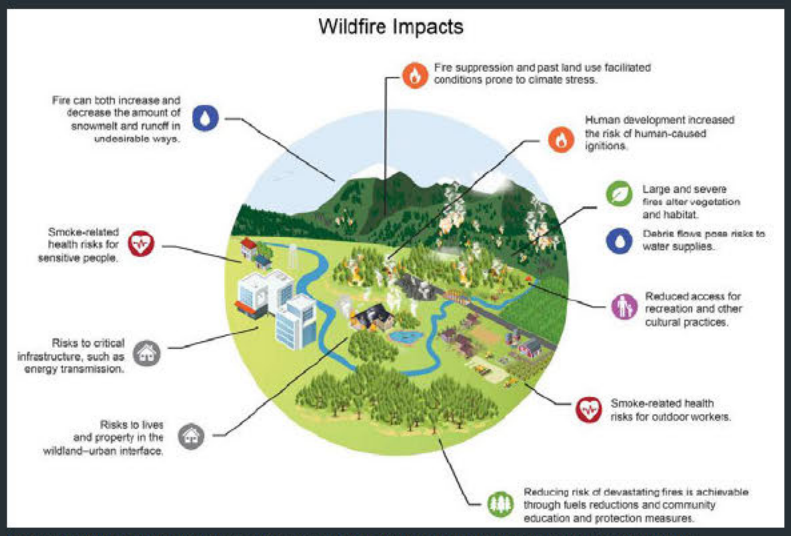
In other words, climate change made an event like this **3x more likely** to occur



Source: Friederike Otto et al., *Reconciling two approaches to attribution of the 2010 Russian heat wave*, Geophysical Research Letters 39 (2012)

WILDFIRE

THE IMPACTS OF WILDFIRE



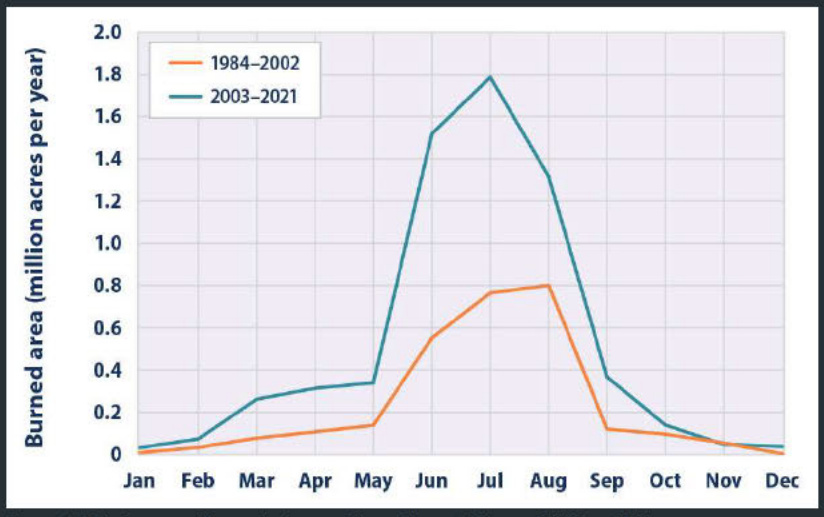
Source: U.S. Global Change Research Program, Fifth National Climate Assessment. Fig. F2.1 (2023)

WILDFIRE

FIRE WEATHER

WILDFIRE

U.S. WILDFIRE TRENDS



Source: U.S. Environmental Protection Agency. Climate Change Indicators: Wildfires. (2024)
https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires

WILDFIRE

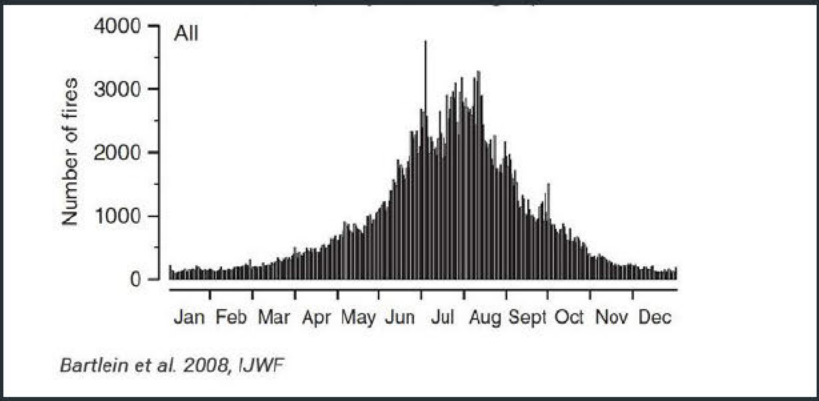
ATTRIBUTION OF WILDFIRE IS COMPLICATED

Any guesses

why?

WILDFIRE

A HINT



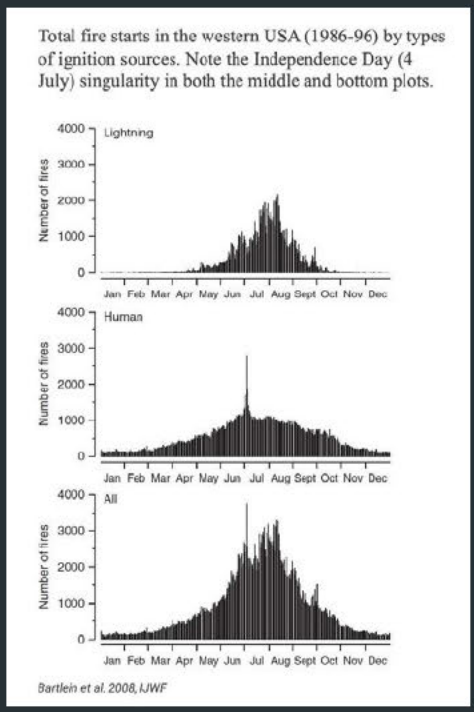
Total fires in the western US (1986-1996)

WILDFIRE

At present, attribution of individual wildfire is difficult because a combination of **climatic** and **non-climatic variables** can influence their occurrence and/or severity:

- High heat
- Low humidity
- High wind speed
- Land use/management
- Human behavior

In other words, **confidence** is relatively low



4 CONFIDENCE

CONFIDENCE - THE IPCC VIEW

High agreement Limited evidence	*High agreement Medium evidence*	*High agreement Robust evidence*
Medium agreement Limited evidence	*Medium agreement Medium evidence*	*Medium agreement Robust evidence*
Low agreement Limited evidence	*Low agreement Medium evidence*	*Low agreement Robust evidence*

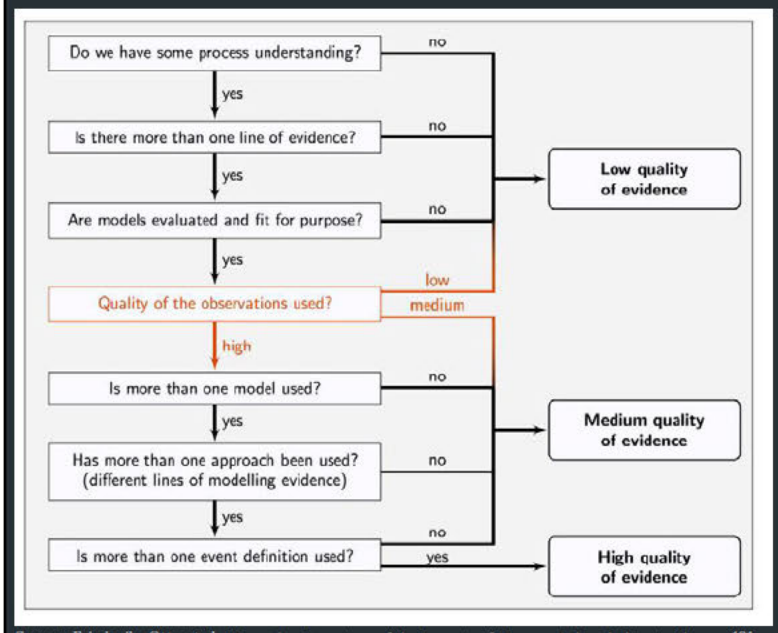
Agreement ↑

Evidence (type, amount, quality, consistency) →

Confidence Scale

Source: Michael Mastrandrea et al., Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties, IPCC (2010)

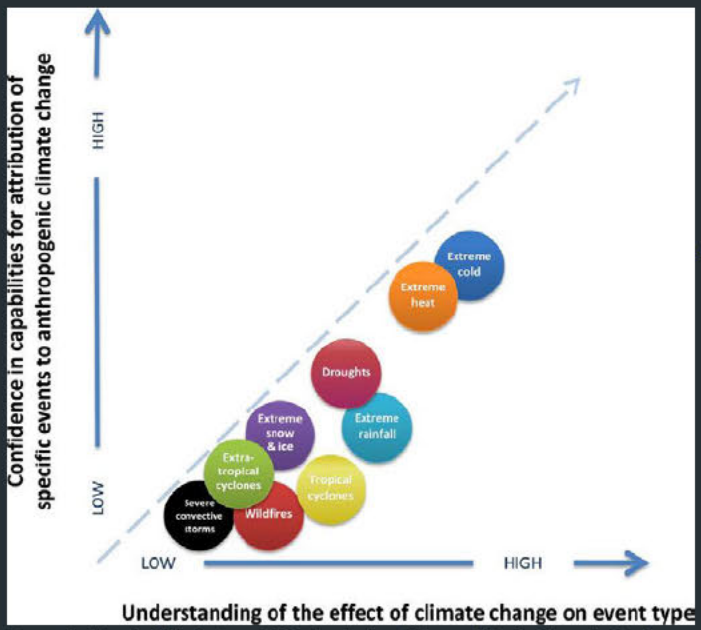
4 CONFIDENCE



Source: Friederike Otto et al., *Toward an Inventory of the Impacts of Human-Induced Climate Change*, 101 Bull. Am. Meteorological Soc'y E1972, E1975 (2020)

CONFIDENCE IN EVENT ATTRIBUTION SCIENCE

4 CONFIDENCE



Source: Nat'l Acad. of Sci., Eng'g, and Med., Attribution of Extreme Weather Events in the Context of Climate Change (2016), https://doi.org/10.17226/21852 (Fig. 4.7)

CONFIDENCE IN EVENT ATTRIBUTION SCIENCE - A PERSPECTIVE FROM 2016

5 FUTURE DIRECTIONS

MORE, SPECIFIC STUDIES

Damages from Hurricane Sandy

Investigating how much of the more than $60 billion in damages from Hurricane Sandy can be linked to climate-related anthropogenic sea level rise

$8 billion

71,000 additional people

Source: Strauss, B.H., Orton, P.M., Bittermann, K. et al. Economic damages from Hurricane Sandy attributable to sea level rise caused by anthropogenic climate change. Nat Commun 12, 2720 (2021). https://doi.org/10.1038/s41467-021-22838-1

5 FUTURE DIRECTIONS

CLIMATE SUPERFUND LAWS

Vermont's Climate Superfund Act

Modeled on federal Superfund law (CERCLA)

Purpose? Money for climate adaptation projects

Who is a responsible party?

- Fossil fuel extractors and crude oil refiners
- VT Agency of Natural Resources can attribute 1 billion metric tons of covered GHGs between 1995 and 2024

How is this determined? A combination of U.S. EPA data and future rulemaking "adopting methodologies using available science and publicly available data"

PREPARING FOR COLLABORATIVE CONVERSATIONS

DIVIDER 13

Yvonne Stedham, Ph.D.
Professor Kelly Tait

OBJECTIVES:

After this session, you will be able to:

1. Mitigate the effects of the polarization associated with climate-related discussions;
2. Use specific phrases that facilitate more collaborative conversations;
3. Recognize the importance of intentions in effective conversations & of adopting a "scientist" style; and
4. Explain the importance of listening & expanding mindful listening skills.

RECOMMENDED READING:
PROFESSOR KELLY TAIT

1. **Center for Climate Change Communication**, George Mason University. They "develop and apply social science insights to help society make informed decisions…." Frequently updated. https://www.climatechangecommunication.org/
2. **Climate Change in the American Mind**. George Mason Center for Climate Change Communication and Yale Program on Climate Change Communication. "Tracks and investigates public understanding of climate change and support for climate policies." Excellent recent (and on-going) reports and tools—most recent reports: Spring 2024. https://www.climatechangecommunication.org/climate-change-in-the-american-mind/
3. Flusberg, Stephen J., Tennie Matlock, and Paul H. Thibodeau. "**Metaphors for the War (or Race) against Climate Change**." *Environmental Communication* 11/6 (2017). Investigated the role of metaphorical framing in shaping attitudes toward climate change; compared "war," "race," and "issue." https://doi.org/10.1080/17524032.2017.1289111
4. Hayhoe, Katharine. "**How To Talk About Climate Change So People Will Listen**." *Chatelaine* Magazine (1/2024). Tips from a climate scientist with emphasis on finding common ground. https://chatelaine.com/living/how-to-talk-about-climate-change/
5. Updated January 26, 2024National Park Service. "**Climate Change Communication Guide: Knowing and Interacting with Your Audience**." U.S. Dept. of Interior. (2024). Resource for NPS staff to "engage visitors in conversations about climate change impacts and actions." https://www.nps.gov/subjects/climatechange/toolkit-audience.htm
6. Peters, Ellen, and Renee N. Salas. "**Communicating Statistics on the Health Effects of Climate Change**." *The New England Journal of Medicine* 387; 193-6 (7/2022). Useful article about communicating scientific information in an understandable way. https://www.nejm.org/doi/full/10.1056/NEJMp2201801
7. Roser-Renouf, Connie, et al. "**Engaging Diverse Audiences with Climate Change: Message Strategies for Global Warming's Six Americas**." Routledge Handbook of Environment and Communication, Anders Hanson & Robbie Cox (Eds.) (2014). https://climatecommunication.yale.edu/wp-content/uploads/2014/03/Global_Warmings_Six_Americas_book_chapter_2014.pdf
8. Shors, Luke. "**Let's Not Wage a 'War' on Climate Change**." *Biomythic* blog (3/2022). Makes the case that using "war" framing for climate change mis-characterizes the issues and limits perception of potential solutions. https://biomythic.substack.com/p/lets-not-wage-a-war-on-climate-change?s=r
9. Thaler, Andrew. "**When I Talk about Climate Change, I Don't Talk about Science**." Southern Fried Science blog (2017). Says that, to reach people who might react to the term "climate change," he talks about fishing, flooding, farming, and faith. https://www.southernfriedscience.com/when-i-talk-about-climate-change-i-dont-talk-about-science/
10. **Yale Program on Climate Change Communication**. Useful—and current (2024)—resources from a program that conducts scientific studies on public opinion and behavior, with informational, educational goals. https://climatecommunication.yale.edu/

Preparing for Collaborative Conversations

Yvonne Stedham, Ph.D.
Professor Kelly Tait

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
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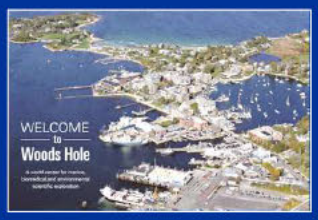
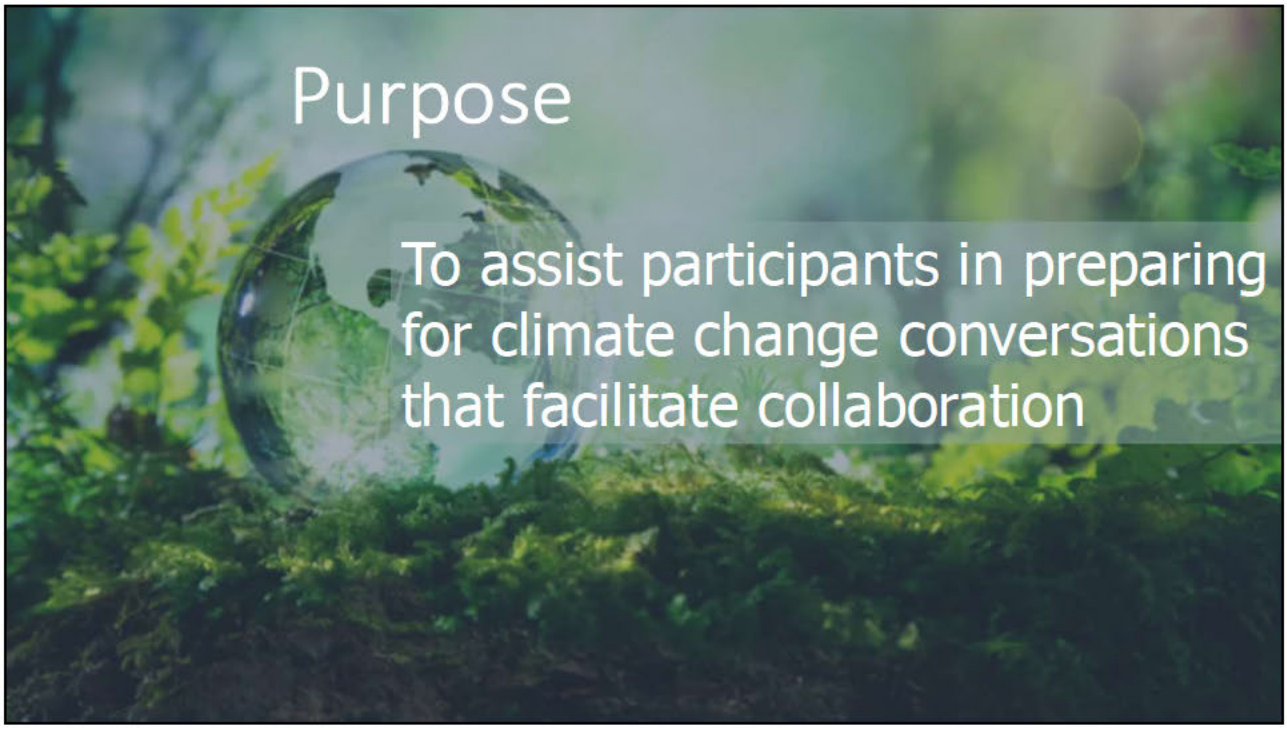




Learning Objectives

Learning Objectives:

1. Mitigate the effects of the polarization associated with climate-related discussions
2. Use specific phrases that facilitate more collaborative conversations
3. Recognize the importance of intentions in effective conversations & of adopting a “scientist” style
4. Explain the importance of listening & expanding mindful listening skills

Helpful Hints from Cognitive Science for More Collaborative Conversations

Helpful Hints from Cognitive Science

1. **Frame the issue constructively**; consider word choice and framing in terms of values
2. **Make information accessible**: give context, avoid technical jargon, show clear significance
3. **Visuals help** (especially with numbers)
4. **Stories can be a frame**; tell stories that exemplify values and rouse emotions
5. The **messenger matters**: ~Credibility

Metaphorical Framing Has Consequences

- Cannot avoid framing: built-in to how we think
- Subconsciously shape thinking
- Influence problem-solving approaches
  - e.g., *"War on Cancer"* = more funding for aggressive chemotherapy, less focus on addressing factors that may lead to cancer
  - Frames: war, race/competition, national security issue, public health issue…

Framing the Issue

Consider:

- What frames are being activated (and strengthened) in people's minds?
- How does the frame affect perceptions of the problem and solutions?
  - e.g., "carbon tax" vs "carbon offset"
- What are appropriate frames?

Make It Accessible: Communicating Numbers

"Evidence shows that people are more likely to understand and be motivated by statistics if communicators present them thoughtfully and strategically."

~Peters and Salas 7/2022
"Communicating Statistics on the Health Effects of Climate Change"
The New England Journal of Medicine

Numeracy: Understanding how math is used in the real world and being able to apply it in terms of thinking and reasoning

Help people understand the numbers:

- Use measures they can grasp
- Visualize
- Use comparisons and analogies
- Provide context and explain the point

Data is the map, storytelling is the journey."

~Andrew Thaler, Duke University

"When I Talk about Climate Change, I Don't Talk about Science." (2017)

Know Your Audience: The Need for Nuance

- Human tendency: simplify a complex continuum into two categories (binary bias)
- "Believers" and "Deniers" ~ Frames it as us vs them
- Fed by news cycle: nuance doesn't go viral

Yale Program on Climate Change Communication and George Mason Center for Climate Change Communication

Some Key Findings

- ✓ **6 to 1** (72% vs 12%) ~ Americans who think global warming is happening vs not
- ✓ **59%** understand that global warming is mostly human-caused [29%: think due mostly to natural changes in the environment]
- ✓ **1 in 5** (20%) understand strength of consensus among scientists [~97%: human-caused]

Findings: Feelings

- ✓ **64%** "somewhat" or "very" worried about global warming
- ✓ **47%** think people in US are being harmed by it right now

