Climate Literacy

Essential Principles for Understanding and Addressing Climate Change

A Guide for Educators, Communicators, and Decision-Makers

U.S. Global Change Research Program

Third Edition: September 2024

globalchange.gov

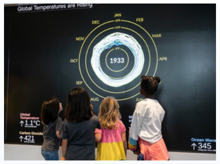
Climate Literacy

Essential Principles for Understanding and Addressing Climate Change

A Guide for Educators, Communicators, and Decision-Makers

Third Edition: September 2024

Cover photo credits, clockwise from upper right:



Students view a global temperature display at an Earth Information Center (EIC) engagement event at NASA Headquarters in Washington, D.C. The EIC combines live datasets with data visualization and storytelling to enable visitors to see how our planet is changing.
CREDIT: NASA, Photo by Keegan Barber

The public art exhibition Climate Signals by Justin Brice, presented by the Climate Museum, installed 10 solar-powered highway traffic signs in parks and public spaces in New York City, sparking dialogue and drawing passersby into the climate conversation.
CREDIT: Justin Brice

Aaron Webb owns and operates a solar farm funded in part by the U.S. Department of Agriculture Rural Energy for America Program, which provides funding for renewable energy systems and energy efficiency improvements.
CREDIT: USDA, Photo by Lance Cheung

Suggested Citation:

USGCRP, 2024: *Climate Literacy: Essential Principles for Understanding and Addressing Climate Change*.
U.S. Global Change Research Program, Washington, D.C., USA.
https://doi.org/10.7930/clg2024

The art included in this guide represent a selection of works from the Fifth National Climate Assessment Art x Climate collection, which can be found at **https://nca2023.globalchange.gov/art-climate/**

U.S. Global Change Research Program

LEADERSHIP

Maria Uhle
Chair, Subcommittee on Global Change Research

Gretchen Goldman
Vice Chair, Subcommittee on Global Change Research

Emily Sylak-Glassman
Chair, Subcommittee on Climate Services

Samantha Medlock
Chair, Subcommittee on Climate Services

Mike Kuperberg
Executive Director, U.S. Global Change Research Program

Stacy Aguilera-Peterson
Deputy Director for Research, U.S. Global Change Research Program

Heidi Roop
Deputy Director for Services, U.S. Global Change Research Program

Ariela Zycherman
Director, National Climate Assessment

Phil Levin
Director, National Nature Assessment

SUBCOMMITTEE ON GLOBAL CHANGE RESEARCH

David Bascom
U.S. Department of Homeland Security, Federal Emergency Management Agency

Lisa Clough
National Science Foundation

Benjamin DeAngelo
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Rebecca Dodder
U.S. Environmental Protection Agency

Pete Epanchin
U.S. Agency for International Development

Gerald Geernaert
U.S. Department of Energy

Gretchen Goldman
U.S. Department of Transportation

Valarie Hall (Acting)
U.S. Department of Defense

William Hohenstein
U.S. Department of Agriculture

Kirk Johnson
Smithsonian Institution

Jack Kaye
National Aeronautics and Space Administration

Aubrey Miller
U.S. Department of Health and HumanServices

Geoffrey Plumlee
U.S. Department of the Interior

Todd Richardson
U.S. Department of Housing and Urban Development

Trigg Talley
U.S. Department of State

National Oceanic and Atmospheric Administration Planet Stewards students learn firsthand about the impacts of ocean acidification. CREDIT: D.J. Kast, University of Southern California

CLIMATE ENGAGEMENT AND CAPACITY-BUILDING INTERAGENCY GROUP

Stacy Aguilera-Peterson
U.S. Global Change Research Program

Maggie Allen
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Susan Aragon-Long
U.S. Department of the Interior, U.S. Geological Survey

Tatiana Ausema
National Endowment for the Humanities

John Balbus
U.S. Department of Health and Human Services

Michael Band
U.S. Environmental Protection Agency

Brandon Barlow
U.S. Global Change Research Program/ICF

Ta Misha Bascombe
U.S. Department of Health and Human Services

Sean Bath
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Thea E. Becton
U.S. Department of Housing and Urban Development

Sarah Beebout
U.S. Department of Agriculture, Agricultural Research Service

Daniel Berkman
U.S. Department of Homeland Security, Federal Emergency Management Agency

Lea-Ann Bigelow
U.S. Department of Homeland Security, U.S. Customs and Border Protection

Mariah Black Bird
U.S. Department of the Interior

Cedar Blazek
U.S. Department of Energy

Brock Blevins
National Aeronautics and Space Administration/Science Systems and Applications, Inc.

Whitney Boone
U.S. Department of the Interior

Victoria Bortfeld
U.S. Global Change Research Program/ICF

Joshua Brown
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Celeste Carter
National Science Foundation

Chris Castro
U.S. Department of Energy

Amanda Catron
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Alison Cawood
Smithsonian Institution

Amy P. Chen
National Aeronautics and Space Administration

Todd Christenson
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Jazmine Cofer
U.S. Department of Homeland Security, Federal Emergency Management Agency

John Dos Passos Coggin
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Jennifer Collins
Smithsonian Institution

Pierre Comizzoli
Smithsonian Institution

Ted Coopwood
U.S. Environmental Protection Agency

Kristen Cordell
White House Council on Environmental Quality

Haley Crim
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Allison Crimmins
U.S. Environmental Protection Agency

Stacy M. Cummings
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Geneviève de Messières
National Aeronautics and Space Administration/Science Systems and Applications, Inc.

Katie Dickinson
U.S. Department of the Treasury

Rebecca Dodder
U.S. Environmental Protection Agency

Matthew Dowiatt
White House Council on Environmental Quality

Carla Easter
Smithsonian Institution

Melanie Follette-Cook
National Aeronautics and Space Administration

Amy Frady
U.S. Department of Agriculture

Ned Gardiner
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Kelsey Gerber
AmeriCorps

Alexandra Giese
U.S. Agency for International Development

Katerina Gonzales
U.S. Environmental Protection Agency

Leo Gumapas
U.S. Department of Health and Human Services

Linsey Haram
U.S. Department of Agriculture

Jenna Hartley
U.S. Environmental Protection Agency

Michelle Hawkins
National Aeronautics and Space Administration

Jennifer Helgeson
U.S. Department of Commerce, National Institute of Standards and Technology

Isabelle Heilman
U.S. Department of Energy

Joseph Heller
U.S. Department of Agriculture

David Herring
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Bonnie Herriott
U.S. Department of Homeland Security, U.S. Customs and Border Protection

Diana Hirshfeld
U.S. Department of Health and Human Services

Cat Hawkins Hoffman
U.S. Department of the Interior, National Park Service

Sharon Homer-Drummond
National Science Foundation

Laurie Howell
U.S. Global Change Research Program/ ICF

Kristin Isabelli
U.S. Department of Homeland Security, U.S. Customs and Border Protection

Marcie Kim
U.S. Department of State

Rebecca King
U.S. Department of Homeland Security, Federal Emergency Management Agency

Bekkah Lampe
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Amber Liggett
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Carlos Martinez
National Science Foundation

Heidi McAllister
U.S. Department of Agriculture, Forest Service

Carrie McDougall
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Bart Merrick
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Laura Huerta Migus
Institute of Museum and Library Services

Christopher Miller
U.S. Department of Agriculture, Natural Resources Conservation Service

Stephanie Morris
U.S. Department of Agriculture

Julie Morris
U.S. Global Change Research Program/ ICF

Bonnie Murray
National Aeronautics and Space Administration

Molly Nation
Millenium Challenge Corporation

Sydney Neugebauer
National Aeronautics and Space Administration

Amelia Nguyen
U.S. Environmental Protection Agency

Frank Niepold
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Kim Noble
U.S. Environmental Protection Agency

Eric Norland
U.S. Department of Agriculture, National Institute of Food and Agriculture

Carol O'Donnell
Smithsonian Institution

Alexis Pelosi
U.S. Department of Housing and Urban Development

Larry Perez
U.S. Department of the Interior, National Park Service

Henry Perillo
U.S. Department of the Treasury

Peter Persall
U.S. Department of the Interior, U.S. Geological Survey

Chanelle Pickens
Smithsonian Institution

Teresa Pohlman
U.S. Department of Homeland Security

Ginger Potter
U.S. Environmental Protection Agency

Holly R. Prendeville
U.S. Department of Agriculture, Forest Service

Julian Reyes
U.S. Department of the Interior, Bureau of Land Management

Justice Rhodes
U.S. Department of the Interior, Office of the Assistant Secretary for Indian Affairs

Lisa Rom
National Science Foundation

Ken Salter
U.S. Global Change Research Program/ ICF

Kristen Schmitt
U.S. Department of Agriculture, Forest Service

Sarah Schoedinger
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Leah Schrodt
U.S. Department of the Interior, Fish and Wildlife Service

Nancy Searby
National Aeronautics and Space Administration

Edil Sepúlveda Carlo
National Aeronautics and Space Administration

Yasmeen Shaheen-McConnell
AmeriCorps

Kathryn Simpson
U.S. Department of Labor

Julie Snow
U.S. Department of Defense and U.S. Department of Commerce

Rebecca Soulen
U.S. Department of Homeland Security

Carissa Spencer
U.S. Department of Agriculture

Chad Stachowiak
U.S. Department of Agriculture, Natural Resources Conservation Service

Jennifer Starr
U.S. Global Change Research Program/ ICF

Siobhan Starrs
Smithsonian Institution

Caiti Steele
U.S. Department of Agriculture

Naomi Stern
U.S. Department of Education

Michael Strobel
U.S. Department of Agriculture, Natural Resources Conservation Service

Marissa Strong
AmeriCorps

Ariana Sutton-Grier
U.S. Department of the Interior, U.S. Geological Survey

Melissa Taggart
U.S. Department of Agriculture, Forest Service

Hiram Lee Tanner III
U.S. Environmental Protection Agency

Alfonso Macias Tapia
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Audrey Taylor
U.S. Department of the Interior, Bureau of Ocean Energy Management