"Six Americas" : Six Categories

Alarmed

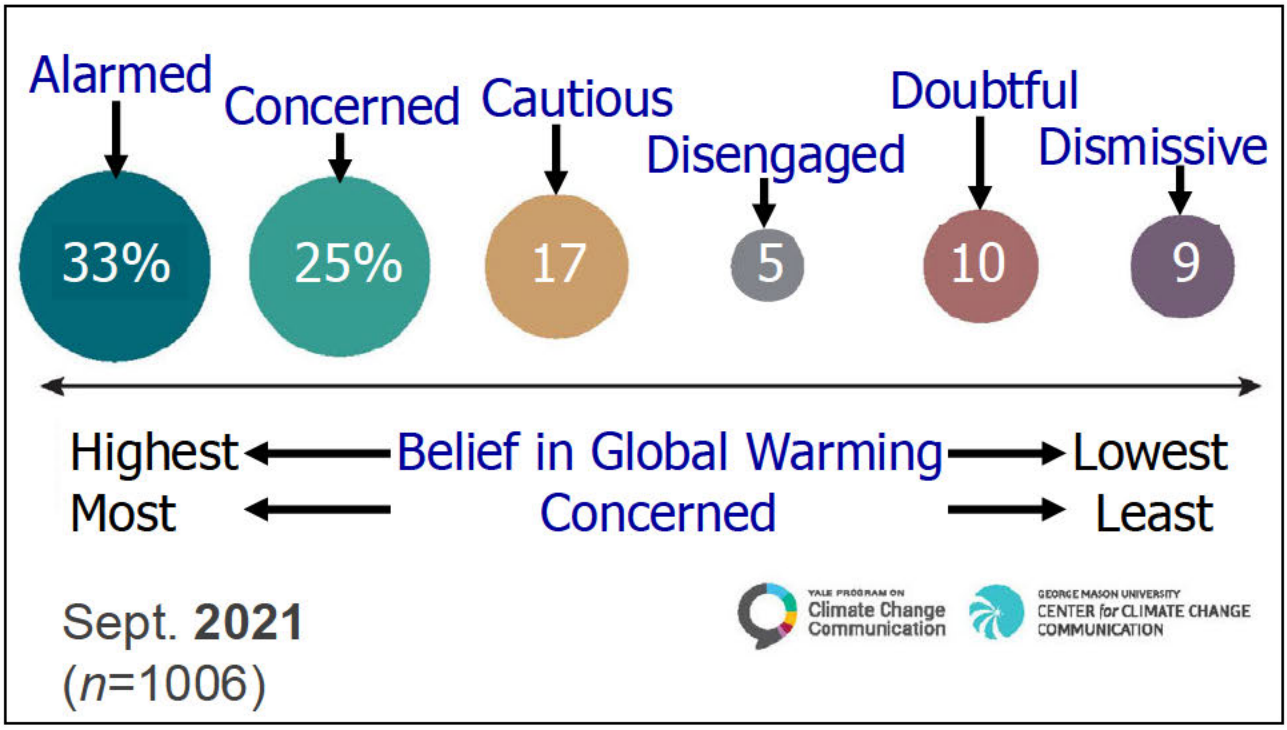
Concerned

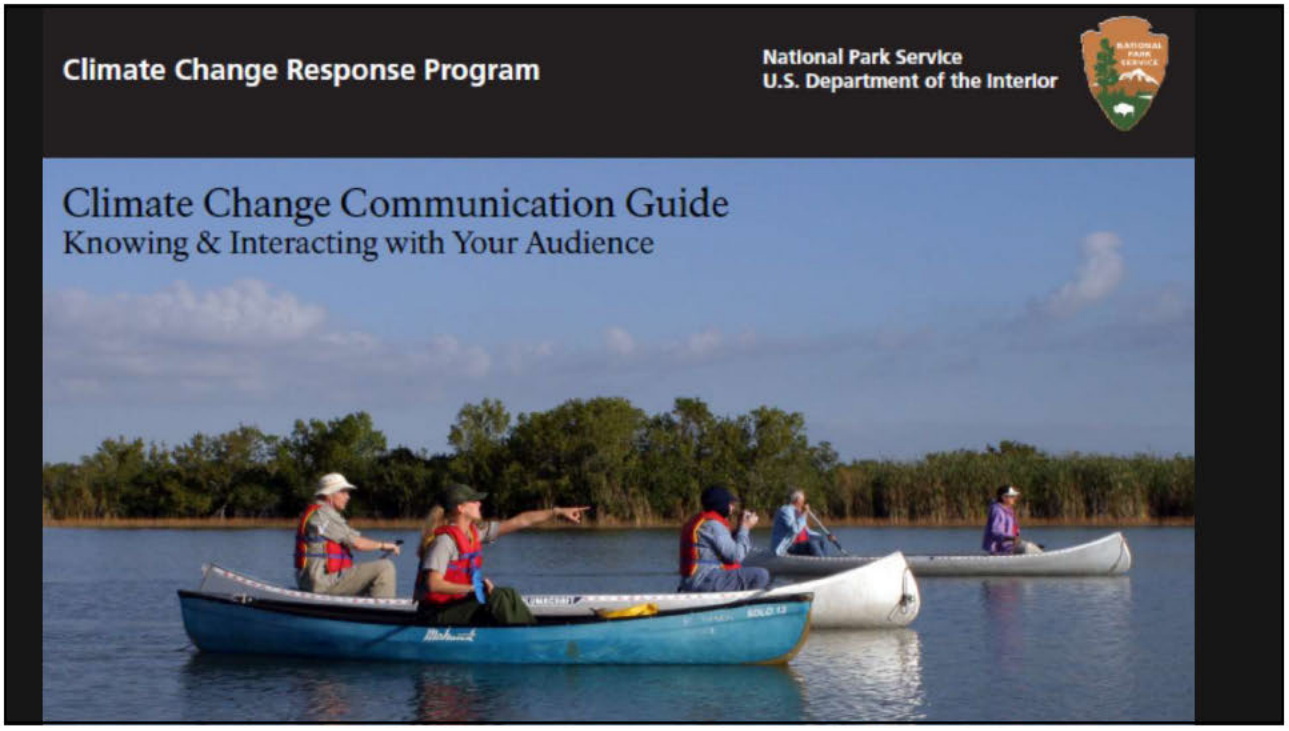
Cautious

Disengaged

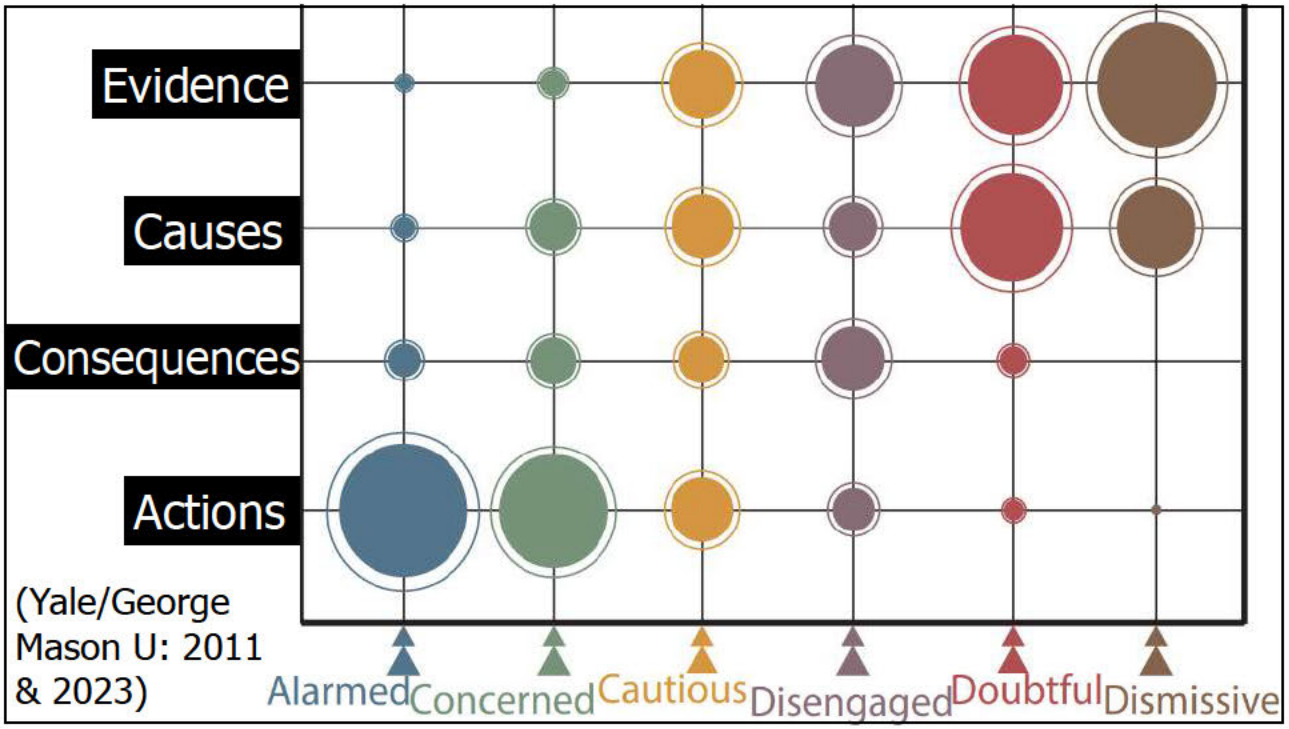
Doubtful

Dismissive




Climate Change Response Program
National Park Service
U.S. Department of the Interior
Climate Change Communication Guide
Knowing & Interacting with Your Audience


"Burning Question" on Climate Change
Based on Six Categories



Strategies for Low Involvement: The Cautious and the Disengaged

Challenge: Create content that will draw audiences in and be easy to understand (low effort)

- Use humor, attractive/credible sources
- ✓ Show rather than tell
- ✓ Personalize: physically close and/or emotionally significant impacts
- ✓ Generate involvement through stories

Strategies for Negative Audiences: The Doubtful and the Dismissive

Nonconfrontational, values-based approaches

For the Doubtful:

- Emphasize scientific agreement
- Concrete personal experiences of like others

For the Dismissive:

- Set a realistic goal: civil dialogue; keep from negatively impacting others

The #TalkingClimate Handbook

Respect your conversational partner

Enjoy it

Ask questions

Listen and show you're listening

Tell your story

Action makes it easier

Learn from your conversational partner

Keep going and keep connected

Key Elements to Approaching Conversations Constructively

- Curiosity
- Perspective-seeking
- Common ground

Choice of language should reflect these

Ask Questions and Listen to Understand

- "What is important to you?"
- "What is your perspective on…?"
- "How did you come to feel that way?"
- "What concerns you about _____?"
- "Can you help me understand why that's important?"
- "What would you like to happen instead?"

Respect and Connect

- “I hadn’t thought of it that way before.”
- “Like you said….”
- “I respect the way that you….”
- “It sounds like we agree on that.”
- “I appreciate….”
- “I also find that [difficult, important, helpful, interesting, etc.].”

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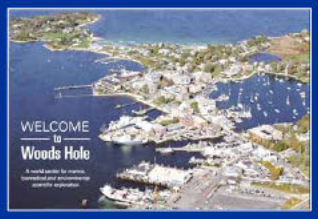
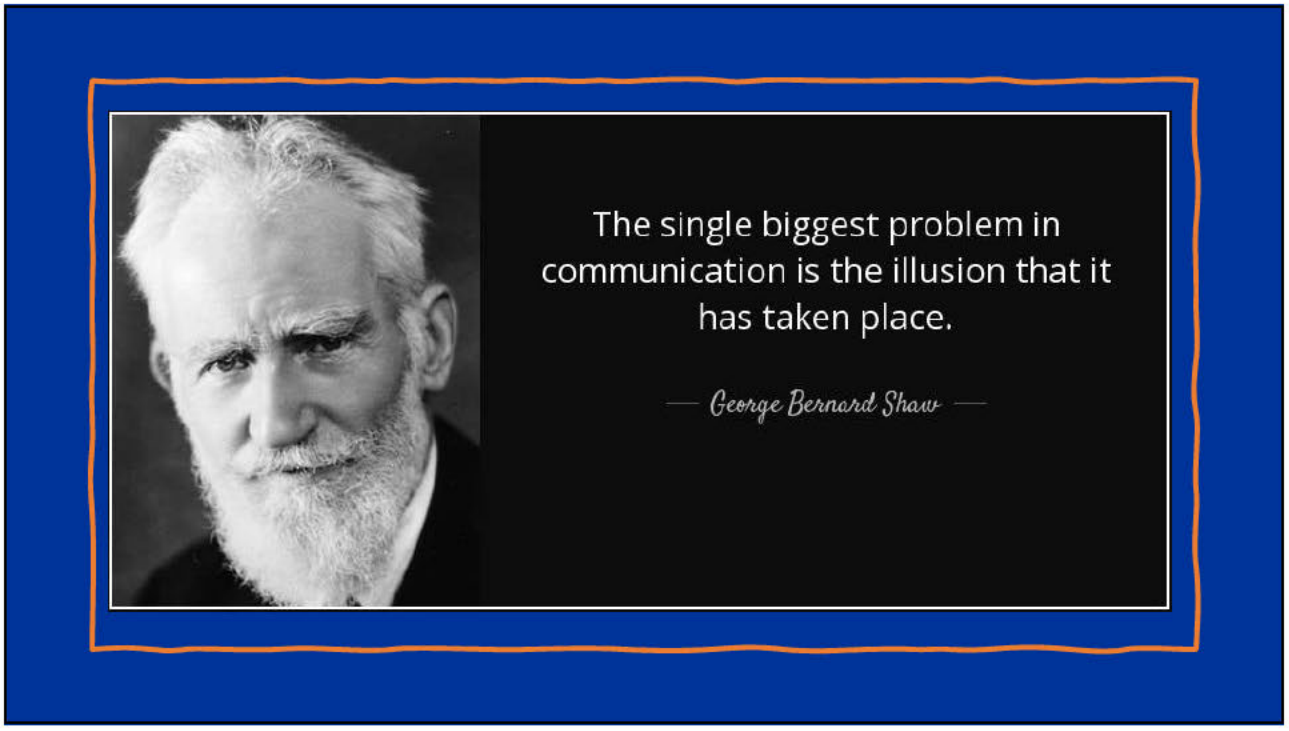
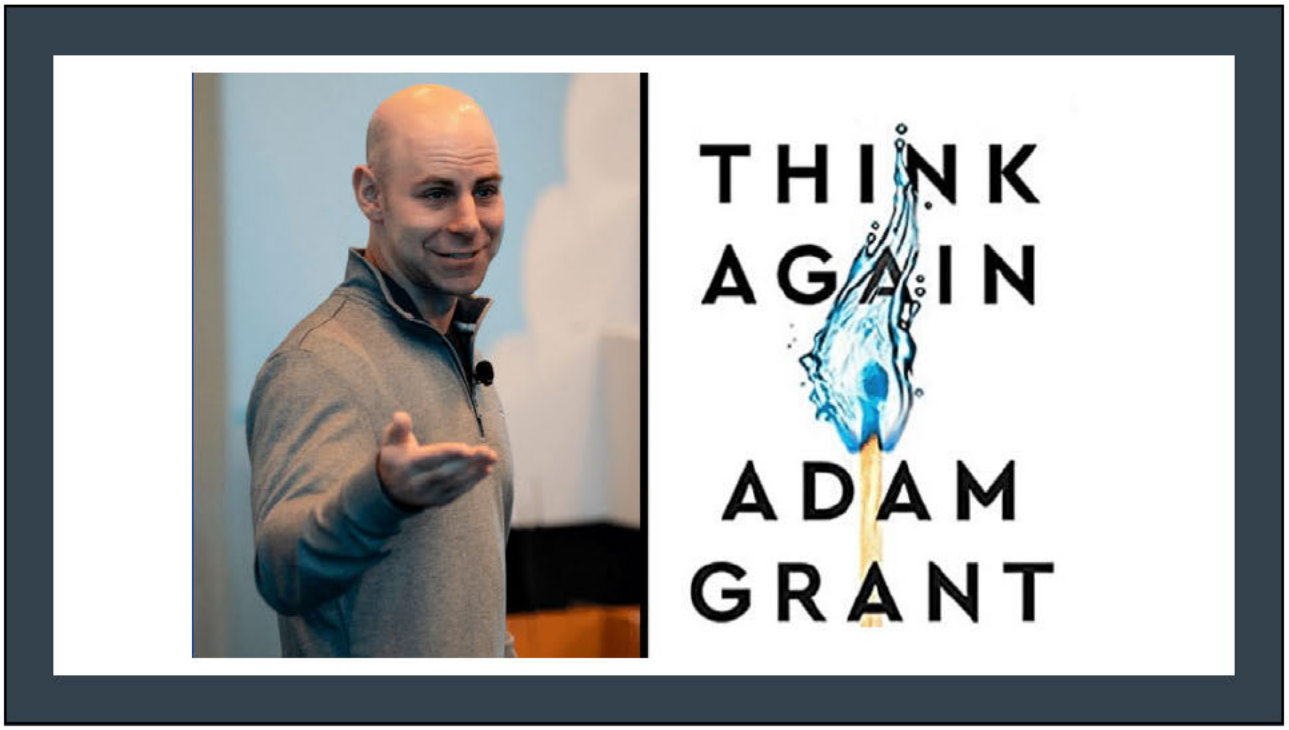
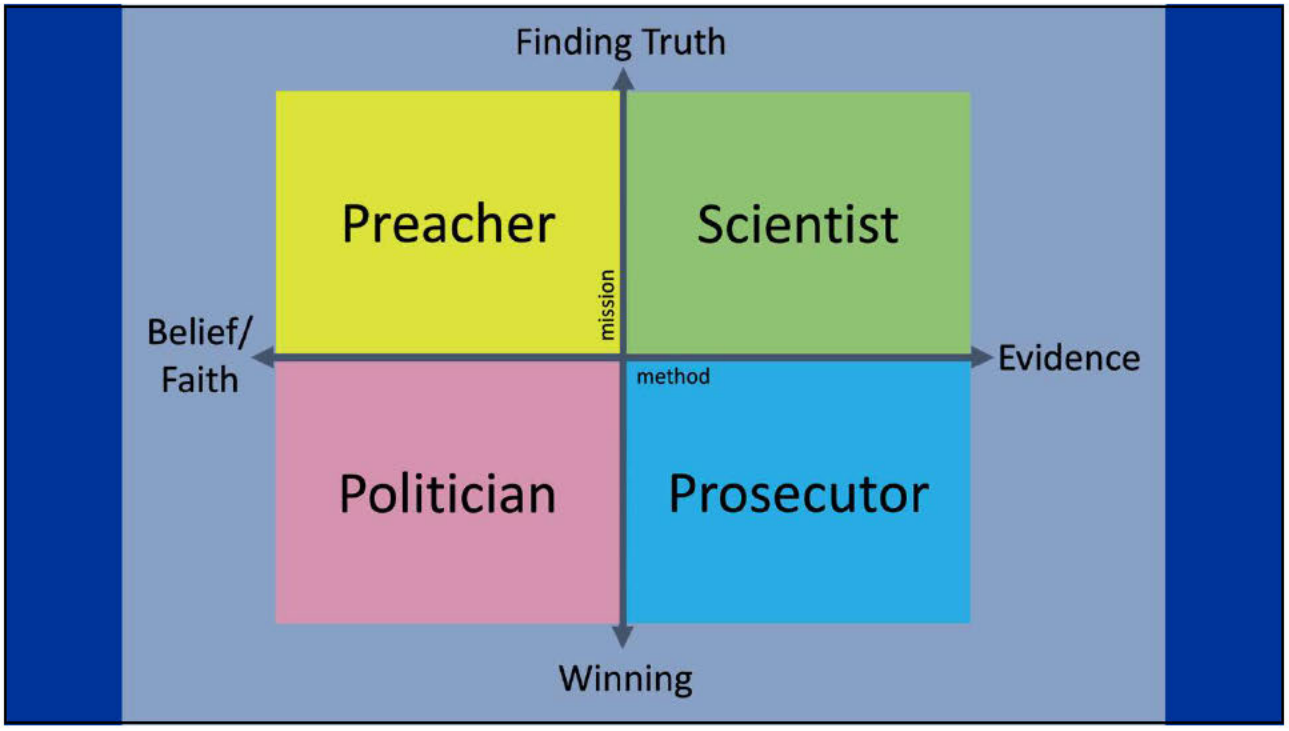



The single biggest problem in communication is the illusion that it has taken place.
— George Bernard Shaw —


THINK AGAIN
ADAM GRANT

Recognize your critic's thinking mode


Finding Truth
Preacher
Scientist
mission
Belief/
Faith
Evidence
method
Politician
Prosecutor
Winning


Using a scientist mindset fosters collaboration

Self-Assessment

Listening

For each of the following questions, select the answer that best describes you.

Remember to respond as you have behaved or would behave, not as you think you should behave.

1. I maintain eye contact with the speaker
   Usually Sometimes Seldom

2. I determine whether or not a speaker's ideas are worthwhile solely by his/her appearance
   Usually Sometimes Seldom

3. I try to understand the message from the speaker's point of view
   Usually Sometimes Seldom

4. I listen for specific facts rather than for the big picture
   Usually Sometimes Seldom

5. I listen for both factual content and the emotion behind the literal words
   Usually Sometimes Seldom

6. I ask questions for clarification and understanding
   Usually Sometimes Seldom

7. I withhold judgment of what the speaker is saying until he or she is finished.

   Usually Sometimes Seldom

8. I make a conscious effort to evaluate the logic and consistency of what is being said.

   Usually Sometimes Seldom

9. While listening, I think about what I am going to say as soon as I have my chance.

   Usually Sometimes Seldom

10. I try to have the last word.

    Usually Sometimes Seldom

Scoring Format

- Questions 1,3,5,6,7,8
  - 3 points for usually
  - 2 points for sometimes
  - 1 point for seldom

Question 2,4,9,10

- 3 points for seldom
- 2 points for sometimes
- 1 point for usually

➢ Sum up total points.

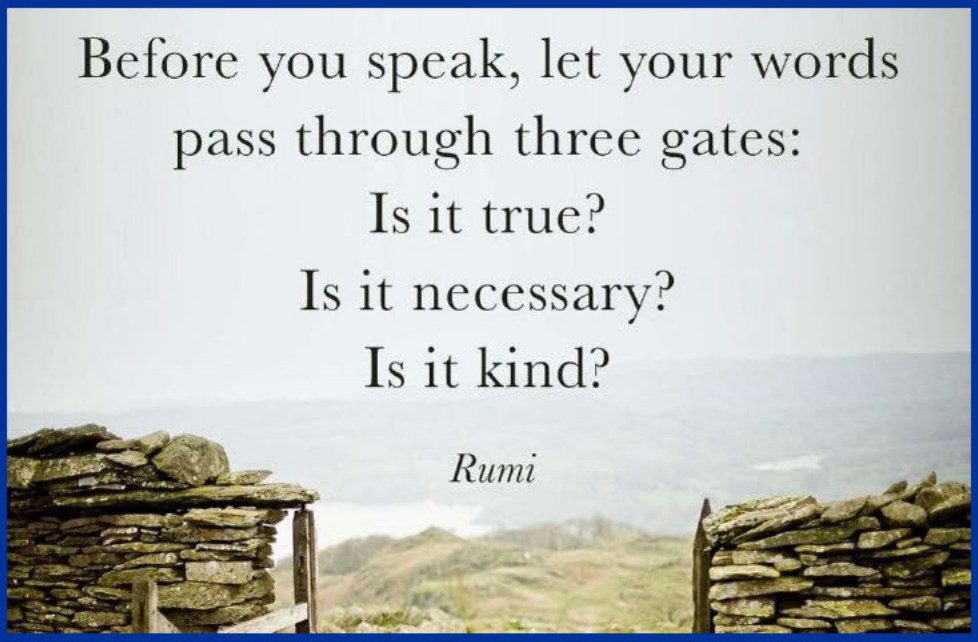
A score of 27 or higher means you are a good listener.
A score of 22-26 suggests you have some listening deficiencies.
A score below 22, you have developed a number of bad listening habits.

Listening with Intention

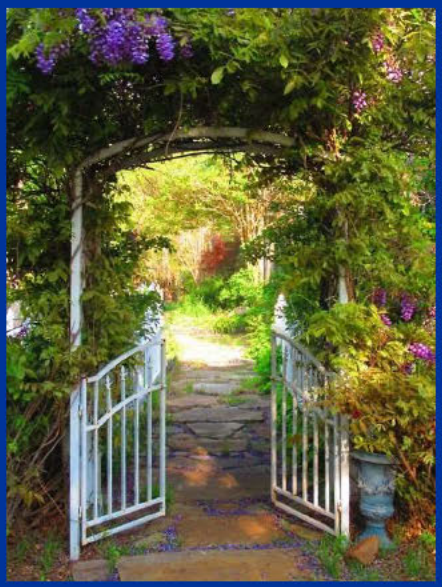
The intention is to learn and foster collaboration.

Adopting a Scientist Mindset

Listening with Empathy

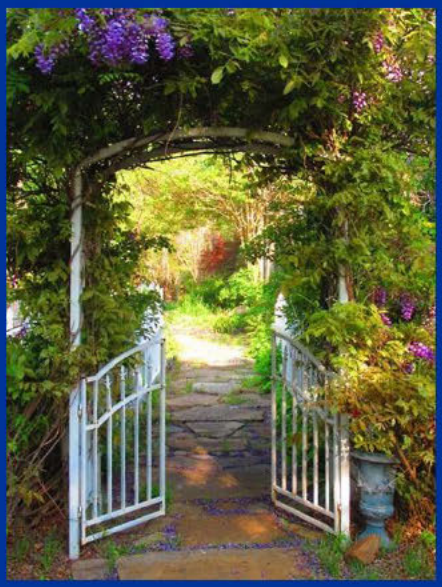

Before you speak, let your words
pass through three gates:
Is it true?
Is it necessary?
Is it kind?
Rumi

Is it true?



Is what I am going to say based on facts or is based on my perception or interpretation of events or on what others have told me? [Implicit bias]

Is it necessary?

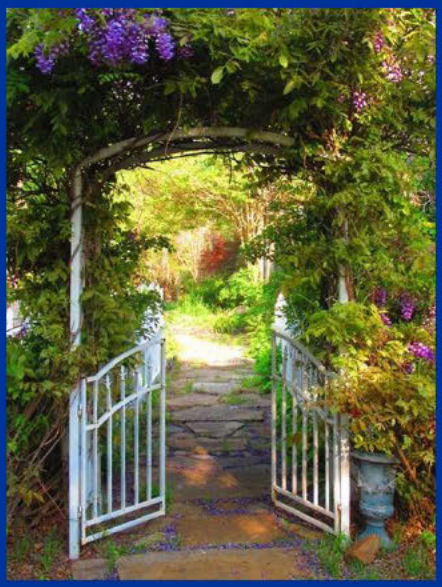


Being mindful/fully aware of the possible consequences of saying what you are getting ready to say!!!!!

W A I T

Why Am I Talking?

Is it kind?