Reginald Taylor
U.S. Department of Health and Human Services

Kaushlendra Tingi
U.S. Department of Agriculture, National Institute of Food and Agriculture

Noah Van Gilder
U.S. Department of the Interior

Paul Wagner
U.S. Department of the Interior
U.S. Geological Survey

Sarah Waldo
U.S. Environmental Protection Agency

Alison Wallace
U.S. Department of State

Margaret Walsh
U.S. Department of Agriculture

Robert A. White
U.S. Department of Homeland Security, Federal Emergency Management Agency

Adam Wilke
U.S. Department of Agriculture, National Institute of Food and Agriculture

Sunita Yadav-Pauletti
U.S. Department of Agriculture, Natural Resources Conservation Service

Angelica Zamora-Duran
U.S. Department of Energy

CLIMATE LITERACY GUIDE WRITING TEAM

Stacy Aguilera-Peterson
U.S. Global Change Research Program

Susan Aragon-Long
U.S. Department of the Interior, U.S. Geological Survey

Ta Misha Bascombe
U.S. Department of Health and Human Services

Jacklynn Beck
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Intern

Heather Bell
U.S. Department of Defense/ Booz Allen Hamilton

Mariah Black Bird
U.S. Department of the Interior

Alison Cawood
Smithsonian Institution

Jazmine Cofer
U.S. Department of Homeland Security, Federal Emergency Management Agency

Haley Crim
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

LuAnn Dahlman
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

John Dos Passos Coggin
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Sophia Dahodwala
U.S. Department of Energy, Pacific Northwest National Laboratory

Rebecca Dodder
U.S. Environmental Protection Agency

Benjamin Everett-Lane
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Intern

Alexandra Giese
U.S. Agency for International Development

Katerina Gonzales
U.S. Environmental Protection Agency

Jenna Hartley
U.S. Environmental Protection Agency

Jennifer Helgeson
U.S. Department of Commerce, National Institute of Standards and Technology

David Herring
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Alexa Jay
U.S. Global Change Research Program/ ICF

Janet Li
U.S. Department of Housing and Urban Development

Rebecca Lindsey
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Jean Lynch-Stieglitz
U.S. Department of State

Carlos Martinez
National Science Foundation

Molly Nation
Millenium Challenge Corporation

Frank Niepold
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Claudia Nierenberg
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Carol O'Donnell
Smithsonian Institution

Jagruti Rekhi
U.S. Department of Housing and Urban Development

Justice Rhodes
U.S. Department of the Interior, Office of the Assistant Secretary for Indian Affairs

Julia Rotondo
U.S. Department of Energy, Pacific Northwest National Laboratory

Viccy Salazar
U.S. Environmental Protection Agency

Sarah Schoedinger
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Julie Snow
U.S. Department of Defense and U.S. Department of Commerce

Suzanna Soileau
U.S. Department of the Interior, U.S. Geological Survey

Melissa Taggart
U.S. Department of Agriculture, Forest Service

Paul Wagner
U.S. Department of the Interior, U.S. Geological Survey

Sarah Waldo
U.S. Environmental Protection Agency

Tamara Wilson
U.S. Department of the Interior, U.S. Geological Survey

EDITORIAL, DESIGN, AND WEB TEAM

Tom Bowman
Bowman Change, Inc. (technical contract for the National Oceanic and Atmospheric Administration Climate Program Office)

John Dos Passos Coggin
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Anna Eshelman
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Richard Aguilar Glupker
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

David Loop
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Groundswell

Michael R. Myers
U.S. Department of Commerce, National Oceanic and Atmospheric Administration

Rosie Nagele
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Intern

Cordelia Norris
Luna Creative (technical contract for the National Oceanic and Atmospheric Administration Climate Program Office)

Katy Perrault
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Intern

Emma Polinsky
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Intern

Kayla Smith
U.S. Department of Commerce, National Oceanic and Atmospheric Administration/FedGeek, Inc.

More than 125,000 people work in the U.S. wind industry, with the potential for hundreds of thousands more in the decades to come, helping support an industry that reduces carbon dioxide emissions by hundreds of millions of metric tons annually. CREDIT: Werner Slocum, National Renewable Energy Laboratory

Climate Literacy Essential Principles

1
HOW WE KNOW
Scientists understand the climate system through interdisciplinary observations and modeling.

2
CLIMATE CHANGE
Greenhouse gases shape Earth's climate.

3
CAUSES
Burning fossil fuels and other human activities are causing the planet to warm.

4
IMPACTS
Rapid warming and other large-scale climate changes threaten human and ecological systems.

5
EQUITY
Climate justice is possible if climate actions are equitable.

6
ADAPTATION
Humans can adapt social, built, and natural environments to better withstand the impacts of climate change.

7
MITIGATION
Reducing emissions of greenhouse gases from human activities to net zero by 2050 can help limit global warming and climate change impacts.