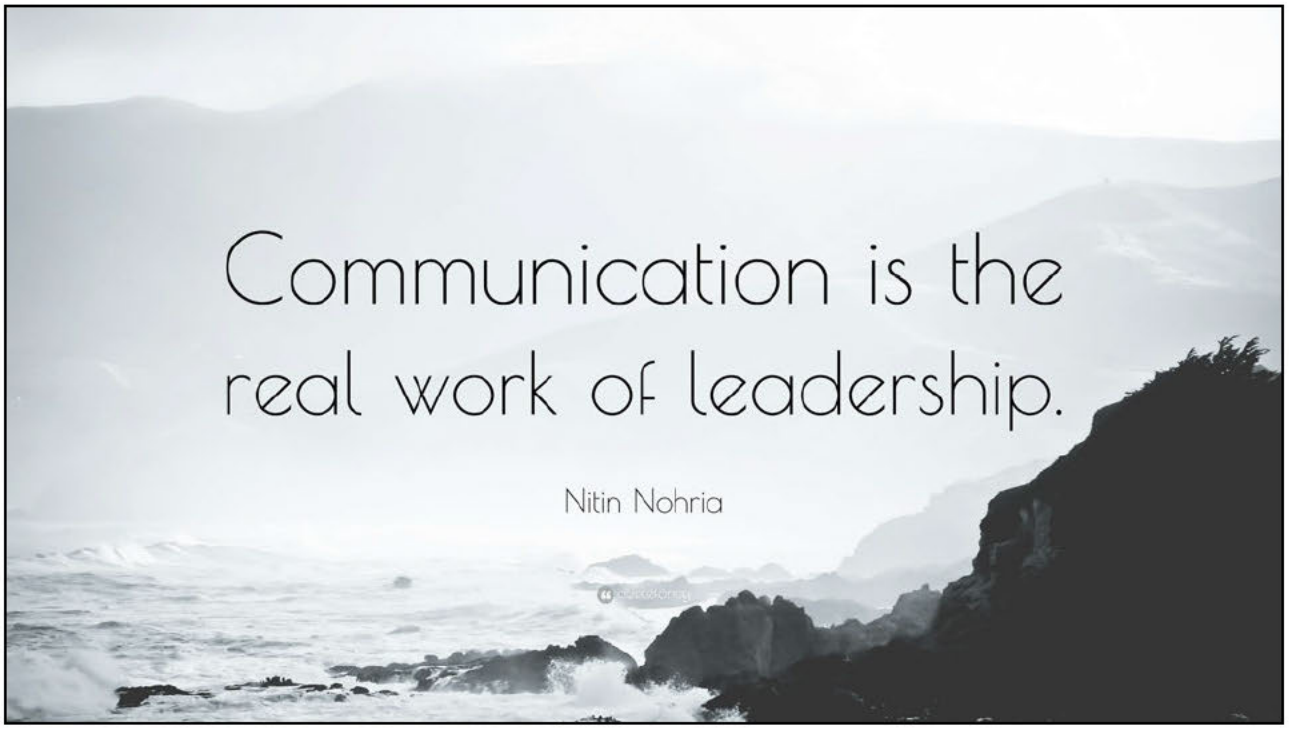


Useful Communication Phrases

Say What You Mean: A Mindful Approach to Nonviolent Communication (Handout)

- Request for dialogue
- Offering empathy
- Eliciting information
- Request for empathy
- Inserting pause
- Taking a break

Adapted from Oren Jay Sofer "Say what you mean"



Transformational Leadership - Listening Self-Assessment

1. I maintain eye contact with the speaker	Usually [3] sometimes [2] seldom [1]
2. I determine whether or not a speaker's ideas are worthwhile solely by his/her appearance	Usually [1] sometimes [2] seldom [3]
3. I try to understand the message from the speaker's point of view	Usually [3] sometimes [2] seldom [1]
4. I listen for specific facts rather than for the big picture	Usually [1] sometimes [2] seldom [3]
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6. I ask questions for clarification and understanding	Usually [3] sometimes [2] seldom [1]
7. I withhold judgment of what the speaker is saying until he or she is finished.	Usually [3] sometimes [2] seldom [1]
8. I make a conscious effort to evaluate the logic and consistency of what is being said.	Usually [3] sometimes [2] seldom [1]
9. While listening, I think about what I am going to say as soon as I have my chance.	Usually [1] sometimes [2] seldom [3]
10. I try to have the last word.	Usually [1] sometimes [2] seldom [3]

Scoring Format

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    - 1 point for usually

3. Sum up total points.

A score of 27 or higher means you are a good listener.

A score of 22-26 suggests you have some listening deficiencies.

A score below 22, you have developed a number of bad listening habits.

Say What You Mean: A Mindful Approach to Nonviolent Communication

Useful Communication Phrases

Requests for Dialogue

- "Would you be willing to take some time to have a conversation with me about …[topic]?"
- "Could we sit down together and look at what we both need to see if we can find a way to work this out? (or: to see if we can find a solution that works for both of us?)"

Offering Empathy

- "Let me see if I'm understanding. What I'm getting is …?"
- "I want to make sure I'm getting it. It sounds like …?"
- "May I recap what I'm hearing so far?"
- "Here's what I'm hearing… Is that right?"

Eliciting Information

- "Tell me more." "Go on…" "What else?"
- "Help me to understand. Would you say more about…"
- "I'm curious about…"
- "Is there anything else you'd like me to understand about this?"
- "Could you tell me one or two things I might say or do right now that would help you to feel more understood / more heard?"

Requests for Empathy

- "What would be most helpful for me right now is just to be heard. Would you be willing to listen for a bit and tell me what you're hearing?"
- "I have so much going through my head right now that I'm struggling to focus. Do you have some space to listen to me before you say more?"
- "I just said a lot and I'm not sure it all came out the way I was intending. Could you tell me what you got from all that?"
- "What I just said is really important to me. Would you be willing to tell me what you're getting?"
- "I'm wondering if you could take a moment to tell me what you've heard. It would really mean a lot and help me to know if I've gotten my feelings across."
- "Could you tell me what you hear matters to me in this situation?"

Inserting a Pause

- "I'd like a moment to gather my thoughts."
- "I'm not sure. Let me think about that."
- "This sounds important. I'd like to give it some time."
- "I'd like some time to take that in. Can we pause here for a moment?"
- "Our conversation is moving so quickly I'm having a hard time taking it in. Can we back up / slow down?"

Taking a Break

- "I'd really like to continue our conversation, and I'm not in the best frame of mind to do that right now. Can we take a break and come back to this . . . ?"
- "I'd really like to hear what you have to say, and I'm feeling a little overwhelmed, so I don't think I'll be able to listen well. Could we take a break and continue tomorrow?"
- "I'm committed to figuring this out together and don't quite have the space to think clearly now. Can we put this on hold until . . . ?"
- "I want to finish our conversation, and I don't think anything else I say right now will be useful. Could we take a break until . . ."
- "I notice that I have so little bandwidth right now. Can we talk …[insert time]?"

- "I'd really like to hear what you have to say, but the way you're saying it is making that very difficult. I wonder if you'd be willing to . . .
  . . . try explaining what's happening for you in a different way?"
  . . . take a break until we've both had a chance to reflect on this?"
  . . . let me have a moment to tell you what's going on for me?"

Interrupting

- "Hang on—Let me make sure I'm still with you . . ."
- "I want to make sure I'm getting everything you said. Can we pause for a moment so I can make sure I'm following it all?"
- "I want to hear the rest of what you're saying, and I'm starting to lose track. Can I summarize what I'm hearing so far?"
- "Can I pause you for a second?"
- "I want you to continue, but I'm a bit confused. May I ask a question?"
- "I want to keep listening, and there's something I want to clarify. May I respond for a moment?"

Redirecting

- "I'm glad you mention that. Before we go there, I'd like to say one or two more things about . . ."
- "I appreciate you bringing that up. I want to discuss that in a minute, but first I'd like to touch on . . ."
- "Yes, that's important. Can we finish talking about this first, and come back to that in a moment?"
- "I'd like to rewind. Can we go back to something you were saying before?"
- "I wasn't quite finished with my thought. Do you mind if I say one or two more things?"

Hearing No

- "I'm curious to know, why not? Could you share more?"
- "What's leading you to say no? Do you have other ideas?"
- "Can we take some time to brainstorm ideas that could work for both of us?"
- "Can you tell me why this doesn't work for you?"
- "What would you need to know, or what could I do, to make it possible for you to say yes?"

Saying No

- "I'd like to say yes, and here's what's getting in the way of that right now."
- "I'm hearing how important this is to you, and I'm not seeing how I can make it work given that I also have a need for... Could we explore some other options that might work for you?"
- "I can't agree to that without a significant cost to myself in terms of . . . [other needs]. Would it work for you if we tried…instead?"

Requests for "Do-overs"

- "That didn't come out quite right. Can I try that again?"
- "I feel like we got off to the wrong start. Could we start over?"
- "I'm concerned some of the things I said aren't helping. May I try again?"
- "Things didn't really go the way I was hoping when we talked. Could we try having the conversation again?"

Other Useful Phrases

- "The story I'm telling myself is…"
- "That's not my experience…"

ENSURING FAIR AND IMPARTIAL DECISIONS IN CLIMATE LITIGATION

DIVIDER 14

Hon. Stacy Boulware-Eurie

CLIMATE SCIENCE AND PRACTICAL APPLICATION IN THE COURTROOM (PART 2)

DIVIDER 15

Hon. Stacy Boulware-Eurie
Dr. Yvonne Stedham
Professor Kelly Tait

HURRICANES AND MODELING

DIVIDER 16

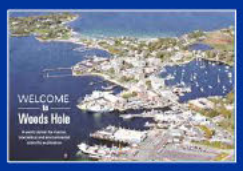
Professor Kerry Emanuel

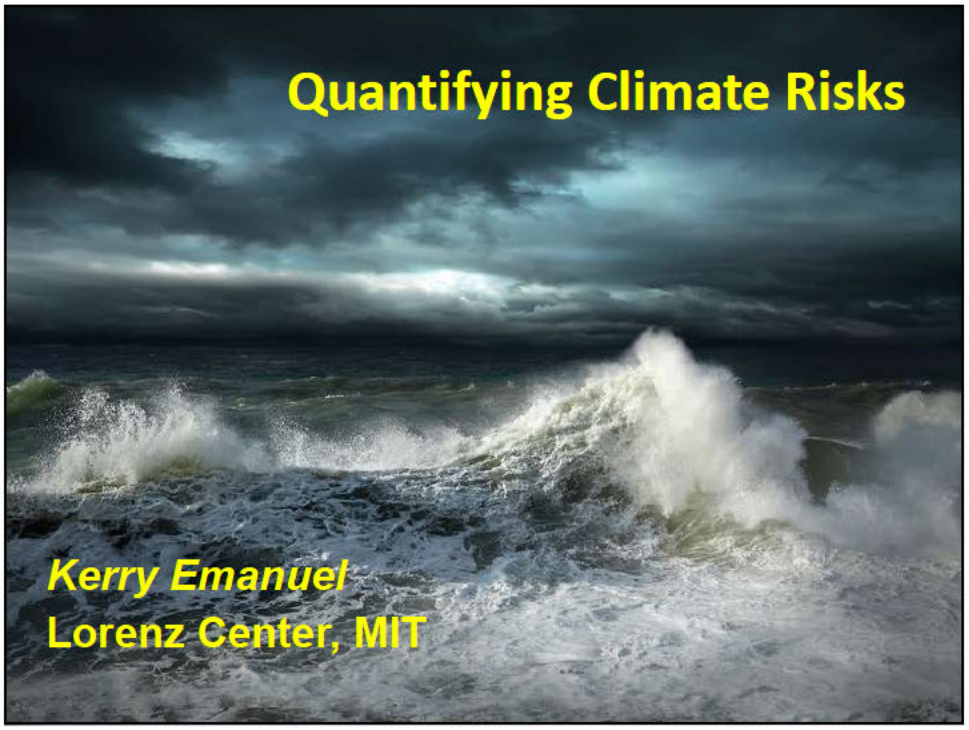
Quantifying Climate Risks

Professor Kerry Emanuel

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE





Program

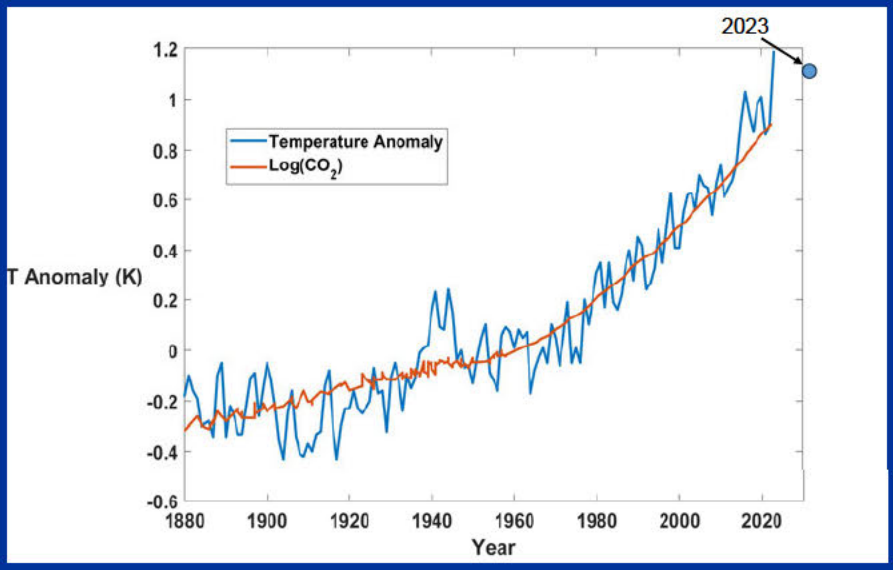
- Global warming in context
- Climate risks
- Quantitative estimates of climate risks
- Implications for legal proceedings

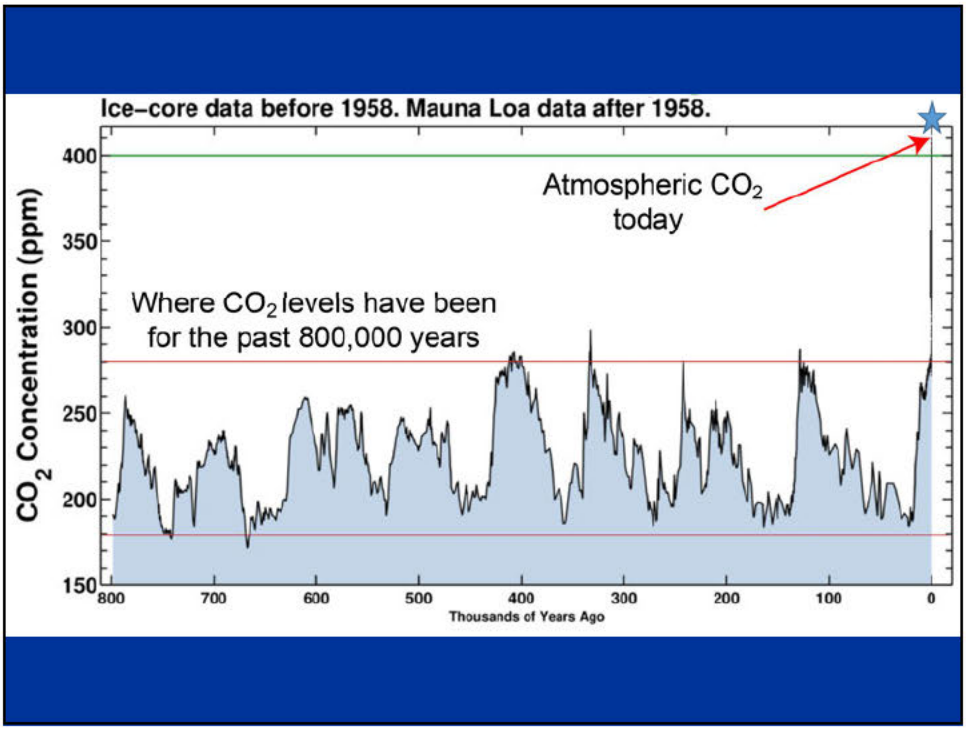
Svante Arrhenius, 1859-1927

"Any doubling of the percentage of carbon dioxide in the air would raise the temperature of the earth's surface by 4°; and if the carbon dioxide were increased fourfold, the temperature would rise by 8°."

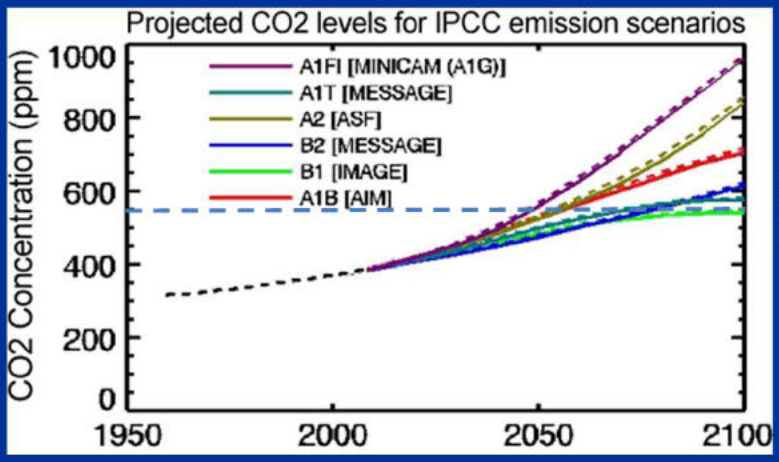
– *Världarnas utveckling* (Worlds in the Making), 1906

Global Mean Temperature and CO_2





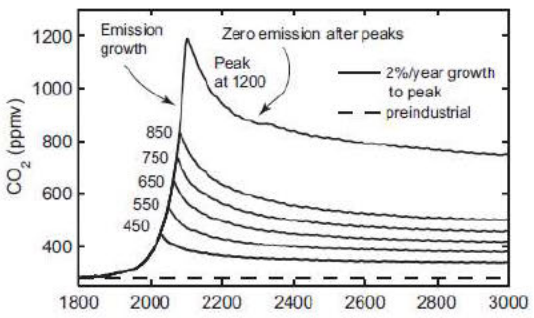
CO_2 May Go Well Beyond Doubling



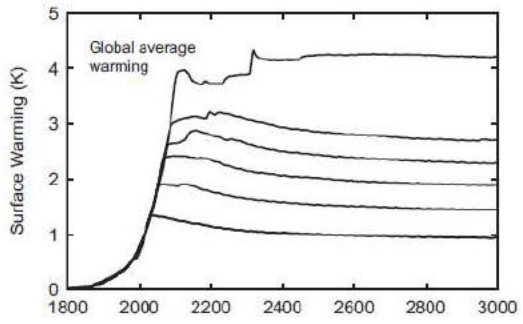
Double Pre-Industrial

IPCC 2007: Doubling CO_2 will lead to an increase in mean global surface temperature of 2 to 4.5 °C.

Atmospheric CO_2 assuming that emissions stop altogether after peak concentrations



Global mean surface temperature corresponding to atmospheric CO_2 above



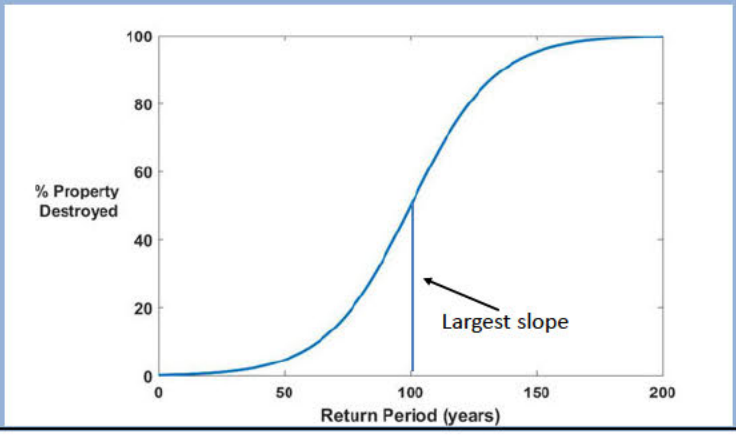
Courtesy Susan Solomon

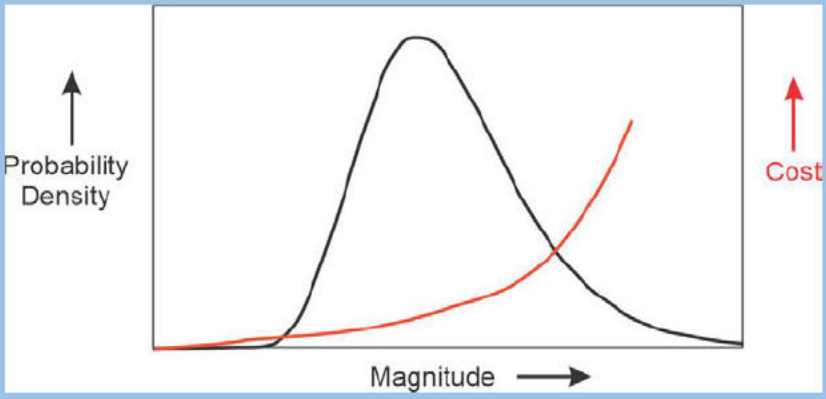
Climate Risks

- No one really cares whether the world will warm up by 3-5 C (nor should they)
- We care about real risks: Heat waves, wild fires, hurricanes, droughts, floods, etc.
- We need to *quantify* these risks, *including uncertainty*, to position ourselves to make intelligent choices
- Insurance is one instrument for quantifying risk, *but it is not currently even accounting for climate change that has already occurred*
- Science is positioned to make rapid progress in quantifying climate risk

Why Climate Risk is Dominated by Extreme Events:

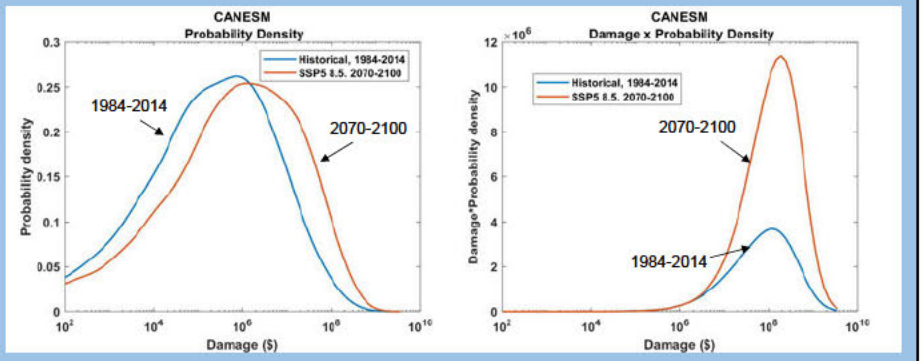
- Societies are usually well adapted to frequent events (> 1/100 yr)
- Societies are often poorly adapted to rare events (< 1/100 yr)
- Large cost increases result when > 100-yr events become < 100-yr events





Much of the cost comes from the far tail of the hazard magnitude

Getting It Right Means Getting The Low-Probability, High Cost Events. For Example, Hurricanes:

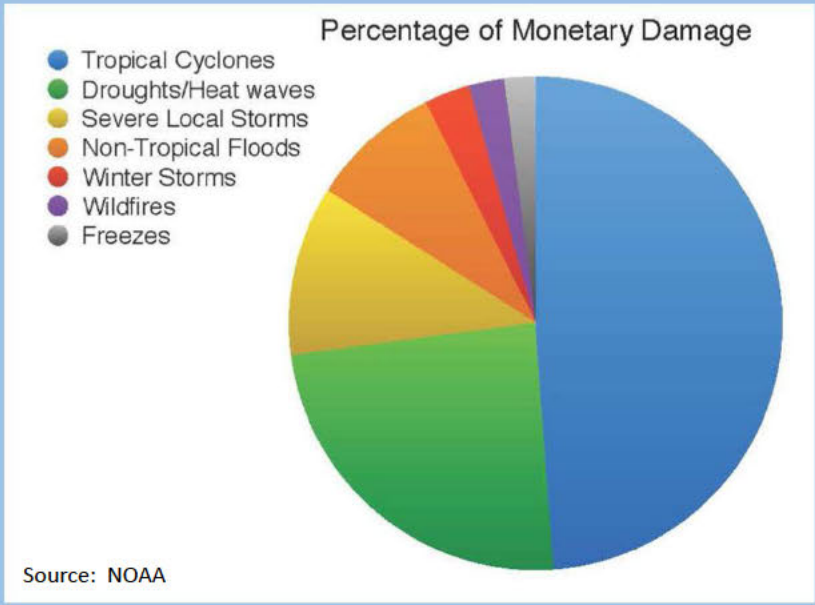


Probability **Cost**

Flawed Basis of Current Risk Assessments

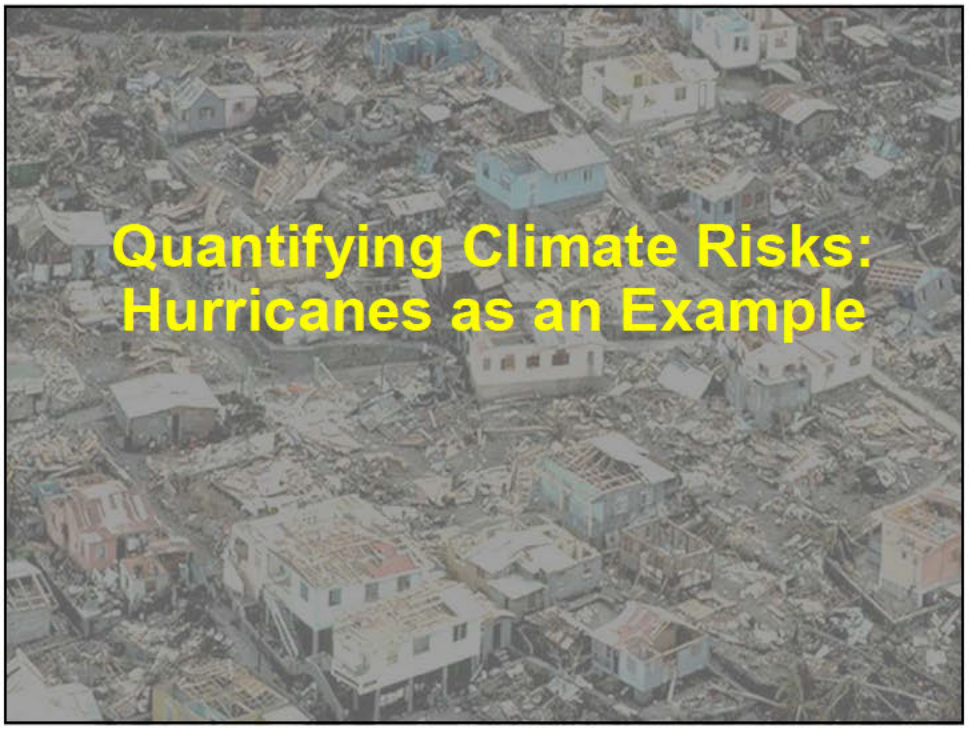
- Almost all current risk assessments, including those used in legal proceedings, are based on historical statistics
- Historical records are flawed and short, particularly outside North America
- Moreover, the past 50-150 years is a poor guide to the present owing to climate change that has already occurred
- Industry risk modelers have been slow to migrate to a physics-based approach

Total US Damages by Natural Hazard, 1980-2012



Source: NOAA

Questions So Far?

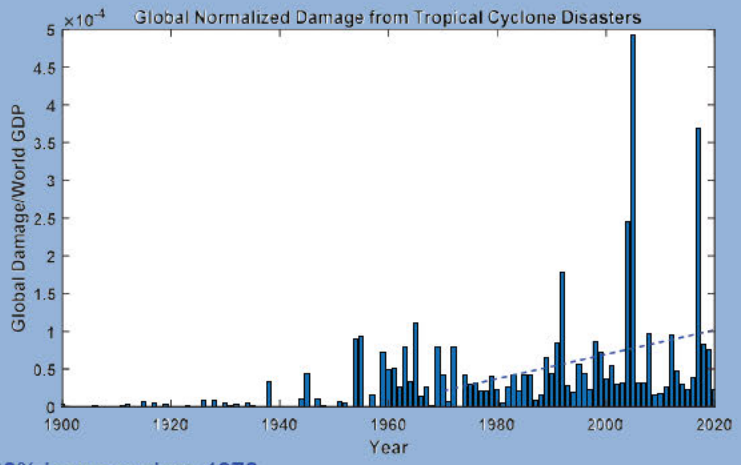


The Global Hurricane Hazard

- About 10,000 deaths per year since 1971
- $700 Billion 2015 U.S. Dollars in Damages since 1971
- Global population exposed to hurricane hazards has tripled since 1970

EM-DAT, 2016: The OFDA/CRED International Disaster Database http://www.emdat.be/.

Global Tropical Cyclone Damage Normalized by Gross World Product

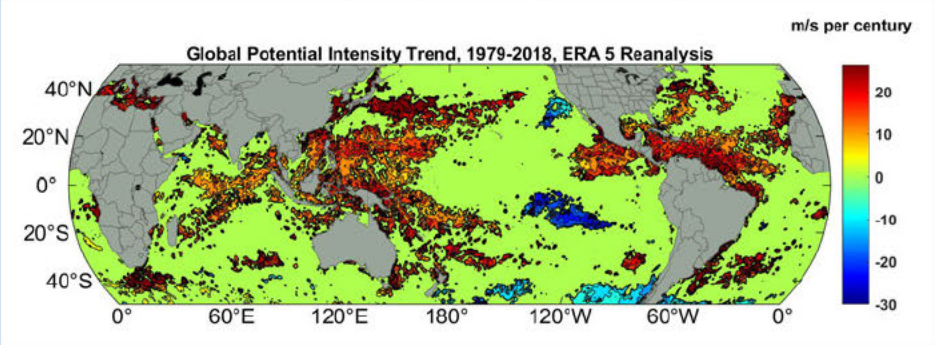


- 380% increase since 1970
- Population of TC-prone regions increased by ~200%
- Suggests that climate change has contributed to increasing damage

EM-DAT, 2020: The OFDA/CRED International Disaster Database
http://www.emdat.be/.

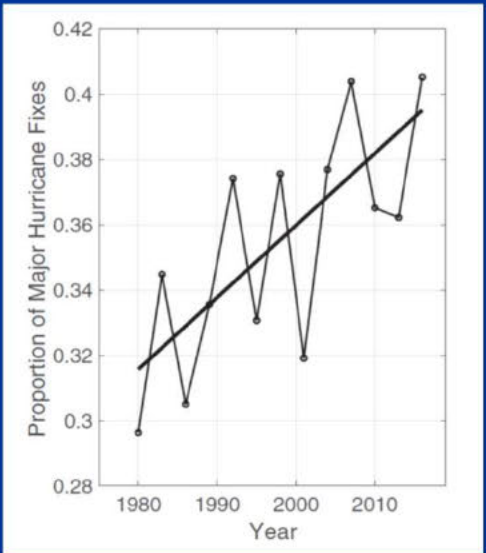
Observed Trend in "Speed Limit" for Hurricanes

Potential Intensity Trend, 1979-2018, ERA 5 Reanalysis



(Trend shown only where p value < 0.05)

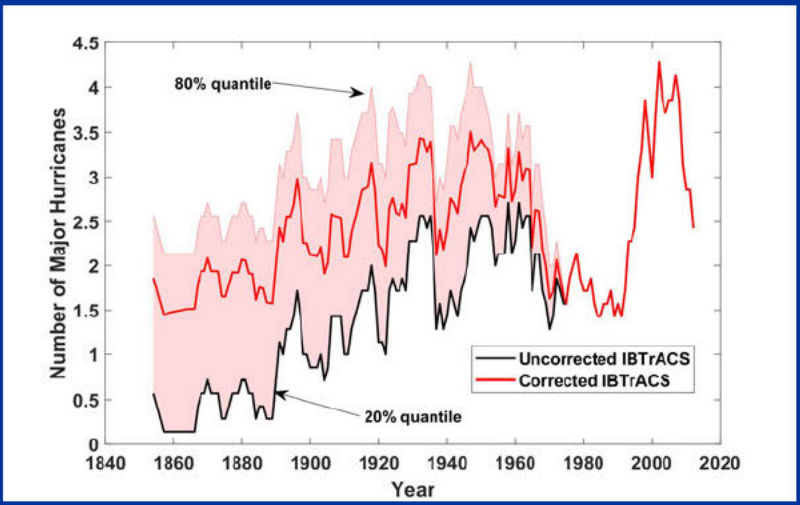
Satellite-Derived Proportion Of Major Hurricane Fixes



Time series of fractional proportion of global major hurricane estimates to all hurricane estimates for the period 1979–2017. Each point, except the earliest, represents the data in a sequence of 3-y periods. The first data point is based on only 2 y (1979 and 1981) to avoid the years with no eastern hemisphere coverage. The linear Theil−Sen trend (black line) is significant at the 98% confidence level (Mann−Kendall P value = 0.02). The proportion increases by 25% in the 39-y period (about 6% per decade).

Kossin et al., *PNAS*, 2020

Red Shading Shows Uncertainty in North Atlantic Hurricane Occurrence



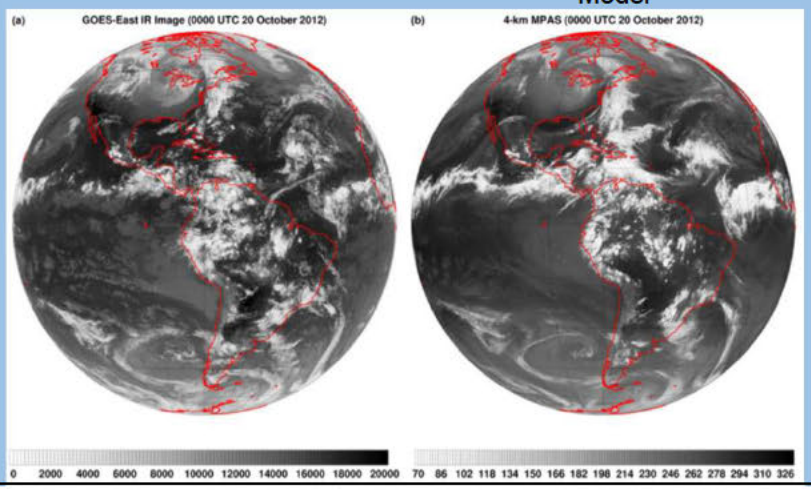
Data from Vecchi et al., *Nature Comm.*, 2021

Historical tropical cyclone database vastly insufficient to quantitatively evaluate current risk and risk trends

Doing it Right: Bring *Physical Models* to Bear on Risk Estimation

Satellite Image

Global Weather Forecast Model

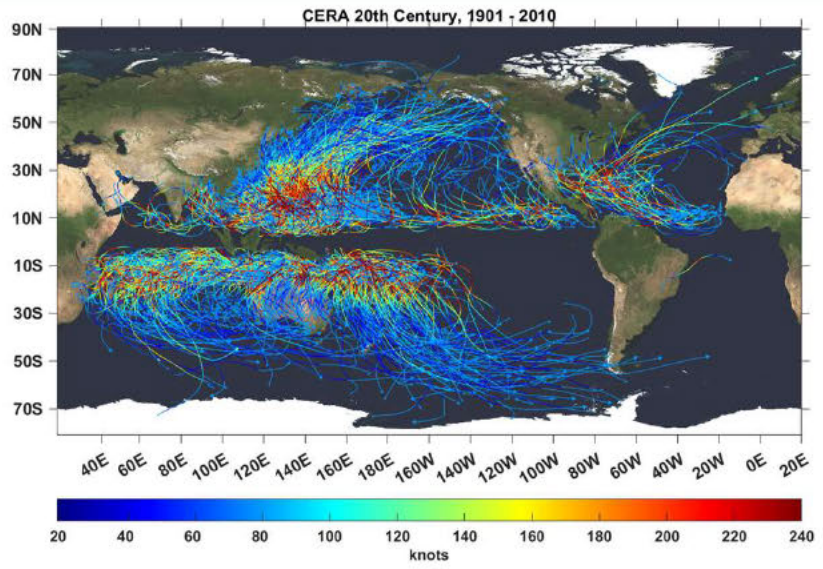


But today's global climate models cannot simulate hurricane at all well

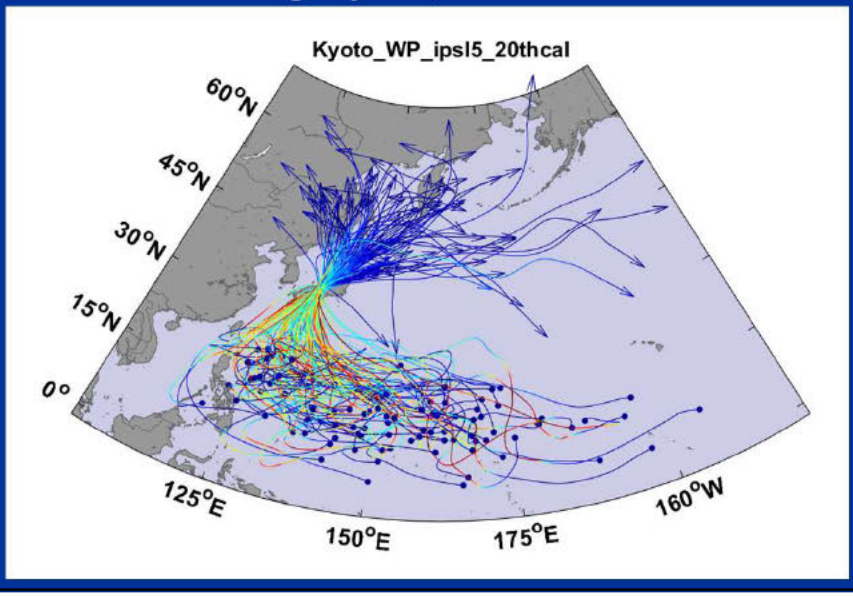
To Get The Tails Right We Need To Simulate **Many** Events

We have learned how to downscale ~100,000 hurricanes from climate models, using an advanced, very high resolution hurricane model embedded in global climate analyses or models

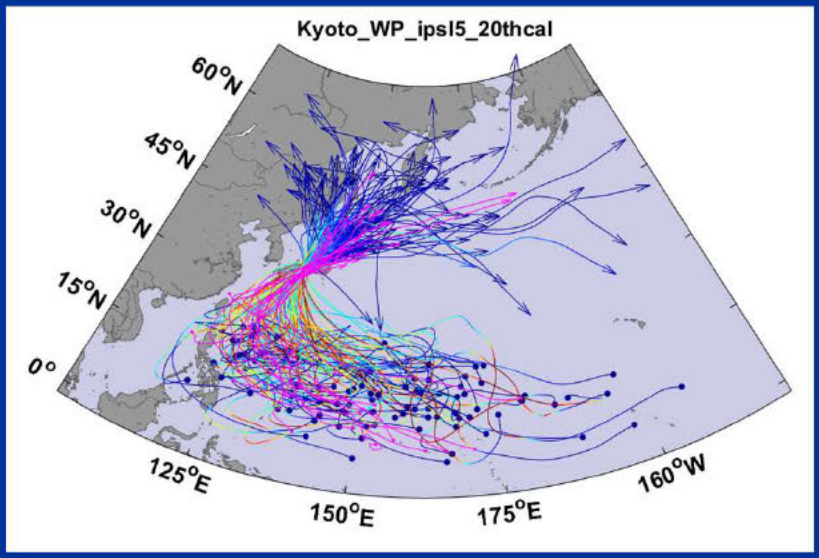
Top 1,000 Storms Downscaled From CERA 20th Century Reanalysis

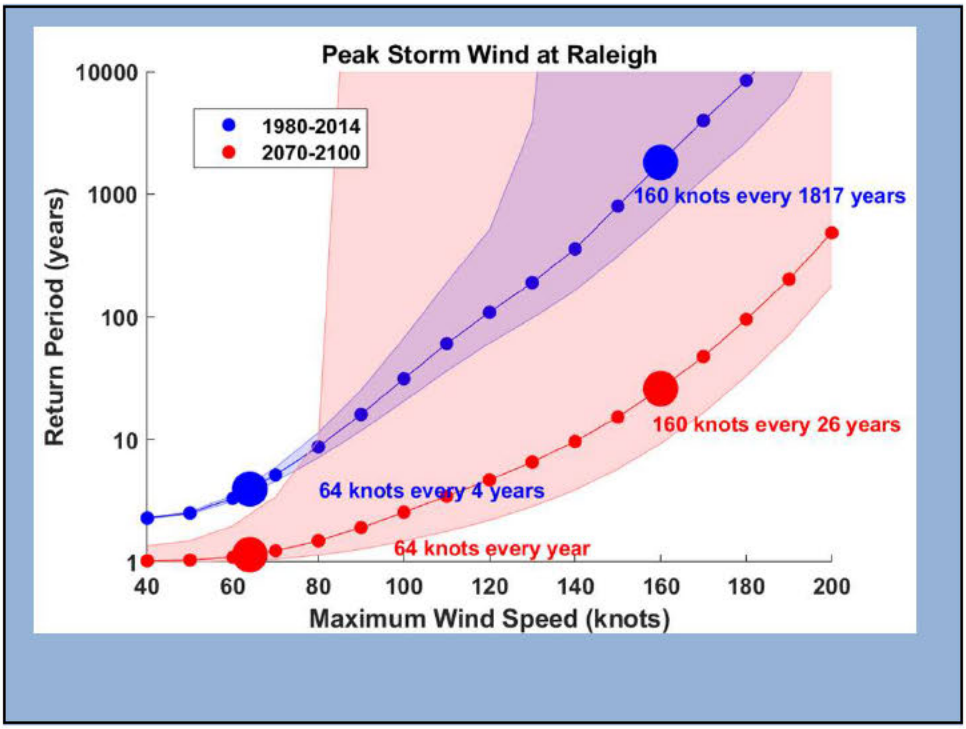


Example: Top 100 out of 2000 TCs Affecting Kyoto, 1981-2000

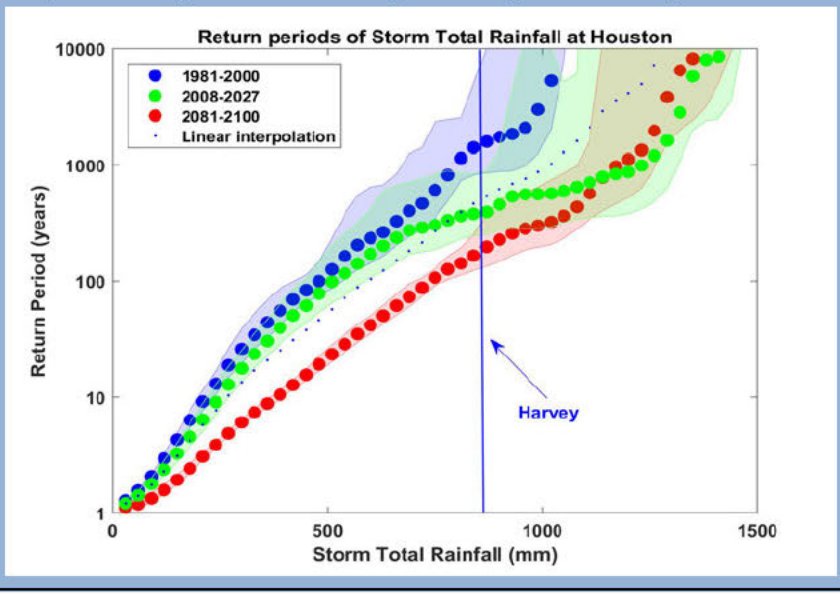


Same, But With Top 20 Historical Tracks





Probability of Storm Accumulated Rainfall in Harris County, from 6 Climate Models, 1981-2000, 2008-2027, and 2081-2100, Based on 2000 Events Each, and Using RCP 8.5. Shading Shows Spread Among the Models.

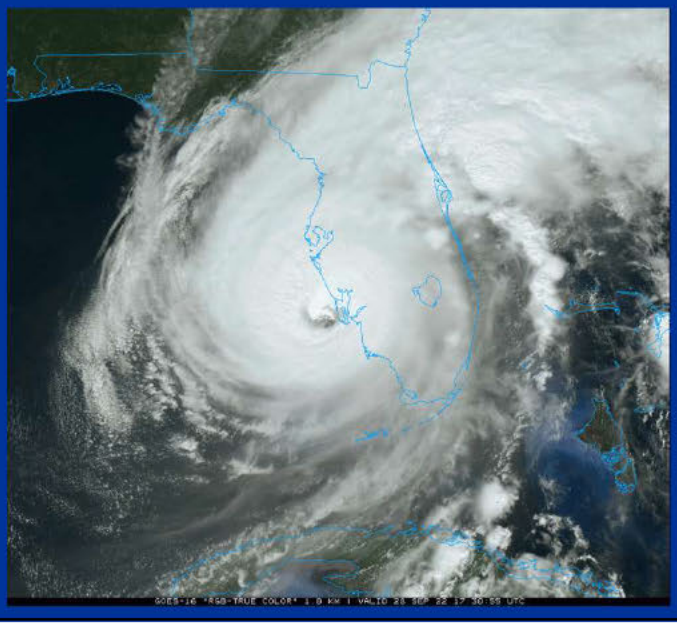


Example: Flooding From Hurricane Harvey, 2017

Three independent scientific studies appeared in 2017:

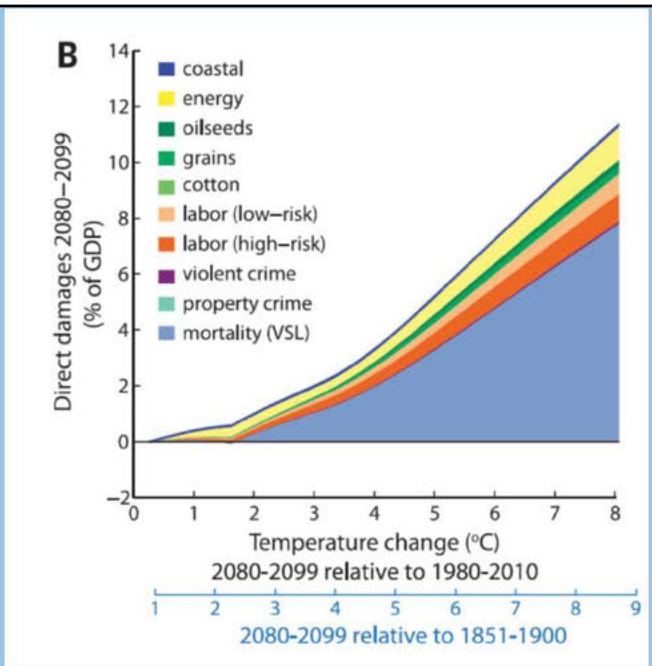
- **van Oldenborgh et al**: *"We conclude that global warming made the precipitation about 15% (8%–19%) more intense, or equivalently made such an event three (1.5–5) times more likely."*
- **Risser and Wehner:** *"We find that human-induced climate change likely increased the chances of the observed precipitation accumulations during Hurricane Harvey in the most affected areas of Houston by a factor of at least 3.5."*
- **Emanuel:** *"In 2017 the annual probability* [of Hurricane Harvey's rainfall in Harris County] *would be 6%, a sixfold increase since the late 20th century.*

Questions So Far?