8
HOPE AND URGENCY
A livable and sustainable future for all is possible with rapid, just, and transformational climate action.

About this guide

Climate Literacy: Essential Principles for Understanding and Addressing Climate Change presents information that is important for individuals and communities to know and understand about Earth's climate, the impacts of climate change, and solutions. Principles in the guide can serve as discussion-starters or launching points for learning about the climate crisis and what's being done to address it across the world. The guide aims to promote greater climate literacy by providing this educational and communication framework of principles and concepts.

To download this guide and related documents, see **globalchange.gov/reports/climate-literacy-guide-third-edition** and **climate.gov/climateliteracy**

The bolded words throughout this guide are defined in the **key definitions** section.

Artist's statement: "This piece shows an Indigenous view of the Earth system. Human beings, grouped as family and community, are an integral but not superior part of the system. There are seven people, indicating the Seventh Generation Principle that our decisions should cultivate a sustainable world seven generations into the future." Artist Star Horn is a Kanien'kehá:ka ("People of the Flint" aka "Mohawk") woman born and raised in Kahnawake in Quebec, Canada.
CREDIT: Star Horn, Unity

Youth leaders with Action for the Climate Emergency at a climate action workshop in New York City.
CREDIT: Action for the Climate Emergency

Who is this guide for?

This guide is written with educators, communicators, and decision-makers in mind. It may be helpful in structuring curricula; assessing gains in people's knowledge and understanding; stimulating dialogue among people with different interests, skills, and perspectives; and informing climate-related decisions and policies.

The guide is also written for anyone who wants to understand how human activities are changing the **climate**, how **climate change** impacts people and our planet, and what can be done about it. This guide applies primarily to the United States, although many of its findings and resources can be applied broadly.

This guide is a starting point; it provides a framework for what **climate literacy** comprises. The guide complements other guides and related educational materials, including:

- **Ocean Literacy: Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages** (2024)
- **Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education** (2017)
- **A Framework for K-12 Science Education** (2012)

What is climate literacy and why does it matter?

Climate literacy is an understanding of how the **climate system** works, how human actions influence climate, and how climate influences people and other parts of the **Earth system**.

Climate literacy is important because people who understand the processes, causes, and effects of climate change are better able to assess evidence and claims about evidence, discuss options to manage **risks**, and take well-informed actions.

A climate-literate person:

- understands the essential principles of Earth's climate system and the options to address human-caused climate change, which are summarized in this guide;
- recognizes credible information about climate change and knows where to find it;
- communicates about climate change in accurate and effective ways; and
- is able to make informed decisions related to climate change.

A climate-literate society is better able to develop and implement effective **climate solutions** that benefit all. Studies show that improving climate literacy can accelerate behavioral changes and climate-related planning. Incorporating scientific concepts as well as Indigenous and local knowledges in communication and education can improve climate literacy and make climate actions more effective.

Being climate-literate does not require understanding all the complexities of climate science. People with a basic understanding can communicate effectively about climate change and work within their communities to design and implement solutions that address climate change and related social, economic, and environmental challenges.

People who are climate-literate recognize that there are social, historical, ethical, legal, economic, psychological, and political dimensions of climate change. They know that various societies, cultures, and traditions have different ways of understanding, documenting, and interpreting changes in the environment and their underlying causes; that the **impacts** of climate change do not affect everyone equally; and that actions taken now to accelerate **emissions** reductions and adapt to ongoing changes can reduce risks to current and future generations.

The Wild Center's Climate Solutions exhibit, funded by the Institute for Library and Museum Services, shares hopeful stories from the Adirondacks in New York State and interactive examples of ways to mitigate climate change.
CREDIT: The Wild Center

The expanding focus of climate literacy

The Climate Literacy Guide was first published in 2008 by the U.S. Global Change Research Program, and was updated in 2009. This third edition of the guide reflects recent advances in our understanding of the climate challenge. As a result, this guide's definition of climate literacy now incorporates other types of knowledge about the climate system, in addition to physical climate science. The term now includes local and **Indigenous Knowledges**, social and cultural contexts, the social sciences, climate solutions, and **climate justice** concepts.

This 2024 edition is built on the most up-to-date climate assessments at the time of publication: the United States' Fifth National Climate Assessment (November 2023) and the Intergovernmental Panel on Climate Change Sixth Assessment Report (2021-2023). These assessments acknowledge that there are many ways to understand climate change.

- The scientific disciplines of physics, chemistry, and biology inform our understanding of the Earth system, underpinning our knowledge in Earth science, atmospheric science, and oceanography. All these disciplines help us understand changes to the climate and **ecosystems**.

- Insights from scientific disciplines including public health, anthropology, geography, economics, engineering, and political science provide essential understanding of how human actions impact climate, how climate impacts diverse communities and their environments, and how we can respond to climate change.