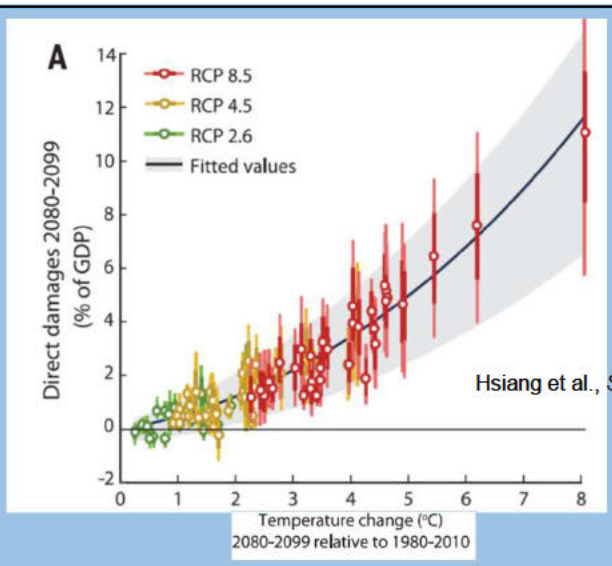


Hurricane Ian, 2022

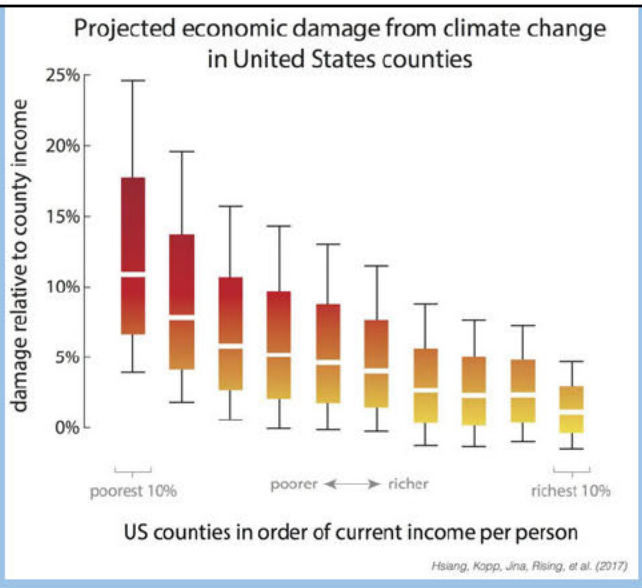
Accounting for All Climate Risks



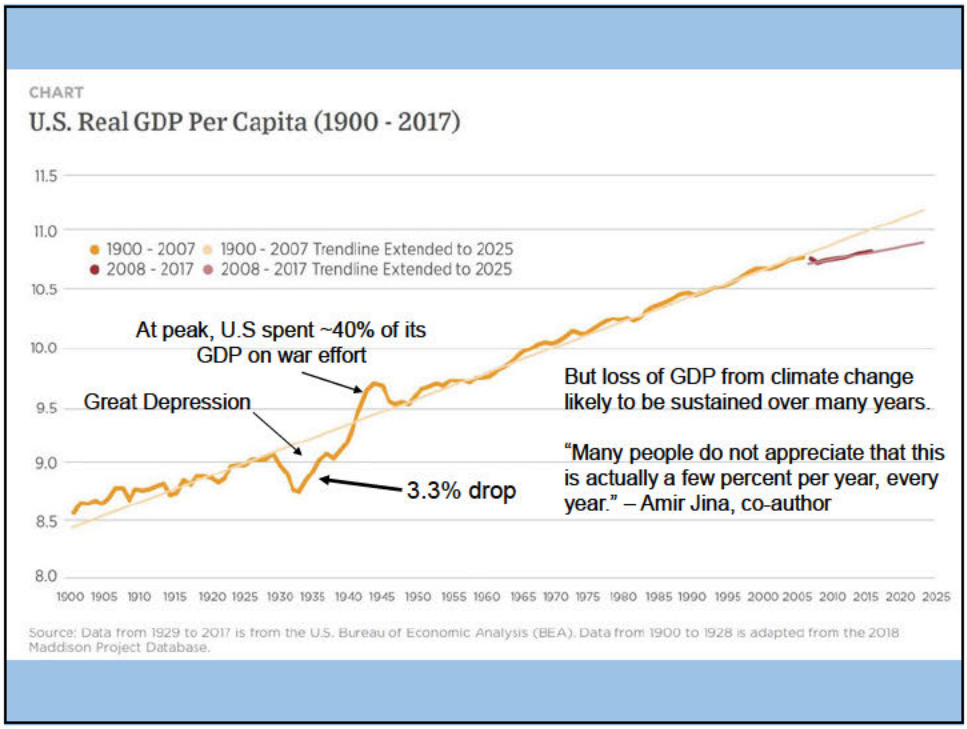
Hsiang et al., *Science*, 2017



Total direct damage to U.S. economy, summed across all assessed sectors, as a function of global mean temperature change. Dot-whiskers indicate the distribution of direct damages in 2080 to 2099 (averaged) for multiple realizations of each combination of climate models and scenario projection (dot, median; dark line, inner 66% credible interval; medium line, inner 90%; light line, inner 95%). Green are from RCP2.6, yellow from RCP4.5, red from RCP8.5



Range of economic damages per year for groupings of US counties, based on their income (29,000 simulations for each of 3,143 counties). The poorest 10% of counties are the leftmost box plot. The richest 10% are the rightmost box plot. Damages are fraction of county income. White lines are median estimates, boxes show the inner 66% of possible outcomes, outer whiskers are inner 90% of possible outcomes.



Summary of Main Points

- We are altering the composition of our atmosphere at considerable risk to ourselves and to future generations
- Long-term risk is dominated by extreme events
- Historical records inadequate for estimating future and current weather risks

Summary of Main Points

- We need to embrace advanced physical modeling techniques for assessing climate risks
- It is likely that expert witnesses in future legal proceedings will increasingly rely on physical modeling as evidence of current and future climate risk

- *At best*, climate science will only be able to quantify the probability that climate change has and/or will contribute to some particular weather event or class of events
- How do courts deal with probabilistic information?

ENERGY TRANSITION

DIVIDER 17

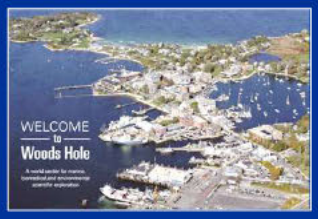
Dr. Jennifer Morris

Energy Transition

Jennifer Morris, Ph.D.

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE



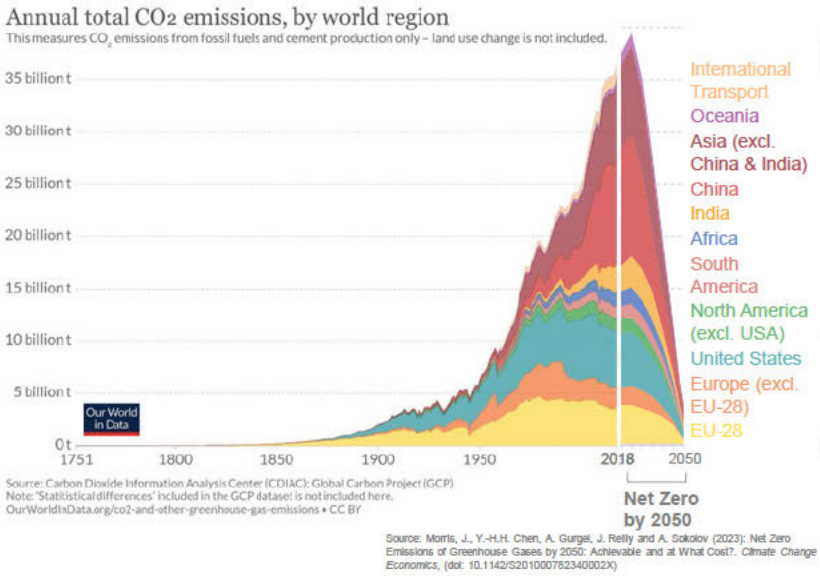
Energy Transition

Jennifer Morris
MIT Joint Program on the Science and Policy of Global Change

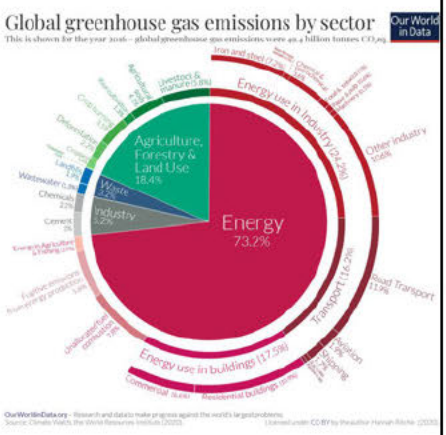
Judicial Leaders in Climate Science

September 16-18, 2024

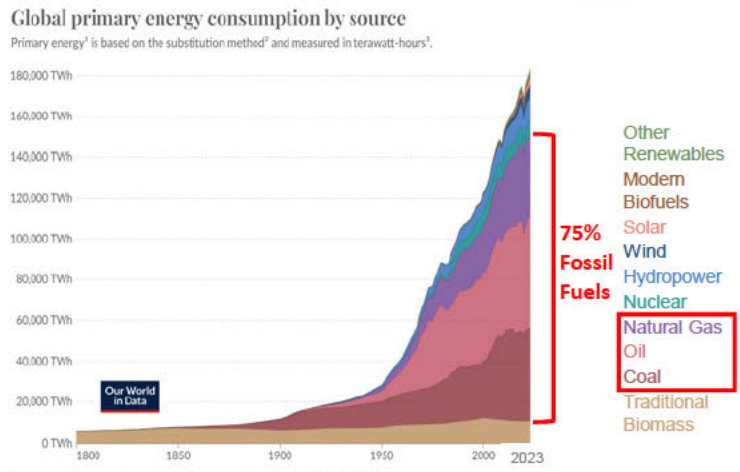
The Context



Source: Morris, J., Y.-H.H. Chen, A. Gurgel, J. Reilly and A. Sokolov (2023): Net Zero Emissions of Greenhouse Gases by 2050: Achievable and at What Cost?. *Climate Change Economics*, (doi: 10.1142/S2010007823400002X)

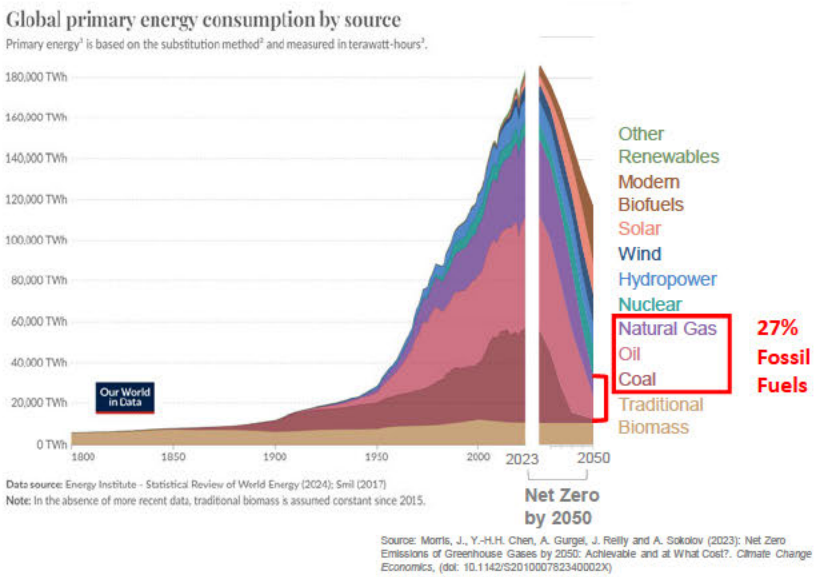


The Context



Data source: Energy Institute - Statistical Review of World Energy (2024); Smil (2017)
Note: In the absence of more recent data, traditional biomass is assumed constant since 2015.

The Context



Source: Morris, J., Y.-H.H. Chen, A. Gurgel, J. Reilly and A. Sokolov (2023): Net Zero Emissions of Greenhouse Gases by 2050: Achievable and at What Cost?. *Climate Change Economics*, (doi: 10.1142/S2010007823400002X)

- Dramatic energy transition is needed to meet long-term climate goals
- This is just **one** scenario… there are **countless** others
- Critical to explore alternative transition pathways and their **implications** for:
  - Cost
  - Land & Water
  - Infrastructure
  - Biodiversity
  - Human well-being (health, jobs, prices, disparate impacts, etc.)…
- Can't rely on technologies alone to drive transition→ need **policies**
- Energy is more than electricity
  - Transportation fuels, heat for industry…

5

What type of energy to transition to?

- **Low-Carbon / Carbon-Free / Clean Energy Technologies**
  - **Energy technologies that produce little to no emissions in their operation**
    - Wind, Solar, Hydropower, Geothermal, Bioenergy, Nuclear, Carbon Capture and Storage (CCS)
  - Still embedded emissions (e.g. those associated with producing their equipment) and other environmental impacts
  - Even accounting for life cycle assessments, significantly better than fossil fuels

	Grams of CO2 per KWh
Coal	1000
Natural Gas	500
Solar	50
Wind	10

- **Renewable Energy Technologies**
  - Subset of low-carbon technologies that **come from an effectively infinite source**, either because they are not depleted or can be replenished
    - Wind, Solar, Hydropower, Geothermal

6

Not all renewable energy is carbon-free, and not all carbon-free energy is renewable: Examples???

- **Bioenergy is renewable, but not necessarily carbon free:** we can regrow plants that we burn for fuel. Growing plants absorbs CO2; burning plants releases CO2. The total impact on CO2 in the atmosphere depends on how sustainably the bioenergy is produced.

- **Nuclear energy is carbon-free, but not renewable:** nuclear power plants do not emit any CO2, or any other greenhouse gases. But nuclear reactors use uranium, and if we run out of uranium, we can never get it back.

7

What type of energy to transition to?

- **Negative Emission Technologies (NETs) / Carbon Dioxide Removal (CDR) Technologies**
  - **Technologies that remove emissions from the atmosphere**
    - Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Capture, Afforestation/ Reforestation, Soil Carbon Sequestration, Biochar, Enhanced Weathering, Ocean Alkalinization/Fertilization
  - Only BECCS is an energy source
  - Others can be used to offset emissions from energy sources
  - Challenges related to monitor, reporting and verification, sustainability, public/political acceptance

8

NET ZERO

Released Emissions = Negative Emissions

Net Zero What?
Fossil Energy CO2
Industrial CO2
LUC CO2?
Non-CO2 GHGs?

Timing of Net Zero?

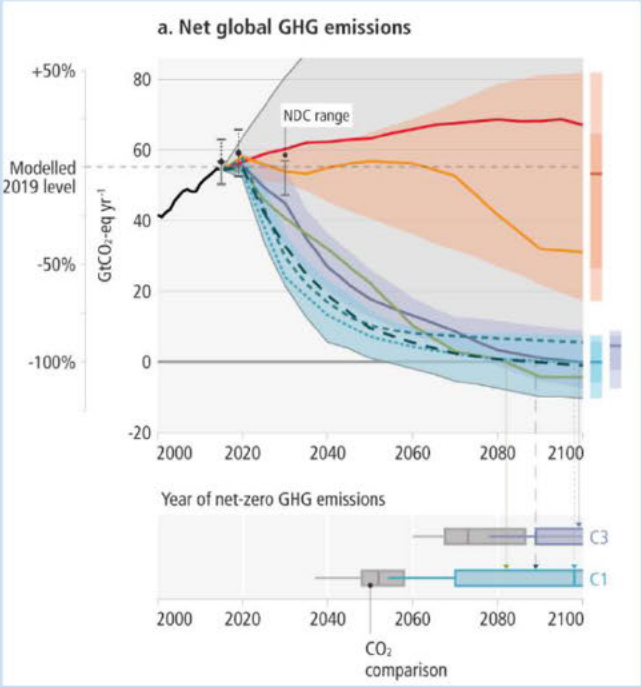
9

Net-zero emissions by 2050 is NOT a requirement for 1.5C

- Long-term climate stabilization at 1.5°C or 2°C requires total **GHG** emissions to ***eventually*** decline to **net-zero**
- Focus on **2050 is *political* choice**… Paris temperature targets can be achieved without net zero global GHG emissions in this century
- IPCC Special Report on 1.5C has 90 individual scenarios with 50% chance of 1.5C in 2100
  - Only 18 of those (20%) have net-zero emissions (CO2 energy sector + industrial process) in 2050

10

- AR6:
  - While all 50% chance 1.5C with limited overshoot scenarios reach net zero **CO2** emissions, the timing ranges from 2035-2070
  - Only **half** of the pathways reach net zero **GHG** emissions at any point during the second half of the 21st century
- Commitments of net zero by 2050 may be recognition of need for climate leadership



11

Net Zero Emissions

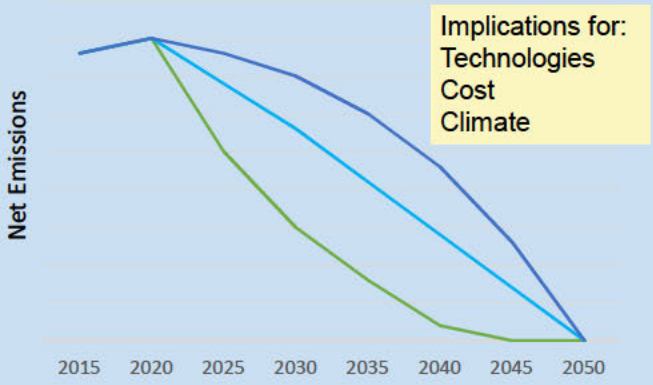
Released Emissions = Negative Emissions

Net Zero What?
Fossil Energy CO2
Industrial CO2
LUC CO2?
Non-CO2 GHGs?

Timing of Net Zero?

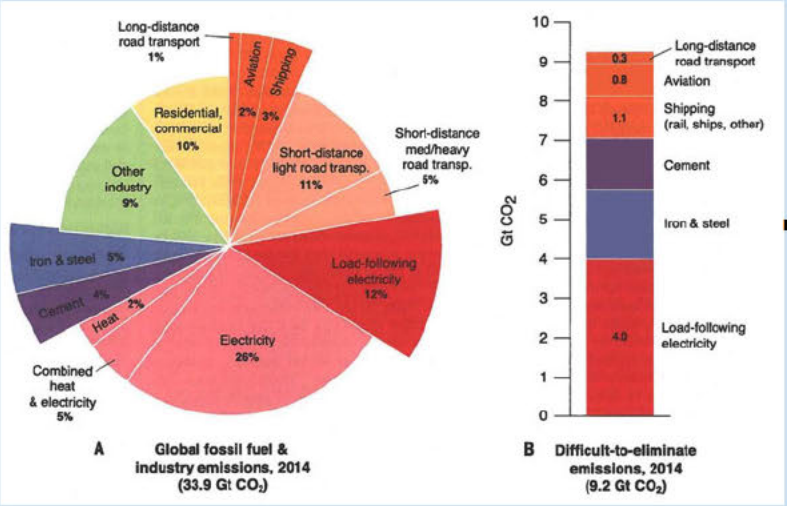
Pathway to Net Zero?

How Much + and - Emissions?



12

Difficult-to-Eliminate Emissions



+

Difficult-to-eliminate GHG emissions from other sectors (e.g., agriculture)

Total non-CO_2 GHGs in 2020 ~3 Gt CO_2e

Source: Davis et al., Science 360 1419 (2018)

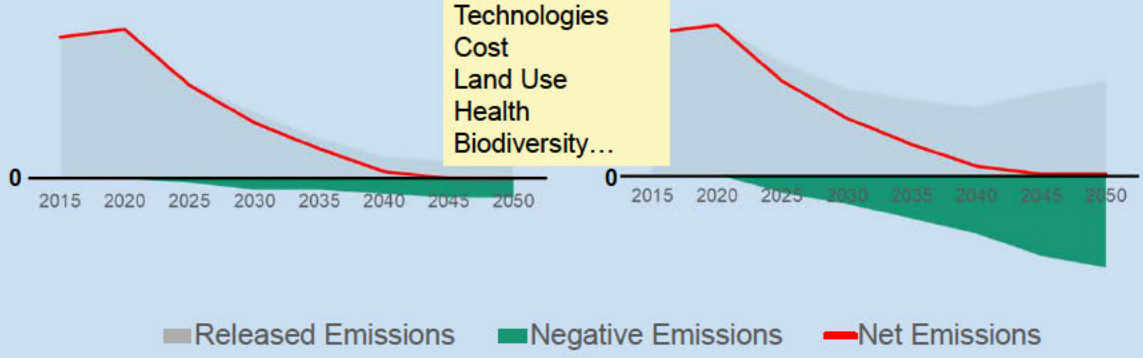
13

How balance released emissions vs. negative emissions?

Reduce emissions as much as possible and offset remaining difficult-to-eliminate emissions with negative emissions

Continue to release, and offset, any emissions with marginal abatement cost > cost per ton negative emissions

Implications for:
Technologies
Cost
Land Use
Health
Biodiversity…



14

Low-Carbon Technologies

Goal: Lower Released Emissions

Power Generation
- Wind, Solar, Hydro, Geothermal
- Bioelectricity
- Nuclear
- Coal or Gas with CCS

Industry
- CCS
- Electrification
- Biomass
- Hydrogen

Hydrogen Production
- Green (electrolysis w/ dedicated renewables)
- Yellow (electrolysis w/ grid electricity)
- Blue (steam methane reforming w/ CCS)

Transport
- Electric Vehicles
- Biofuels
- Hydrogen
- Synthetic fuels
- Ammonia

Negative Emission Technologies

Goal: Offset Released Emissions

Bio Energy with CCS (BECCS)
- Bioelectricity with CCS
- Biofuels with CCS

Direct Air Capture (DACCS)

Nature-Based Solutions
- Afforestation
- Soil Carbon Sequestration
- Biochar
- Enhanced Weathering
- Ocean Alkalinization / Fertilization

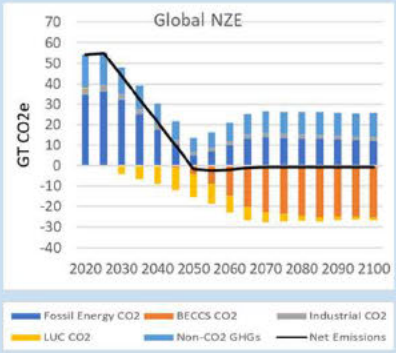
Tradeoff: More Low Carbon Technologies → Less Negative Emissions, and vice versa

15

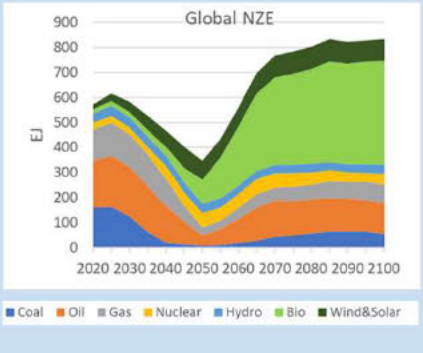
Global Net Zero GHG by 2050

Significant role for negative emissions

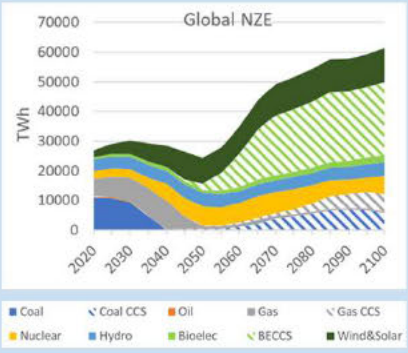
Global CO2e Emissions



Global Primary Energy Use



Global Electricity Generation



More cost-competitive technological options for abating emissions (e.g. in energy intensive industries and commercial transportation) could reduce the reliance on negative emissions

Paper: Net Zero Emissions of Greenhouse Gases by 2050: Achievable and at What Cost?

16

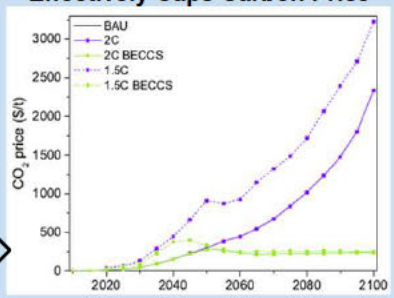
Research Suggests Better Economic Outcomes with More Negative Emissions

2C and 1.5C NO BECCS

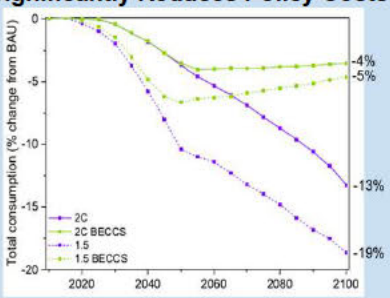
vs.

2C and 1.5C WITH BECCS

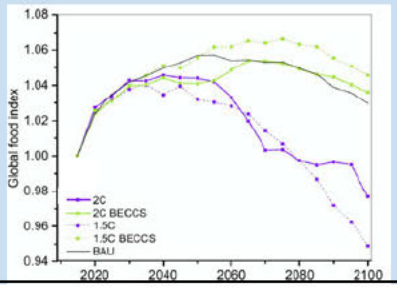
Effectively Caps Carbon Price



Significantly Reduces Policy Costs



Limited Impact on Food Prices



Paper: The economics of bioenergy with carbon capture and storage (BECCS) deployment in a 1.5°C or 2°C world

17

Key Technology Options

There are pros and cons to each option

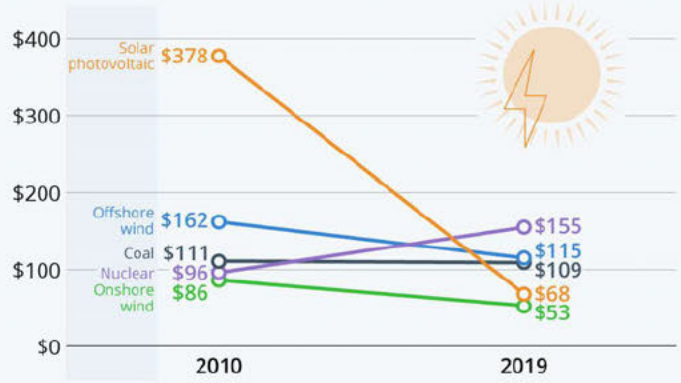
Wind and Solar

- **Low / declining costs**

  Driven by:
  - Technology advancements
  - Increased manufacturing efficiency
  - Economies of scale
  - Policy incentives: tax credits, rebates, net metering, and feed-in tariffs, etc.

The Falling Cost of Renewable Energy

Price per megawatt hour of electricity, by source*



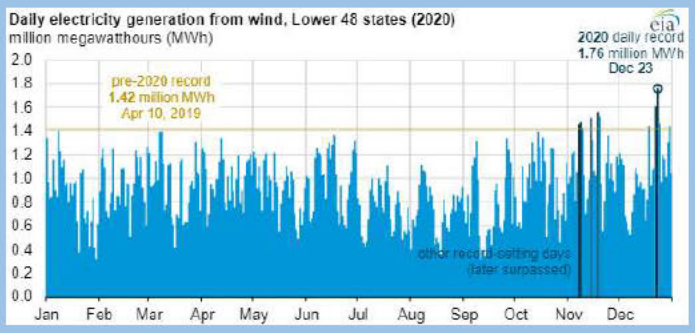
* Global weighted average of levelized costs of energy (LCOE), without subsidies.
Source: OurWorldinData.org

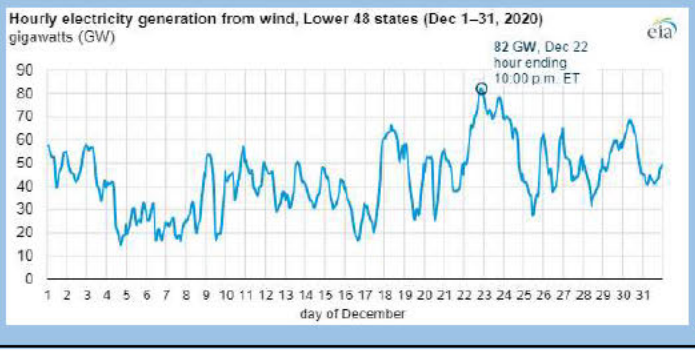
statista

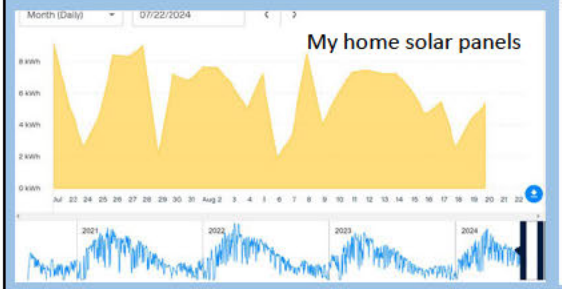
19

Wind and Solar

- **Variability / Intermittency**
  - May not align with demand
  - Backup and/or storage needed to keep system in balance→ expensive
    - Increased system costs



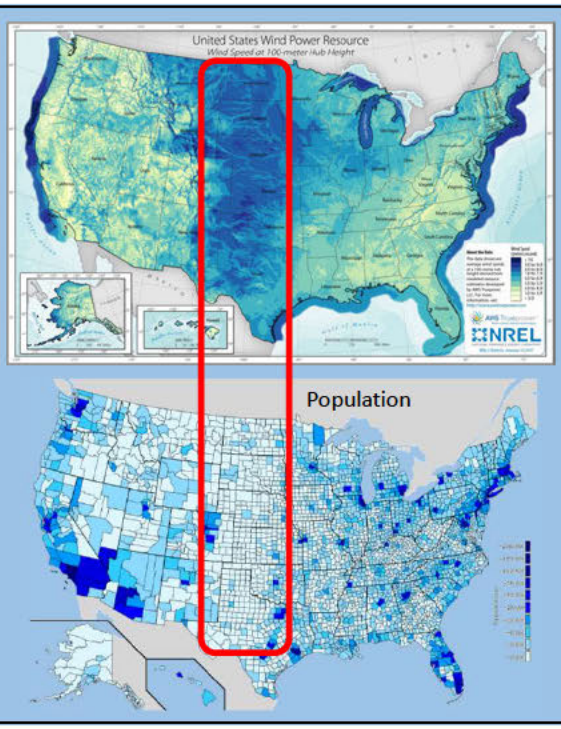




20

Wind and Solar

- **Renewable sources not located near demand**
  - Transmission infrastructure is expensive and difficult to permit / pass
  - NIMBYism

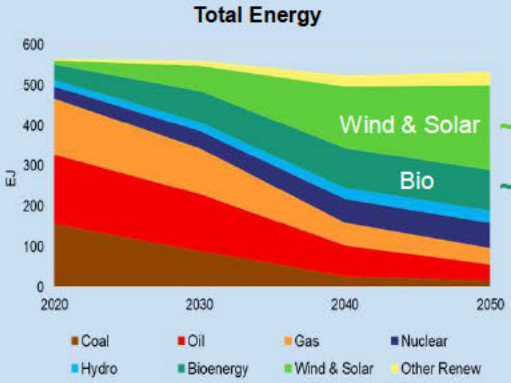


21

Wind and Solar

- **Land use implications**
  - Farming / other uses can be integrated with wind; less so with solar

International Energy Agency (IEA) NZE by 2050 Scenario



Land Requirements
ha/MW based on NREL (2019)

~220 Mha (1.5% World)

~400 Mha (2.7% World)

Together: 80% Contiguous US

EU= ~400Mha

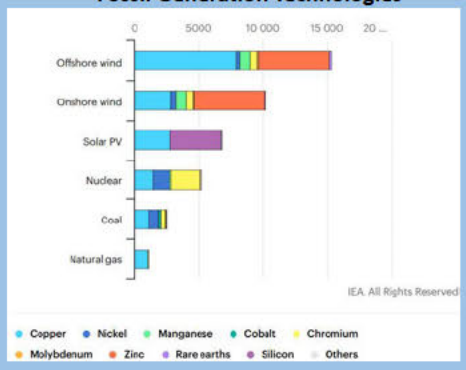
Renewables in Germany: 8-16% of land area (30-60x size of Berlin)

22

Wind and Solar

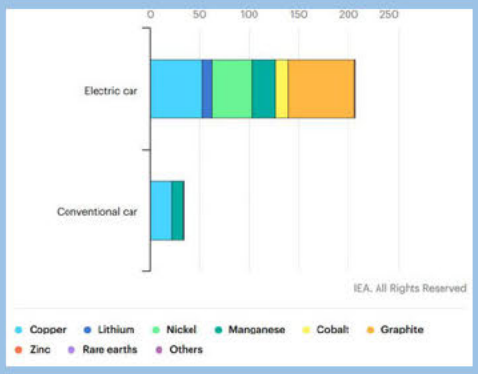
- **Critical minerals, extraction and processing**

Materials Used in Low-Carbon vs. Fossil Generation Technologies



An offshore wind plant requires 13x the mineral resources of a similarly sized gas-fired power plant

Materials Used in EVs vs. ICEs



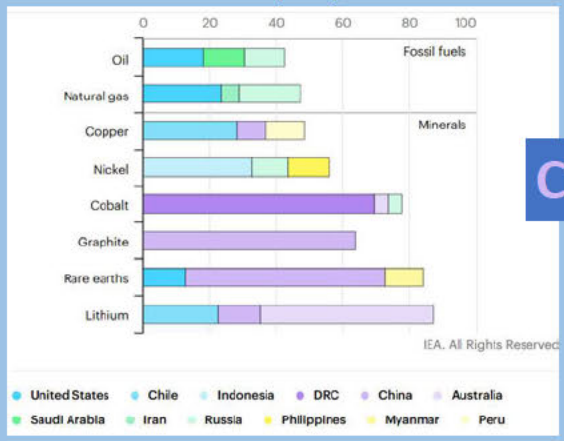
A typical electric car requires 6x the mineral resources of a conventional car

23

Wind and Solar

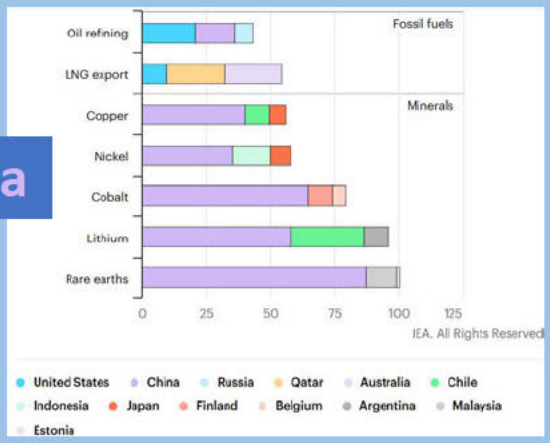
- **Critical minerals, extraction and processing**

Share of top three producing countries in extraction (2019)



China

Share of top three producing countries in processing (2019)

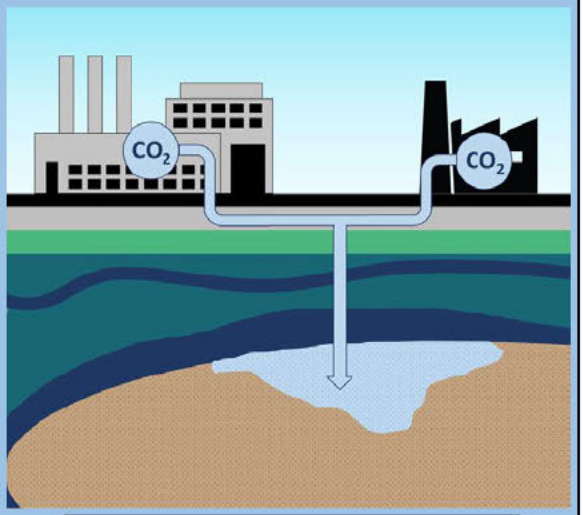


24

Carbon Capture and Storage (CCS)

- **Can be applied to:**
  - **Fossil power plants**
  - **Industrial processes (e.g. cement, iron & steel, etc.)**
  - **Bioelectricity or biofuels production**
  - **Hydrogen production (blue H_2)**

- **Key Issues:**
  - Capture efficiency
  - Storage availability & cost
  - CO2 transport- pipelines, shipping
  - Public acceptance
  - For electricity, it is dispatchable and flexible and can provide baseload power



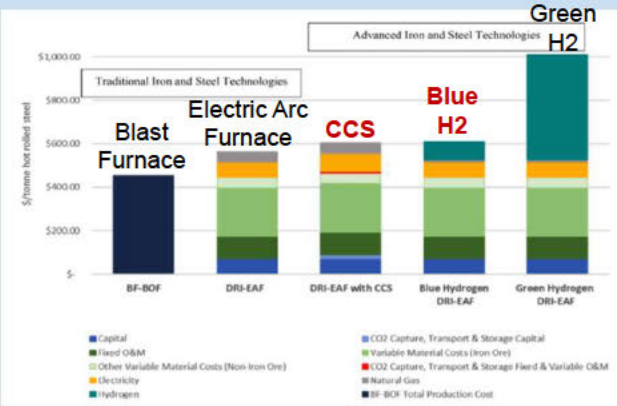
Paper: Scenarios for the deployment of carbon capture and storage in the power sector in a portfolio of mitigation options

25

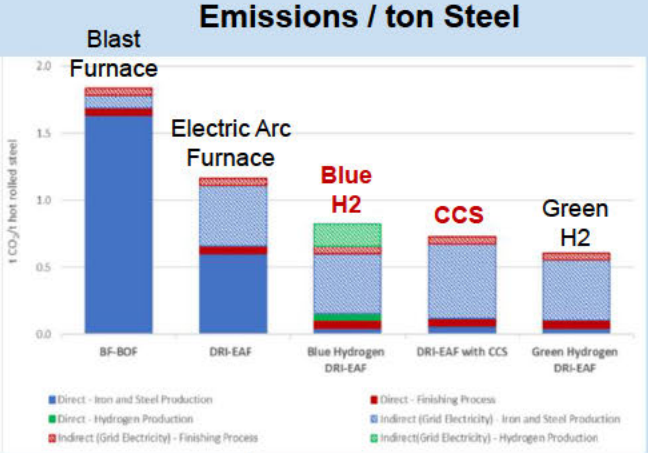
Growing Focus on CCS for Industry and Hydrogen

STEEL PRODUCTION

Levelized Cost ($/ton Steel)



Emissions / ton Steel



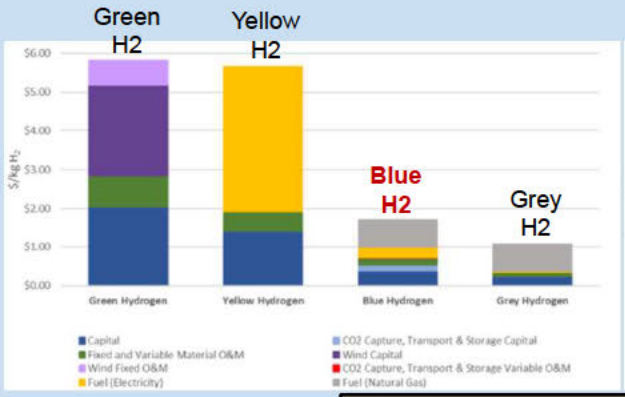
Paper: Mitigating Emissions in the Global Steel Industry: Representing CCS and Hydrogen Technologies in Integrated Assessment Modeling

26

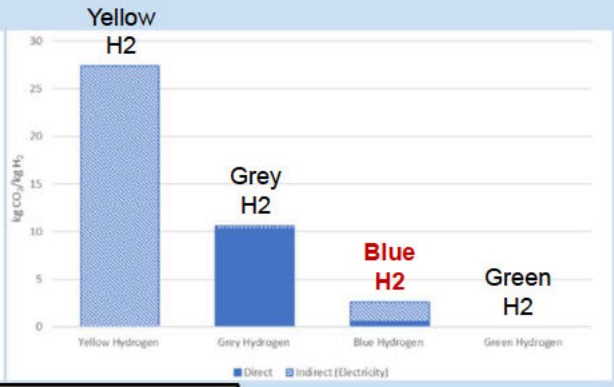
Growing Focus on CCS for Industry and Hydrogen

HYDROGEN PRODUCTION

Levelized Cost ($/kg$H_2$)



Emissions per kgH_2



Paper: Mitigating Emissions in the Global Steel Industry: Representing CCS and Hydrogen Technologies in Integrated Assessment Modeling

27

Bioenergy

- **Different Options:**
  - **Solid bioenergy for electricity**
  - **Solid bioenergy for industry (heat)**
  - **Liquid bioenergy for transportation**
  - **Gaseous bioenergy for vehicles or natural gas replacement**
  - **Bioenergy with CCS (BECCS) for carbon offsets (negative emissions)**

- **Key Issues:**
  - Scale of sustainable bioenergy
    - Limited residues and woody crops
  - Feedstocks and crop yields
  - Land use change
  - Impact on food prices (using land for energy vs. for food)
  - Competition across different uses
    - Which sectors/activities are the best / most economic use?
      - Where easiest / most practical? Where no other clear options? Where most valuable?
  - Infrastructure

28

Liquid Biofuel Pathways for Transportation

Heavy-duty trucks, aviation and shipping

(General consensus that electricity is best bet for passenger vehicles)

Each pathway with different implications for costs, emissions and infrastructure

Feedstock

Corn
Sugarcane
Rapeseed Oil
Palm Oil
Soy Oil
Lignocellulosic (e.g. switchgrass)
Landfill Biogas (MSW)
Woody crops
Residues
UCO

Crop yields are important

Production Process

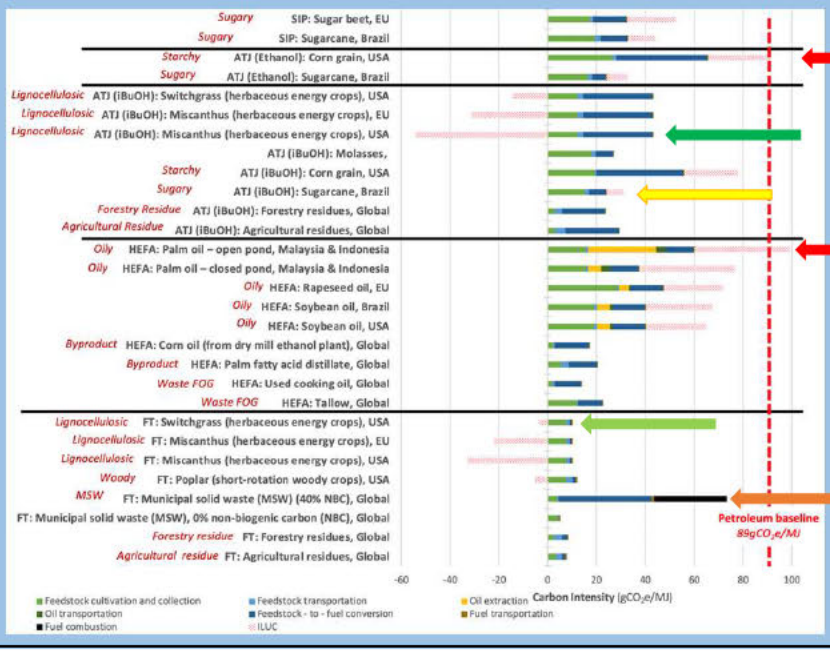
e.g., hydrotreating, gasification and upgrading, fermentation, transesterification

Fuel Type

Ethanol
Biodiesel
Biojet
Cellulosic fuels
E-fuels / synthetic fuels

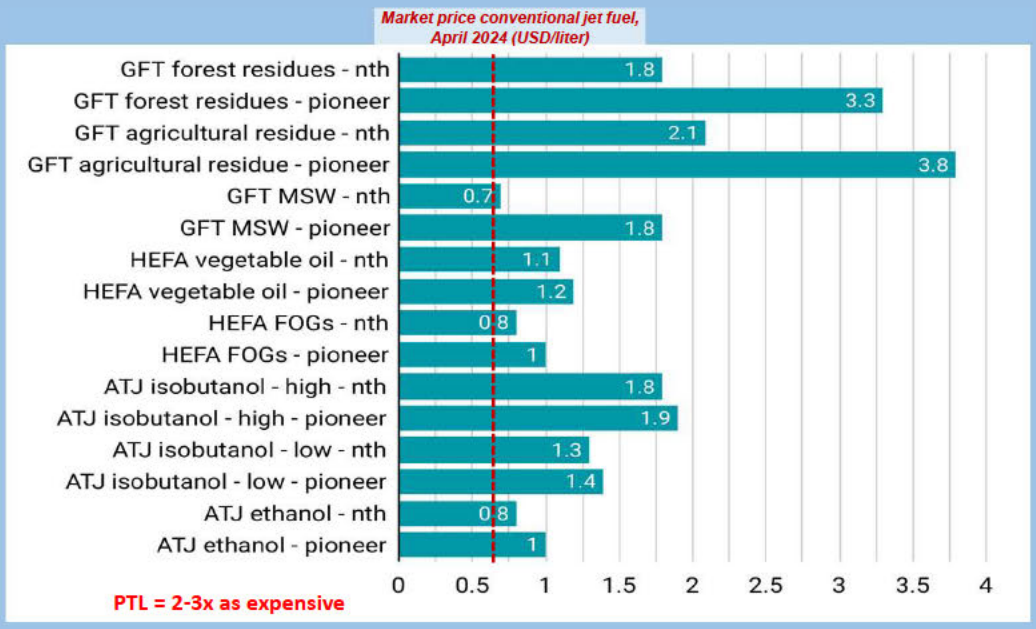
29

Sustainable Aviation Fuel (SAF): Difference in Emissions



30

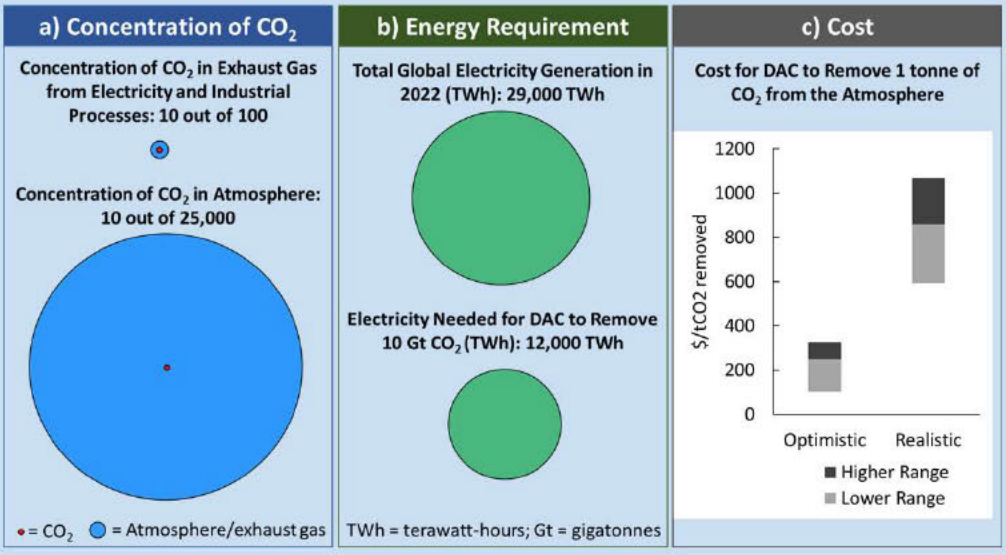
Sustainable Aviation Fuel (SAF): Difference in Cost and Maturity (1st vs nth plant)



31

Direct Air Capture (DAC)

Unavoidable engineering challenges



32

Key Technology Breakthrough Areas

- Storage & battery
- Advanced nuclear
- Industry & buildings
- Hydrogen
- Advanced grid, smart cities
- CO_2 capture and utilization
  Bio sequestration
- Aviation & commercial transport fuels/ technologies
- ?