- Indigenous Knowledges from many communities and cultures include long-standing and rigorous observations, valuable insights, and historically proven practices that support understanding of climate change.
  >> **Learn more about Indigenous Knowledges and climate change**

- Local or place-based knowledge, which is developed and shared by residents or land managers based on lived experience or professional expertise, can provide important information about local climate change impacts and the efficacy of potential solutions.

- Practical knowledge from the private sector provides insights into the potential of sector-based practices for addressing climate change.

Artist's statement: "This painting is about the effects of human-caused climate change and sea level rise on island and coastal populations. The people trapped within the composition, like fish in an aquarium, are disproportionately affected but not responsible for their circumstance. This piece was inspired by the noticeable effects of climate change in Polynesia. I witnessed eroding coastal areas and a reduced ability to provide agricultural subsistence due to saltwater infiltration when I returned to Samoa after 25 years."
CREDIT: James Keul, Art x Climate, Fish in Troubled Waters (2013, oil on canvas)

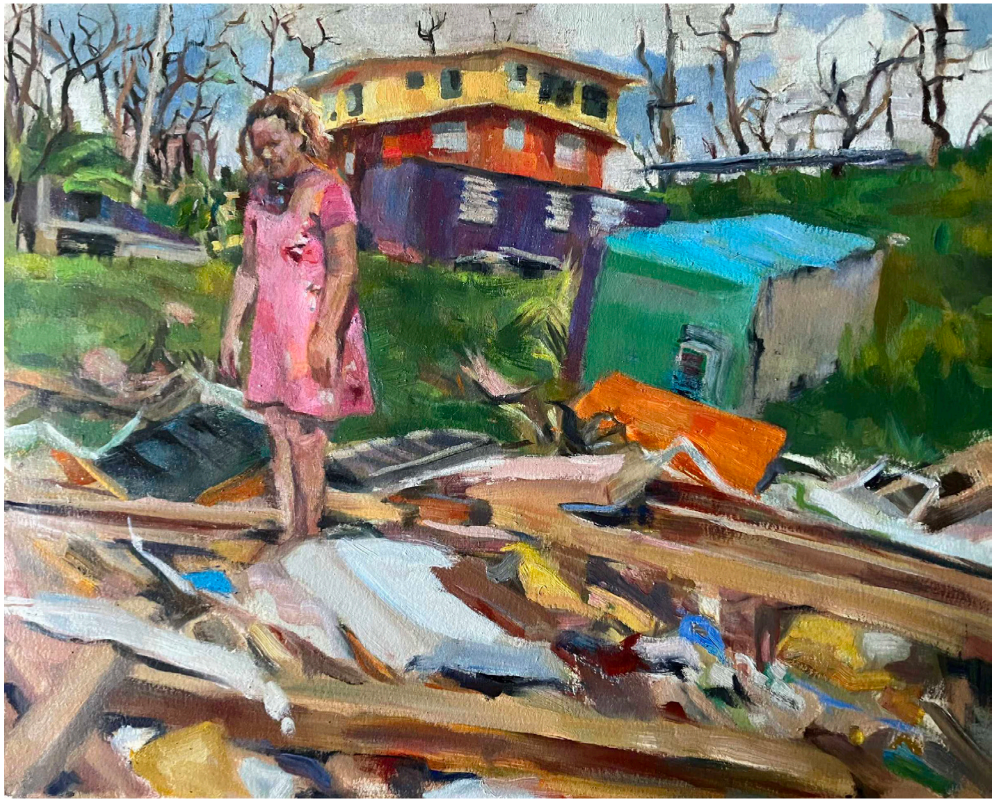
What is climate change and why is it often called a crisis?

Our planet is warming at an unusually rapid rate compared to changes over the past 2,000 years. This **global warming** is unequivocally caused by emissions of **greenhouse gases** from human activities, mainly from burning **fossil fuels** (such as coal, oil, and natural gas) for transportation and energy. Global warming and related climate changes are, in turn, causing increasingly severe and harmful impacts on people and the ecosystems that support us, with worsening effects on our health, safety, security, and prosperity.

Climate change is often called a challenge or crisis due to the severity of its impacts, the urgency of implementing solutions, and the complexity of the problem. Climate change is already intensifying pressure on physical infrastructure and the social, economic, and political systems we rely on, in addition to threatening the health and **well-being** of humans and all life on Earth.

Some future climate changes are unavoidable and/or irreversible, such as **ice sheet** loss and permanent **flooding** of coastal areas, but can be limited by large and rapid cuts in global greenhouse gas emissions. Urgent action to cut emissions and expand **adaptation** in this decade is key to minimizing impacts on people and ecosystems. Rapid action would also deliver many benefits, especially for air quality and health. These transitions would involve large-scale technological, infrastructure, land-use, and behavioral changes and shifts in governance structures.

The greenhouse gases released by human activities include **carbon dioxide** (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Increasing the amount of greenhouse gases in the atmosphere causes our planet to warm, with far-ranging effects on the climate system.