33

Energy Transition

Drivers, Key Considerations and Scenarios

Main Decarbonization Pathway Envisioned

1) Decarbonize electricity, with heavy focus on **renewables**

2) **Electrify** as much of the economy as possible

Domestic strategy that reduces energy security concerns regarding fossil fuels

BUT new energy security challenges…

Variability of renewables
Stability of the grid
Critical minerals
…

Image: https://sympower.net/what-is-electrification-definition-and-examples/

35

Heavy Dependence on Electricity

- Low diversity of energy mix
- Huge increase in electricity demand
  - Electrification
  - Green hydrogen
  - DAC
  - Synthetic/ E-fuels
- Scale challenge: Competition for clean electricity
- Enormous infrastructure requirement
- Growing stressors threatening reliability and resilience of electricity system

Credit: peterschreiber.media

36

How the energy to transition unfolds depends on:

- **Technologies available**
- **Cost of technologies– relative costs** are what matters

37

Levelized Cost of Electricity: USA

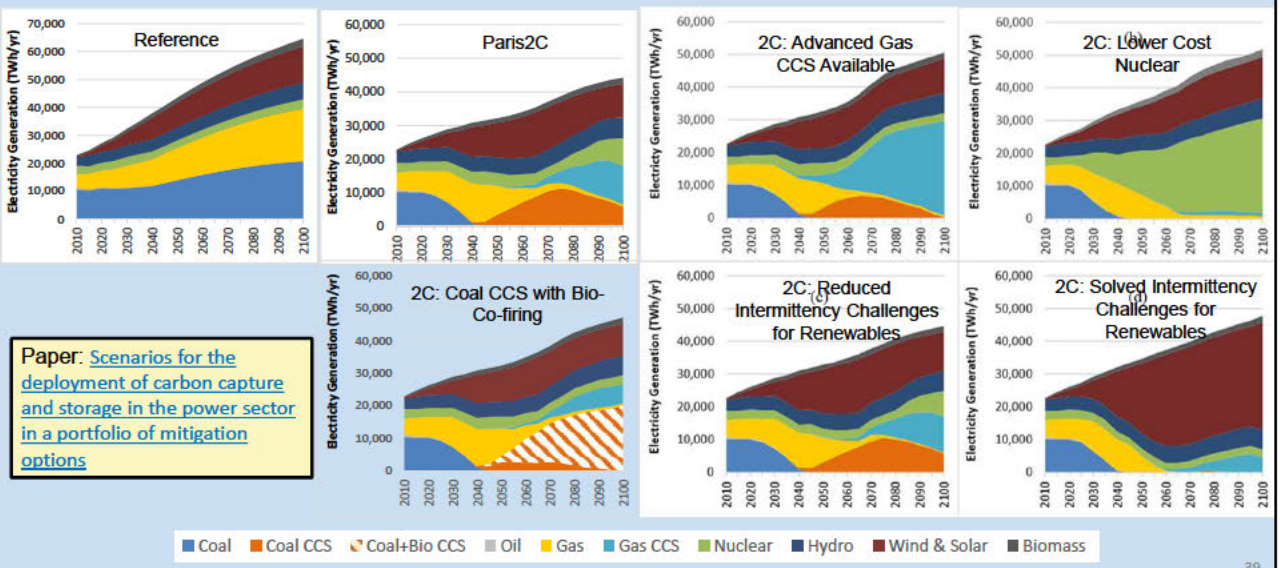
		Units	New Pulverized Coal	Pulverized Coal with CCS	Biomass plant	Biomass plant with CCS	NGCC	NGCC with CCS	Advanced Nuclear	Wind	Solar PV
[1]	"Overnight" Capital Cost	$/kW	2148	4100	4181	8867	1031		4286	1845	1581
	Scaled Overnight Capital Cost	$/kW	2365	4514	4602	9762	1135		4718	2031	1740
[2]	**Total Capital Requirement**	**$/kW**	**2743**	**5417**	**5339**	**11714**	**1226**	**2336**	**6133**	**2194**	**1879**
[3]	Capital Recovery Charge Rate	%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%
[4]	Fixed O&M	$/kW	38.8	*62.2*	108.7	169.5	30.3	*58.8*	70.8	50.5	25.6
[5]	Variable O&M	$/kWh	0.0035	*0.0057*	0.0054	0.0087	0.0028	*0.0065*	0.0035	0.0147	0.0168
[6]	Project Life	years	20	20	20	20	20	20	20	20	20
[7]	Capacity Factor	%	85%	85%	80%	80%	85%	85%	85%	35%	20%
[8]	(Capacity Factor Wind)										
[9]	(Capacity Factor Biomass/NGCC)										
[10]	Operating Hours	hours	7446	7446	7008	7008	7446	7446	7446	3066	1752
[11]	Capital Recovery Required	$/kWh	0.0389	0.0769	0.0805	0.1766	0.0174	0.0332	0.0870	0.0756	0.1133
[12]	Fixed O&M Recovery Required	$/kWh	0.0052	0.0084	0.0155	0.0242	0.0041	0.0079	0.0095	0.0165	0.0146
[13]	Heat Rate	BTU/kWh	8176	10352	11373	16443	6407	7598	10479	0	0
[14]	Fuel Cost	$/MMBTU	2.19	2.19	3.31	3.31	4.39	4.39	0.92	0.00	0.00
[15]	(Fraction Biomass/NGCC)	%									
[16]	Fuel Cost per kWh	$/kWh	0.0179	0.0227	0.0377	0.0544	0.0281	0.0333	0.0096	0.0000	0.0000
[17]	**Levelized Cost of Electricity**	**$/kWh**	**0.0656**	**0.1230**	**0.1391**	**0.2797**	**0.0523**	**0.0845**	**0.1097**	**0.1068**	**0.1447**
[20]	Transmission and Distribution	$/kWh	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
[21]	**Levelized Cost of Electricity incl. T&D**	**$/kWh**	**0.0956**	**0.1530**	**0.1691**	**0.3097**	**0.0823**	**0.1145**	**0.1397**	**0.1368**	**0.1747**
	Base Year Elec Price	**$/kWh**	**0.0924**	**0.0924**	**0.0924**	**0.0924**	**0.0924**	**0.0924**	**0.0924**	**0.0924**	**0.0924**
[22]	**Markup Over Base Elec Price**		**1.03**	**1.66**	**1.83**	**3.35**	**0.89**	**1.24**	**1.51**	**1.48**	**1.89**

Paper: Representing the Costs of Low-Carbon Power Generation in Multi-region Multi-sector Energy-Economic Models

38

Role of Technology Costs

Electricity Generation in a 2C scenario under different technology assumptions



Paper: Scenarios for the deployment of carbon capture and storage in the power sector in a portfolio of mitigation options

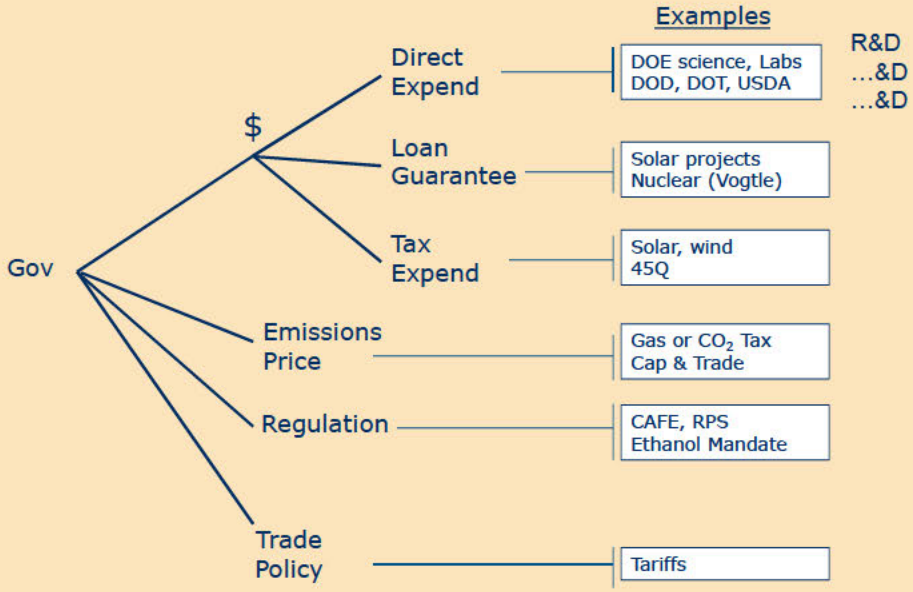
39

How the energy to transition unfolds depends on:

- **Technologies available**
- **Cost of technologies– relative costs** are what matters
- **How quickly new technologies can expand–** how much willing to pay?
- **Policies: stringency and design**

40

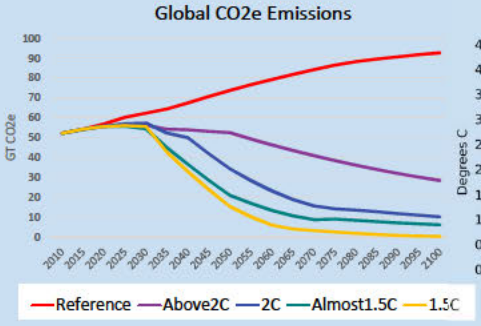
Menu of Policy Options

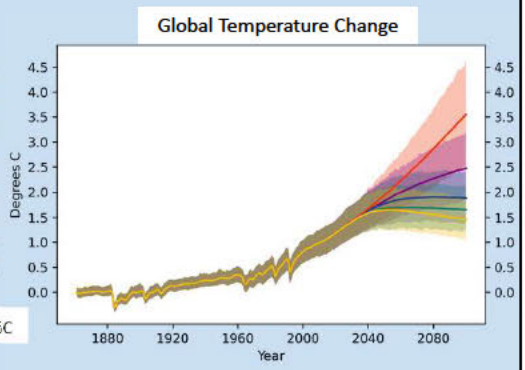


41

Uncertainty in Climate Policy Level and Design

Emissions Price: **"Optimistic" and "Pessimistic" GHG management conditions that represent deep uncertainties for climate strategy: international emissions cooperation, coverage of land use related emissions, and availability of carbon dioxide removal technologies**





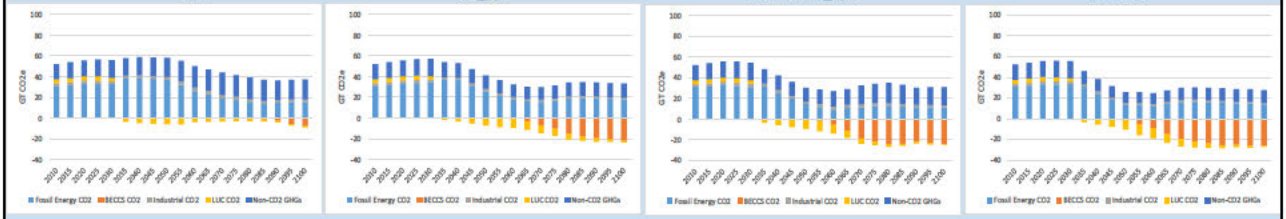
	CDR (BECCS & afforestation)	Land Mitigation Covered	International Permit Trading
Optimistic	Yes	Yes	Yes
Pessimistic	No	No	No

Preliminary. EPRI-MIT work in progress. 42

Global Emissions

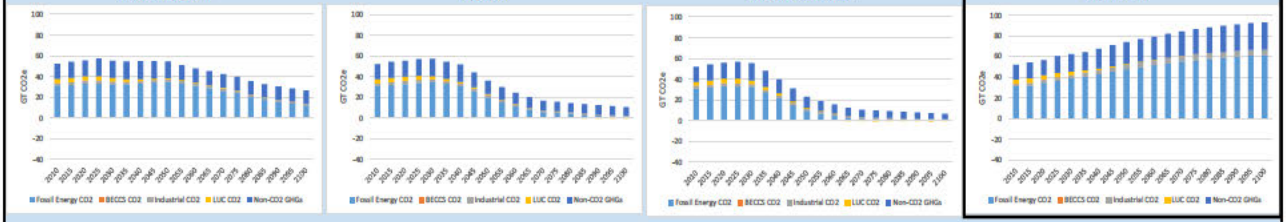
Optimistic Policy Design Assumptions:

Above2C_opt | 2C_opt | Almost1.5C_opt | 1.5C_opt



Pessimistic Policy Design Assumptions:

Above2C_pes | 2C_pes | Almost1.5C_pes | Reference



Fossil Energy CO2 | BECCS CO2 | Industrial CO2 | LUC CO2 | Non-CO2 GHGs

Units = GT CO2e

Preliminary. EPRI-MIT work in progress.

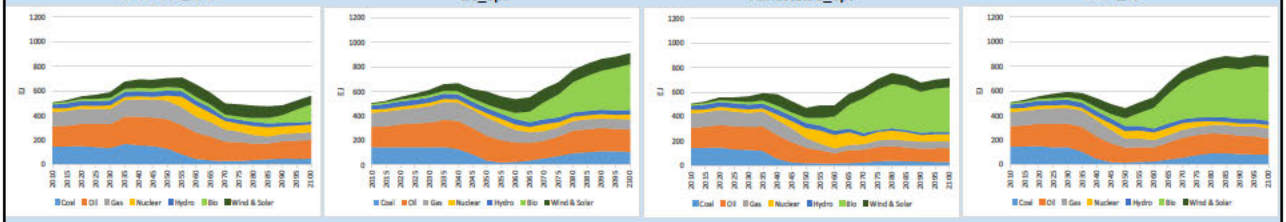
*Optimistic and Pessimistic same net emissions but very different composition

43

Global Primary Energy

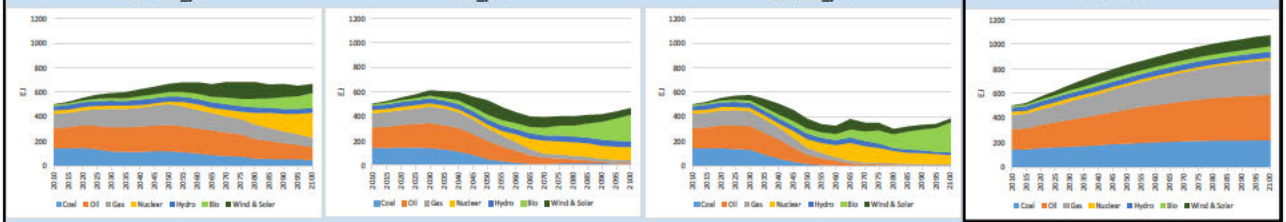
Optimistic Policy Design Assumptions:

Above2C_opt | 2C_opt | Almost1.5C_opt | 1.5C_opt



Pessimistic Policy Design Assumptions:

Above2C_pes | 2C_pes | Almost1.5C_pes | Reference



Coal | Oil | Gas | Nuclear | Hydro | Bio | Wind & Solar

Units = EJ

Preliminary. EPRI-MIT work in progress.

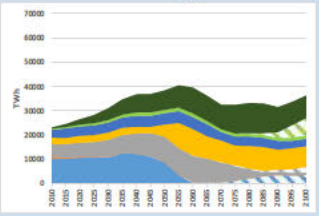
*Optimistic and Pessimistic with very different implications for fossil fuel use

44

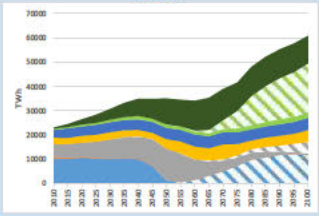
Global Electricity Generation

Optimistic Policy Design Assumptions:

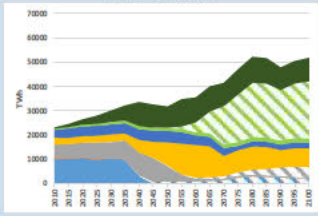
Above2C_opt



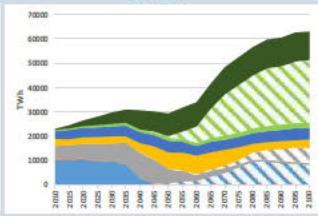
2C_opt



Almost1.5C_opt

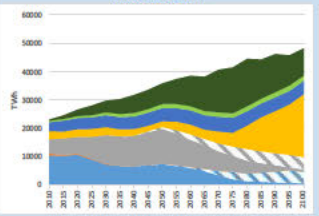


1.5C_opt

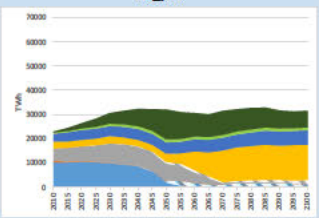


Pessimistic Policy Design Assumptions:

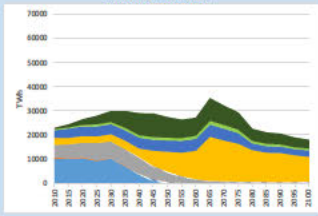
Above2C_pes



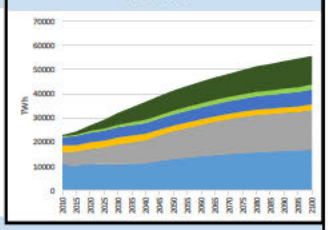
2C_pes



Almost1.5C_pes



Reference



Coal | Coal CCS | Oil | Gas | Gas CCS | Nuclear | Hydro | Bioelec | BECCS | Wind&Solar

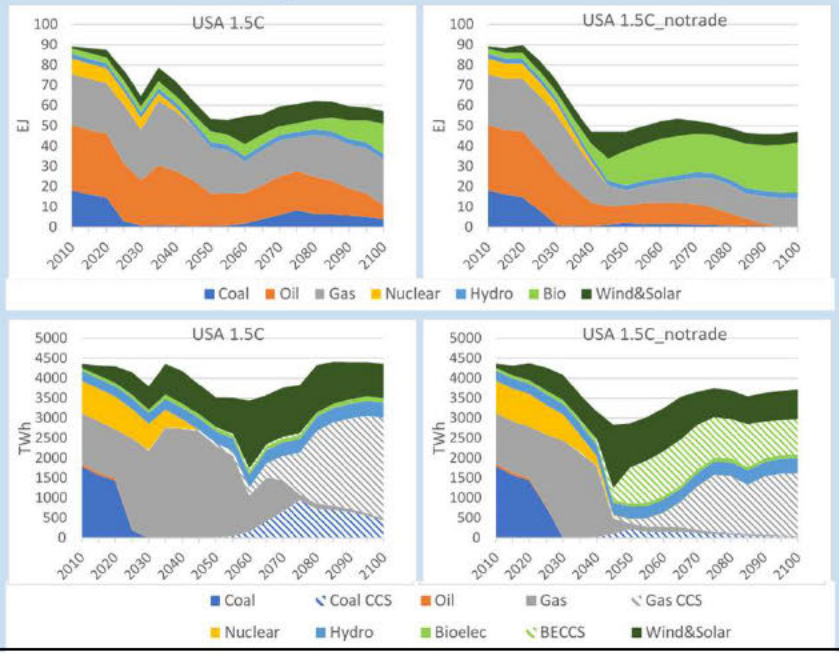
Units = TWh

Preliminary. EPRI-MIT work in progress.

***Optimistic and Pessimistic with very different implications for electricity mix**

45

Results: USA Achieving Net Zero without International Offsets



46

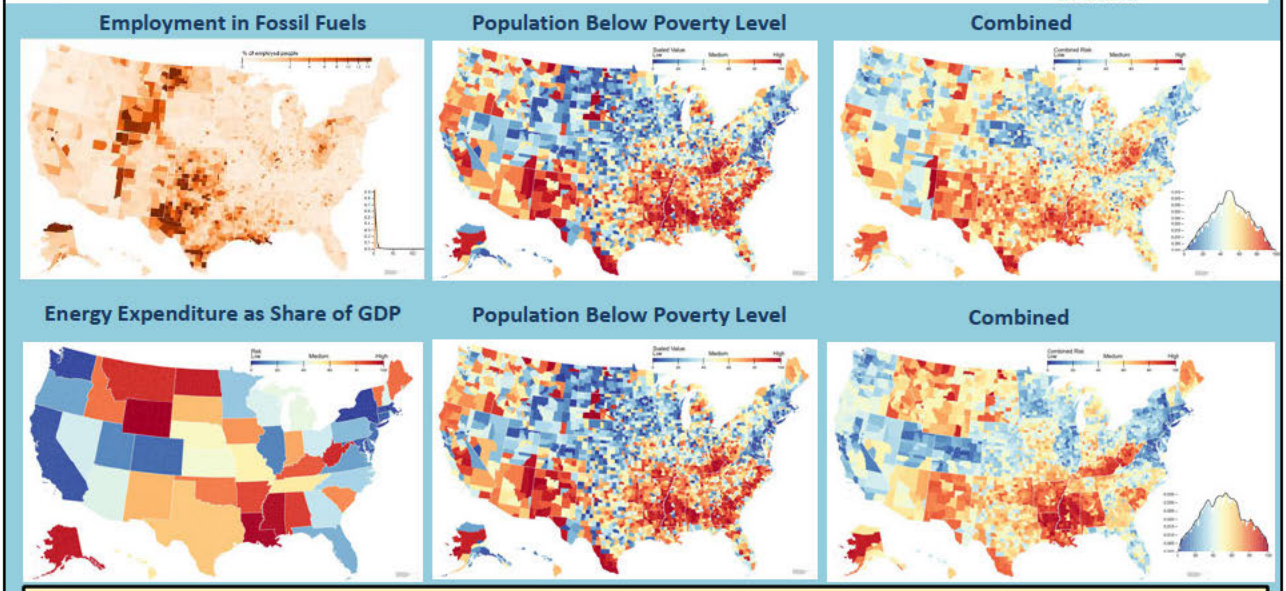
How the energy to transition unfolds depends on:

- **Technologies available**
- **Cost of technologies–** **relative costs** are what matters
- **How quickly new technologies can expand–** how much willing to pay?
- **Policies: stringency and design**
- **Public acceptance**
  - Transition risks (stranded assets, jobs, etc.)
  - Risk perceptions (e.g. safety)
  - Energy prices
  - Disparate impacts
  - Policy costs

47

STRESS Platform

System for the **T**riage of **R**isks from **E**nvironmental and **S**ocio-economic **S**tressors



Paper: Assessing Compounding Risks Across Multiple Systems and Sectors: A Socio-Environmental Systems Risk-Triage Approach

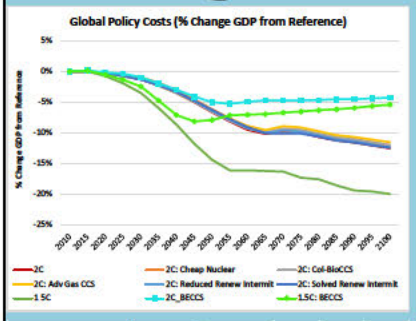
Policy Costs (global example, costs compared to no policy)

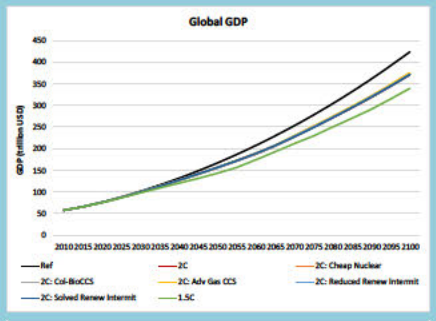
- 12% GDP loss in 2100
- $75 trillion loss in 2100
- 5% loss in Net Present Value GDP from 2025-2100
- GDP in 2100 is 4.9x larger than 2020 rather than 5.6x
- Average annual GDP growth rate from 2020-2100 is 2% instead of 2.17%

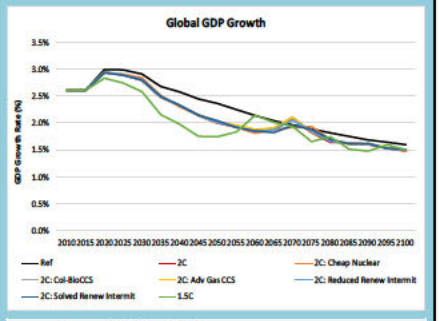
These are different cost metrics for the same exact policy and outcome

49

Framing of Costs Matters







NPV % Change GDP (2020-2100)

	P2C (4% DR)	P2C (5% DR)	2CNow (5% DR)	2CNow BECCS (5% DR)	P1.5C (4% DR)	P1.5C (5% DR)	1.5C Now (5% DR)	1.5C Now BECCS (5% DR)
NPV 2020-2100	-5.11%	-4.59%	-3.59%	-2.10%	-10.6%	-9.4%	-7.5%	-4.03%

DR = Discount Rate

GDP in 2100 vs. 2020

	Ref	2C	2C: Cheap Nuclear	2C: Col-BioCCS	2C: Adv Gas CCS	2C: Reduced Renew Intermit	2C: Solved Renew Intermit	1.5C
2100 GDP /2020 GDP	5.58	4.89	4.90	4.93	4.95	4.90	4.90	4.50

Average Annual GDP Growth Rate

	Ref	2C	2C: Cheap Nuclear	2C: Col-BioCCS	2C: Adv Gas CCS	2C: Reduced Renew Intermit	2C: Solved Renew Intermit	1.5C
Av. An GDP Growth Rate 2020-2100	2.17%	2.00%	2.01%	2.01%	2.02%	2.01%	2.01%	1.90%

50

Summary

- There are many possible emissions and energy transition pathways consistent with long-term climate goals
  - Need to consider broad range for risk assessment and planning
- Alternative transition pathways have different implications for:
  - Cost
  - Land & Water
  - Infrastructure
  - Biodiversity
  - Human well-being (health, jobs, prices, disparate impacts, etc.)…
- Can't rely on technologies alone to drive transition→ need policies
- Energy is more than electricity
  - Transportation fuels, heat for industry…

30 51

Thank You

[redacted]

MIT with expertise in **scenario development**, **techno-economic analyses**, **energy-economic modeling** and **policy analysis**

MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE

ECONOMICS OF A CHANGING CLIMATE

DIVIDER 18

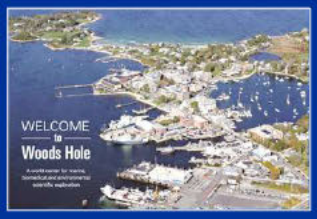
Professor Christopher R. Knittel

Economics of a Changing Climate

Professor Christopher Knittel

Judicial Leaders in Climate Science
Woods Hole, Massachusetts
October 16-18, 2024

THE NATIONAL JUDICIAL COLLEGE



THE ECONOMICS OF CLIMATE CHANGE

Christopher Knittel
George P. Shultz Professor of Energy Economics, MIT
Associate Dean for Climate and Sustainability, MIT Sloan
Director, Center for Energy and Environmental Policy Research
Director, MIT Climate Policy Center

MIT MANAGEMENT SLOAN SCHOOL

A Little About Me

- Academic work:
  - Research focuses on understanding how consumers, firms, and therefore markets, respond changes to the market environment
    - Often focusing on changes caused by policy
  - Then, to use these relationships to understand the costs and benefits of policy
    - Often applied to markets related to energy and the environment
- Litigation consulting:
  - I've served as an expert witness in several cases applying these tools to issues involving patents and class action suits, usually involving high-tech industry
    - With very few exceptions, I avoid energy and environmental cases

What do Economists Have to Say?