Artist's statement: "This piece was painted after the devastation of Hurricane Maria in Puerto Rico. The reality of the climate crisis and its impact on those experiencing poverty was visually clear in the reference photo I used. As I painted, I connected even more with the violence and rawness of the losses Puerto Ricans faced. My intention in painting is to stir up the empathy in others. This woman's vibrant clothes and home seem to defy the hopelessness of her stance and circumstance. I don't want her to feel alone in this crisis."
CREDIT: Mia Merlin, Art x Climate, Maria (2017, oil on paper)

Homes on the Florida coast are threatened by sea level rise and increasing extreme weather as Florida is hit by the most hurricanes of any state. CREDIT: Aerial_Views/E+/Getty Images Plus, Smithsonian Institution

Climate change has widespread consequences for the health and well-being of people and ecosystems, including more frequent and severe flooding, **drought**, damaging storms, and **wildfires**; changes in food availability and crop-growing patterns; threats to water supplies; and increases in **vector**-borne diseases, mental health challenges, and heat-related illnesses and deaths. Together, these consequences can also worsen risks to our national security.

Although some people and places may experience limited or short-term benefits from climate change, adverse impacts already outweigh most positive effects and will increasingly eclipse any benefits as warming continues.

While climate change affects us all, the consequences are not the same for everyone. Some individuals and communities face higher health risks depending on factors such as their age, where they work or live, their access to resources, and preexisting health conditions. These factors are shaped by social and economic contexts. For example, low-income communities and communities of color face more severe risks and harms because they are more likely to live or work in places that are exposed to climate **hazards**, and often have fewer resources to respond to the impacts. In rural areas, these risks can be even higher due to lack of resources or infrastructure to adapt. Younger people will also face increasing burdens from climate change throughout their lifetimes. Understanding how and why people experience climate change impacts differently, and how social and cultural contexts shape their capacity to respond, is an important part of climate literacy.

International efforts to limit global warming

Through the **Paris Agreement**, nearly every country has joined a collective goal of limiting global warming to "well below 2°C above pre-industrial levels" and pursuing efforts to "limit the temperature increase to 1.5°C above pre-industrial levels." This builds on the objective of the **United Nations Framework Convention on Climate Change** of stabilizing "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

World leaders celebrate the adoption of the Paris Agreement at the 21st United Nations Climate Change Conference (COP21) in 2015. The United Nations climate change process seeks to advance international efforts to mitigate climate change and address its adverse effects.
CREDIT: U.S. Department of State

These global warming thresholds refer to the global surface temperature averaged over many decades. In order to pass the thresholds stated in the Paris Agreement, the long-term average of the global surface temperature must exceed 1.5°C (2.7°F) or 2°C (3.6°F) of warming. It is to be expected that temperatures on individual days, months, and years will pass these marks before the long-term average does. Even a small difference in global average surface temperature represents a significant change in the Earth system—and the temperatures and climate impacts that people and the environment experience.

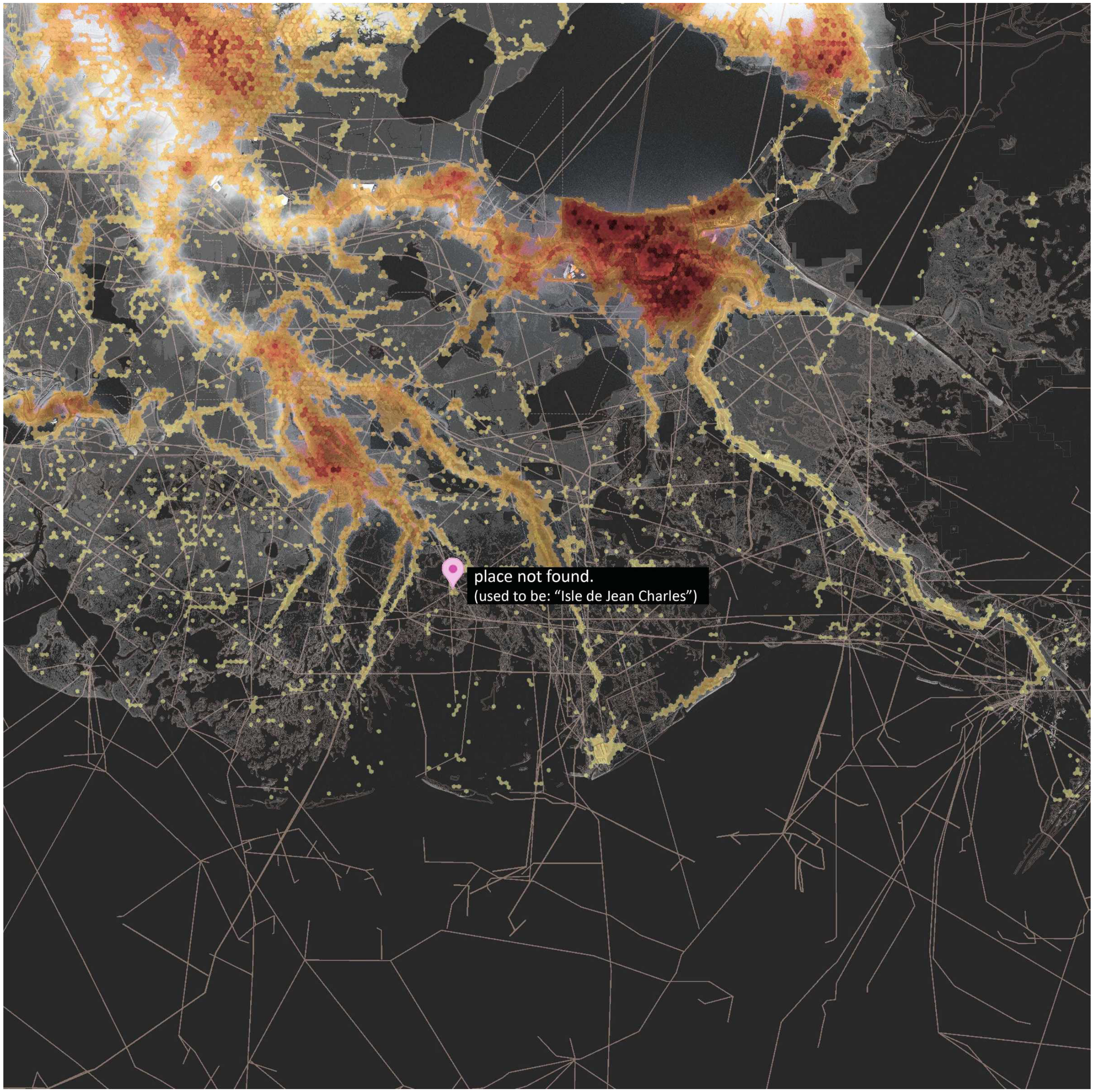
Reaching an increase of 1.5°C or higher temperatures introduces higher **risk**. The more the planet warms, the greater the risk to human health as