- A big focus of the environmental economics literature is on estimating the costs and benefits from environmental policy
- These are often more complex than one might think
- **Thought exercise:** Imagine you wanted to measure the costs and benefits associated with "Corporate Average Fuel Economy" standards
  - CAFE Standards require automobile manufacturers to increase the average fuel economy of the vehicles they sell

Let's Brainstorm…

- Costs
- Benefits

Let's Brainstorm…

Costs

- Technology costs
- Less obvious:
  - Increase in accidents and congestion because of "rebound"
  - Change in maintenance costs
- Even less obvious
  - Vehicle-to-consumer mismatch
  - Prolonged life of old, inefficient, vehicles

Benefits

- Reduction in fuel costs
- Reduction in CO2 emissions
- Reduction in other pollutants
- Increase in energy security
- Benefits from "rebound"
- Reduction in refueling time

Why is This Important?

- Starting with Ronald Reagan, each president has issued an executive order that requires some form of cost-benefit analysis for (major) regulations
- Each president has adapted the original order in certain ways, but the principle remains

How'd We Do? Taking a Look at Two RIAs

- The regulatory impact analyses focus on more direct costs
- They do not account for "downstream" market effects
  E.g., how the used car market changes
- Notice anything else?
- Large economic literature on each of these "rows"
- Let's dive deeper into "CO2 damages avoided"

Table 3
Comparison of the Costs and Benefits of the CAFE Standards between the 2016 TAR and the 2018 NPRM

	2016 TAR (Billion 2016$)	2018 NPRM (Billion 2016$)
Costs:		
Vehicle technology costs	90.7	252.6
Noise and congestion	4.3	51.9
Rebound crash costs	1.8	106.8
Nonrebound crash costs	.0	90.7
Maintenance	5.2	.0
Total costs	102.0	502.0
Benefits:		
Pretax fuel savings	125.7	132.9
Energy security	9.3	10.9
CO_2 damages avoided	27.8	4.3
Non-GHG damages avoided	11.3	1.2
Refueling benefits	6.2	8.5
Rebound benefits	9.3	167.9
Total benefits	189.6	325.7
Total net benefits	87.6	−176.3

The Social Cost of Carbon

- Let's think about estimating the damage generated from releasing a ton of carbon dioxide into the air
  Known as the "social cost of carbon"
- You've learned: that ton of CO2 stays in the atmosphere >300 years, leading to climate change

▪Useful AI warning…

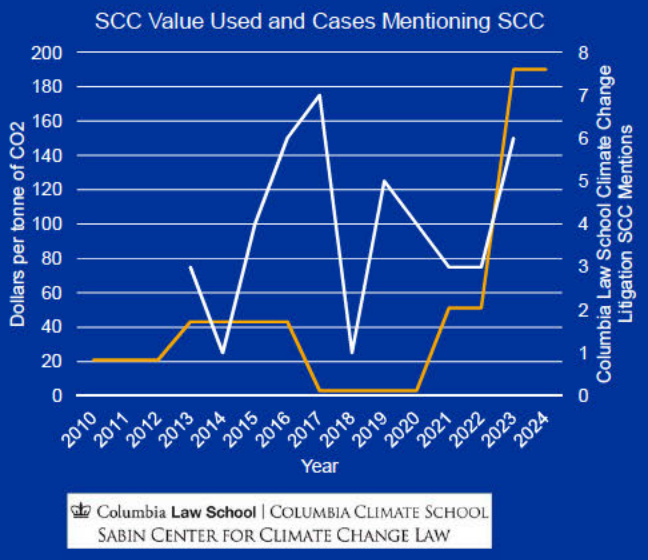
In the Courts

Missouri v. Biden

- No proper procedural safeguards, violating the Administrative Procedure Act

Louisiana v. Biden

- "arbitrary and capricious"

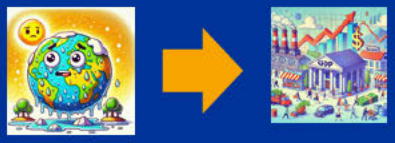


Economics of Climate Change

- **Thought exercise:** What is required to estimate the social cost of carbon?

You Need *Five* Key Elements

Mapping between GHGs and climate change



Mapping between climate change and "wealth"

Mapping between wealth and GHGs

The Fourth Element

We have to decide how much we care about the future

The Fifth Element

We have to decide how much we care about other countries

The Original US SCC Exercise

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of the Interior
Department of Transportation
Department of the Treasury
Environmental Protection Agency
National Economic Council
Office of Management and Budget
Office of Science and Technology Policy

The Role Of Economics

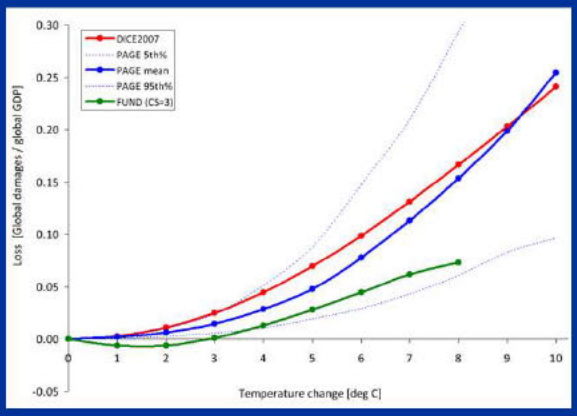
- Use an "Integrated Assessment Model"
- This is a computable model that contains each of these elements within a self-contained model
  - That is, the feedbacks are incorporated
  - Three models: DICE (Norhaus at Yale), FUND (Tol at Sussex), and PAGE (Hope at Cambridge)
- This was first introduced under the Obama Administration

Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

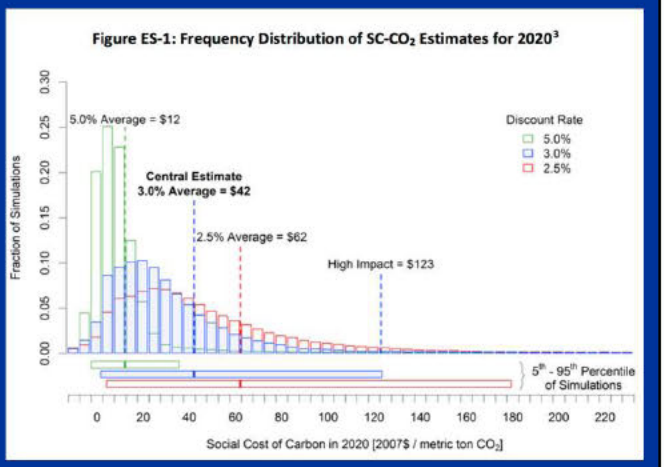
Key Economic Relationship

- The "Damage Function"
- Relationship between changes in temperature and GDP
- Not very empirically grounded (will come back to)



Distribution Of Estimates

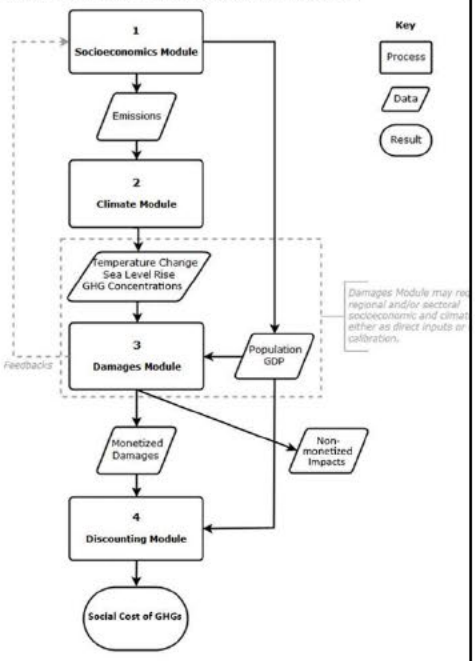
- These empirical relationships are not known for certain
  - This is not new to the social cost of carbon
- Important economics result: uncertainty does imply it is optimal to do less
  - Think about insurance
  - Indeed, the economic modeling implies we want to do more now in the face of uncertainty (Daniel, Litterman, and Wagner, *PNAS,* (2018))



The New Methodology

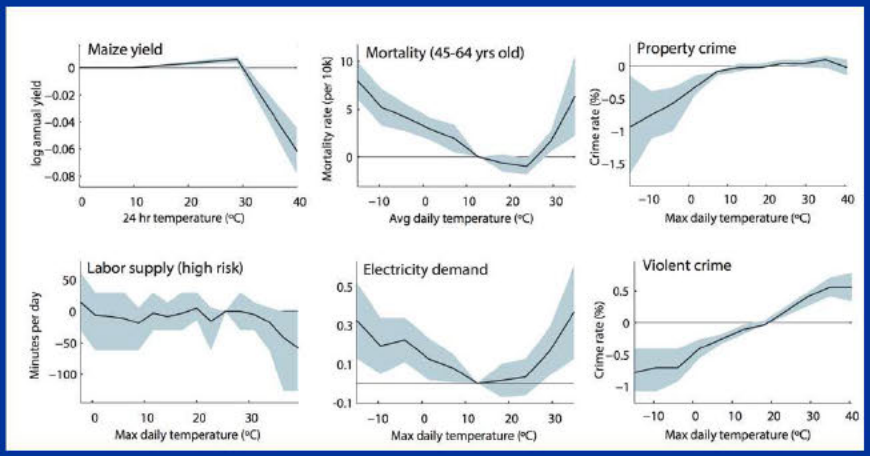
- Split the estimation into four models
  - With some potential feedback across them
- First, measure things like population growth, income growth, etc and how that affects emissions
- **Second, measure how the change in emissions affects the climate**
- **Third, estimate how this change in climate affects welfare**
- **Finally, think more about discounting**

Figure 2.1: The Four Components of SC-GHG Estimation



Source: Adapted from National Academies of Sciences, Engineering, and Medicine (2017)

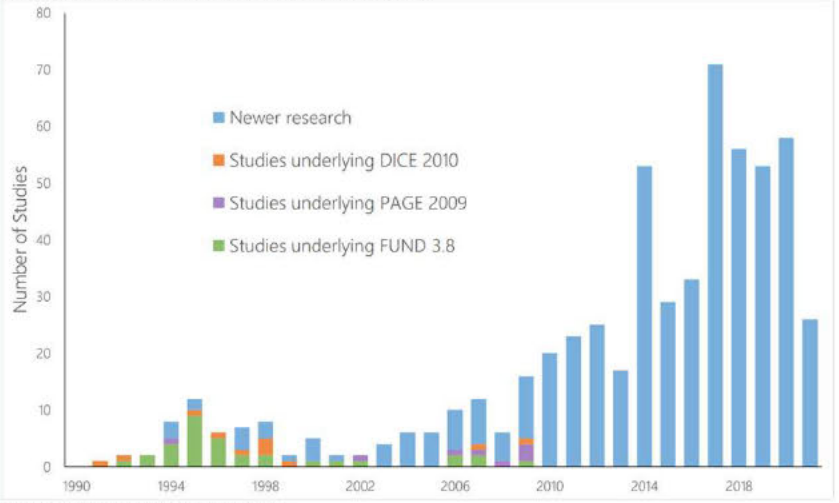
Motivated By Huge Increase In Empirical Evidence



Estimating economic damage from climate change in the United States

Module 3: New Damage Estimates

Figure 2.3.1: Research on Climate Impacts, 1990-2021[75]



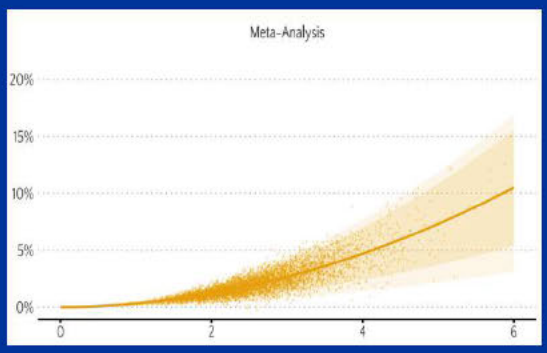
Source: Greenstone (2016), updated in 2021.

What Is The "Newer" Research?

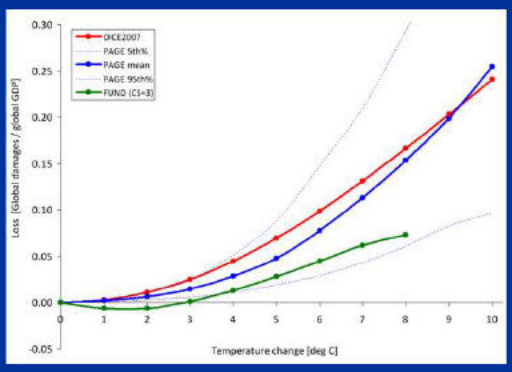
- We have good empirical estimates that look at weather and:
  - Labor supply
  - Crime
  - Mortality
  - Energy Demand
  - Agriculture
- What does this miss?

Comparison Of Damage Functions (Contorted To Equate Scales)

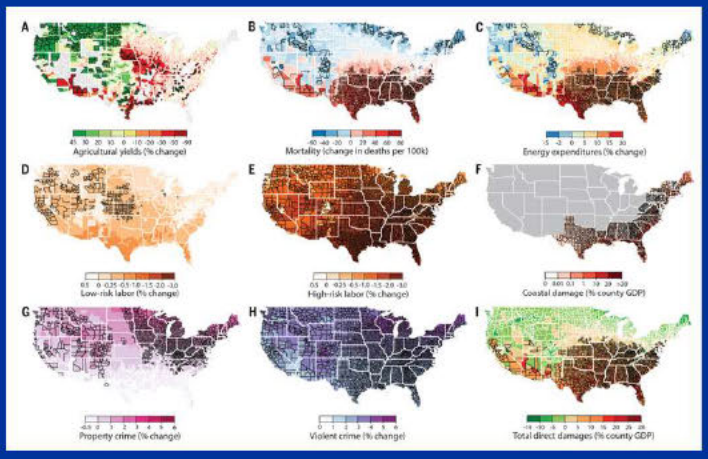
New estimates



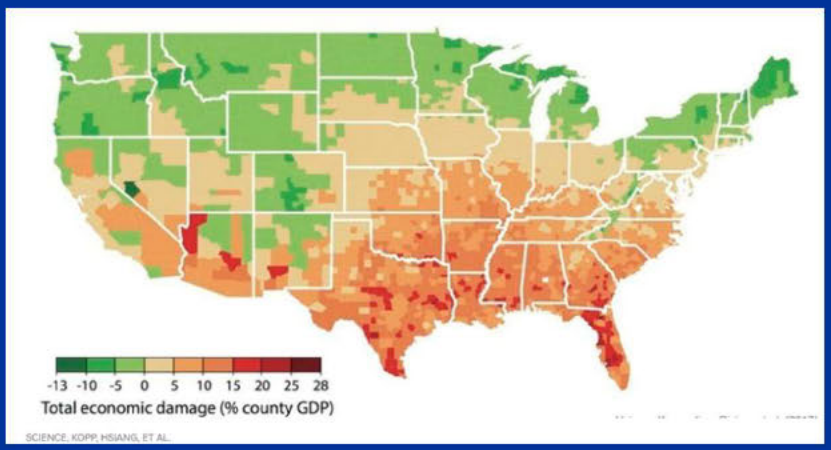
Old estimates



US Estimates



Us Example



The Key Unknown: Adaptation

- Weather and climate are different
- When weather changes, many choices are fixed
  - HVAC systems, housing stock, where we live, where the jobs are, technology, etc.
- When the climate changes, we may alter these
- Harder to get traction on changes in climate and costs because of this
  - Current attempts: allow weather sensitivity to depend on income
  - This misses technological progress

Key Unknown: Discount Rate

- What is the correct discount rate?
  - US Federal Agencies have typically used something between 3 and 7 percent
  - Stern uses 1.4 percent
  - In some sense a philosophical debate
- Why does it matter so much: what's $100B worth in 50 (100) years:
  - 1.4%: $50B in 50 years, $25B in 100 years
  - 3.0%: $23B/$5B
  - 7.0%: $3.4B/$0.11B

The Right Discount Rate: Descriptive V. Prescriptive

- Two trains of thought
- Descriptive:
  - Use the discount rates economic agents use in the real economy
  - This is reflecting actual tradeoffs
- Prescriptive:
  - Use the discount rates that we *want* economic agents (policy makers, mostly) to use for these decisions
  - Ramsey (1928) argued that it is "ethically indefensible" to apply a positive pure rate of time preference to discount values across generations
- Is there a "right" answer?

Should We Care About Other Countries?

- This is what makes climate change special
  - Potential analogy: The US is polluting upstream of a Mexico city
- A ton of carbon effectively does the same damage regardless of where it emitted
  - This is in stark contrast to other pollutants we regulate
- Would love to hear from you on this issue

Lessons

- Economic modeling and empirical papers suggest the cost of climate change are substantial
- These results, combined with atmospheric science models, can provide estimates of the damage from greenhouse gases
  - We can discuss methane, here, if interested!
- There are key uncertainties
  - And, important moral judgements
- Uncertainty in no way implies inaction is the efficient path

JUDGES HELPING JUDGES—MODELING CLIMATE EDUCATION IN HOME STATES—ACTION PLANS

DIVIDER 19

Hon. Stacy Boulware-Eurie
Dr. Yvonne Stedham
Professor Kelly Tait

Action Plan Template – Judicial Leadership in Climate Science

Name: _____

Goal: _____

_____

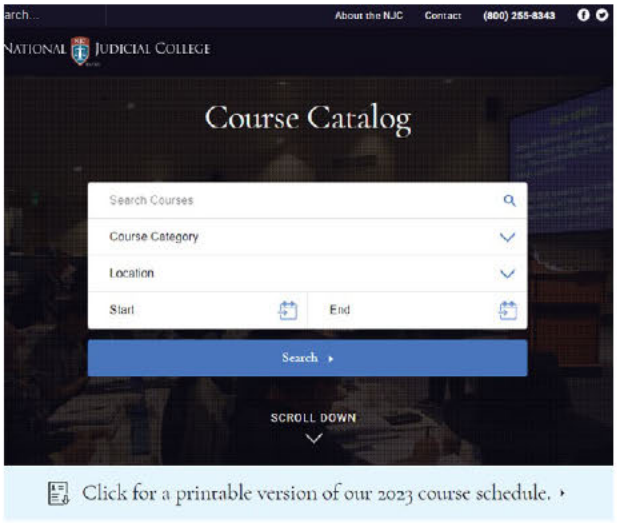
Adapt the template for your project. (Also, if you want, you can include steps you've already taken in your plan so that you have a record of the overall progress toward the goal.)

Actions / Steps / Tasks Specific, measurable, attainable, relevant *(sequentially ordered)*	**Responsible Person(s)**	**Timeline** *When due* ✓**= Done**	**Resources Required** **+ = Available** **- = Needed** *(Note plan to get resource)*	**Potential Barriers** *Possible roadblocks/ resistance (Consider how to address barriers)*	**Additional Notes**
1.					
2.					
3.					
4.					
5.					
6.					

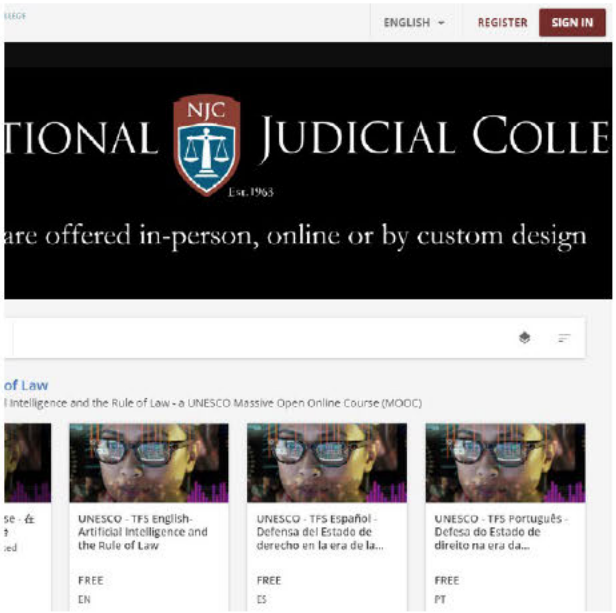
Additional Resources

THE NATIONAL JUDICIAL COLLEGE

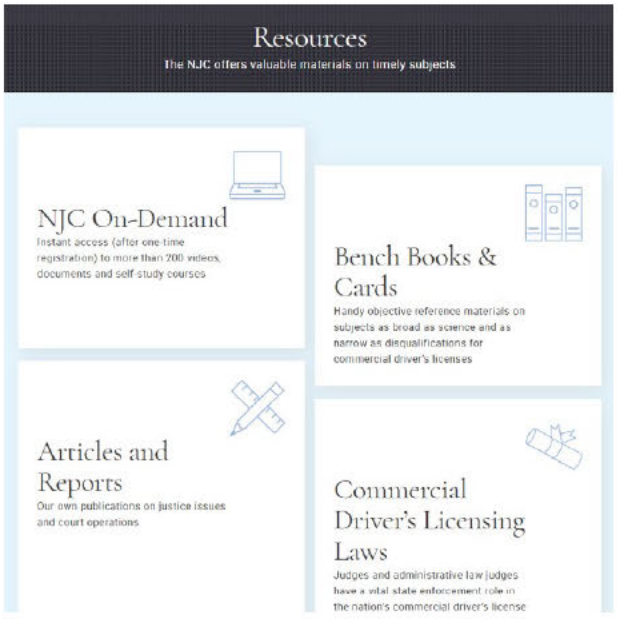
For a full catalog of courses visit: judges.org/courses



Online courses, recorded webinars, international courses are all available on NJC On-Demand: golearn.judges.org



The NJC offers valuable materials on timely subjects including benchcards, tool-kits and white papers: judges.org/resources



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