Panelists engage in climate discussions at the Dubai Youth Climate Dialogue + Youth Stocktake Outcomes Launch during the 28th United Nations Climate Change Conference (COP28) in Dubai in 2023.
CREDIT: COP28, Photo by Anthony Fleyhan

well as to our built and natural environments and the ecosystems we depend on. In setting these goals, countries recognized that limiting warming would significantly reduce risks and impacts. Scientists warn that without rapid, large-scale action to reduce global emissions of greenhouse gases, the world is likely to reach these temperature levels in the near term. Every increment of warming that the world avoids reduces risks from climate change.

Limiting global warming requires **net-zero carbon dioxide emissions** globally: where emissions fall to zero, or remaining emissions are balanced by removal of carbon from the atmosphere. To keep warming well below 2°C (3.6°F), global carbon dioxide emissions would need to reach net zero around 2050, along with substantial reductions of emissions of all greenhouse gases. The current scale and rate of action is not keeping pace with what is needed to limit warming to 1.5°C (2.7°F) or to adequately manage climate risks.

Reaching net zero will require transformative action worldwide to both reduce emissions and develop new capacity to remove carbon from the atmosphere. Across all sectors of the economy in the United States, options to reduce emissions are economically feasible now. However, reaching net-zero emissions by 2050 cannot be achieved without exploring additional **mitigation** options through research and development.



Artist's statement: "The Isle de Jean Charles Band of Biloxi-Chitimacha-Choctaw Tribe are widely recognized as having been displaced by climate change. Their home, the Isle de Jean Charles in Terrebonne Parish, Louisiana is no longer habitable, and they are being forced to relocate. There has been a long history of relocation for people who face racial discrimination and deep economic inequality. Those groups are also usually the first to experience climate change. The map marks their former home and includes lines of gas and oil, population density, and elevation."
CREDIT: Changsong Li, Art x Climate, Used to be: Isle de Jean Charles (2023, digital)

ESSENTIAL PRINCIPLE 1

HOW WE KNOW

Scientists understand the climate system through interdisciplinary observations and modeling.

A. Climate is not the same thing as **weather**. Weather is the minute-by-minute condition of the atmosphere (such as temperature and precipitation) on a local scale. Climate is the long-term average weather conditions of an area. The term climate change refers to significant and persistent change in an area's average climate conditions or their extremes.

>> **Learn more about climate science**

B. The components and processes of Earth's climate system are governed by the laws of science. Therefore, the behavior of the climate system can be understood and modeled through careful, systematic study. Our understanding of the climate system will only continue to improve as science advances.

>> **Learn more about recent advancements in climate science**

C. To learn about how climate has changed in the distant past, scientists use natural records, such as tree rings, ice cores, and sedimentary layers. Indigenous Knowledges and historical observations such as personal journals also document past climate change.

D. Scientific observations indicate that the global climate varies over time; it has changed in the past, is changing now, and will change in the future. The natural processes driving Earth's long-term **climate variability**, such as changes in solar energy reaching Earth, do not explain the rapid climate change observed in recent decades. The only credible explanation for recent climate change is human activities.

>> **Learn more about how natural causes alone do not explain climate change**

Artist's statement: "Climate change has compressed and conflated human and geologic time scales, making it essential to find ways to conceptualize 'deep time.' This work seeks to make notions of deep time comprehensible through visual exploration of glacier ice, as well as other earthly archives. This project includes intimate collaborations with paleoclimatologists by having them annotate directly onto my photographic prints—a contemporary taxonomy of ice and climate. This portrait was photographed in a cold/clean lab at Montana State University. The ice shown is 10,827 (left side) to 10,833 years old."
CREDIT: Ian Van Coller, Art x Climate, Dr. Avila Holding Cut Antarctic Icecore (2017, pigment print on washi with annotations)

E. The magnitude and trends of climate change are not the same at all locations on Earth. For example, the land warms faster than the ocean, and the polar regions warm faster than the tropics.

F. Research into past climate changes has shown that there are parts of the Earth system that change gradually until they reach a **tipping point**, after which they change more quickly. Some of these changes may be irreversible. The risk of crossing these tipping points increases as climate change intensifies. Ecosystems, ice sheets, and ocean currents may all have tipping points.
>> **Learn more about tipping points**

G. **Climate models** have been constructed using observational data and physical laws. These models can project a range of potential future climate conditions that result from different assumptions about the future, such as the amount of greenhouse gas

emissions. Models that include both human and natural systems examine how climate impacts cascade across sectors and scales and, in turn, how human systems and choices influence climate.

>> **Learn more about climate modeling**

H. Integrated approaches that bring together knowledge from many contexts and areas of study are essential to understanding the full picture of climate change. Considering the perspective of only a single sector, topic, or region may cause climate impacts or solutions to be overlooked.

>> **Learn more about interdisciplinary climate research**

I. Coproduced climate change research projects integrate both community-based and science-based insights and solutions to climate change. Coproduced research often includes experts within relevant knowledge contexts, such as Indigenous Knowledge holders or multi-generational farming communities. This kind of research can give rise to community-based climate solutions.

>> **Learn more about coproduction of climate research**

A citizen scientist measures precipitation after a very long summer drought over a two-day period in Alberta, Canada. Citizen science involves the public and aids in bridging the gap between communities and scientists to make informed decisions.
CREDIT: Susan Risk

ESSENTIAL PRINCIPLE 2

CLIMATE CHANGE

Greenhouse gases shape Earth's climate.

A. Nearly all the energy that flows through the Earth system comes from sunlight. Earth's climate is determined by the movement of energy through the Earth system—the ocean, atmosphere, clouds, ice, land, and life—and also includes energy and heat produced by humans and human activity.
>> [Learn more about Earth's energy balance]

B. Some of the sunlight that reaches Earth is reflected back to space by Earth's atmosphere and surface, but about 70% of it is absorbed by the atmosphere, land, and ocean. The warmed Earth radiates heat back into the atmosphere, where the heat is absorbed by greenhouse (also known as heat-trapping) gases that radiate some of this heat back toward Earth. This leads to the overall heating of Earth's surface—known as the **greenhouse effect**.
>> [Learn more about the greenhouse effect]

C. Greenhouse gases added to the atmosphere by human activities intensify the greenhouse effect and drive global warming. The greenhouse gases produced by human activities include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.
>> [Learn more about greenhouse gas emissions]

D. Water vapor (H_2O) also traps heat, and a warmer atmosphere holds more moisture than a cooler one. As a result, water vapor amplifies the warming caused by the addition of human-produced greenhouse gases.
>> [Learn more about water vapor and the greenhouse effect]

E. Some greenhouse gases are more effective at warming the planet than others. The heat-trapping ability of a greenhouse gas, plus how much of it is in the atmosphere and how long it endures,

Artist's statement: "My drawing depicts 11 endangered species and their different ecosystems found in the Western United States. The most difficult challenge was making this piece cohesive, even across different habitats that normally wouldn't be found together. I live in Boise, Idaho, and am surrounded by wild places that I consider part of my home. I want to ensure that these ecosystems are protected. I hope viewers come away with an appreciation for our Western wild places and the importance of biodiversity and healthy ecosystems threatened by climate change and habitat loss."
CREDIT: Taelyn B., Art x Climate, Endangered West (2022, colored pencil)

determines its contribution to total warming. For example, even though there is about 200 times more carbon dioxide in the atmosphere than methane, and carbon dioxide stays in the atmosphere for much longer, methane has contributed 20% to 30% of global warming to date.
>> **Learn more about the strength of greenhouse gases**

F. Life—including microbes, plants, animals, and humans—is a major driver of the global **carbon cycle** and can influence global climate by modifying the chemical makeup of the atmosphere. The geologic record shows that life has significantly altered the atmosphere during Earth's history.

G. Carbon naturally moves very slowly between the atmosphere and reservoirs in the Earth, including rocks, soils, and the deep ocean. Human activities are disrupting this cycle by taking carbon out of storage underground and releasing it into the atmosphere, primarily by burning fossil fuels such as coal, oil, and natural gas.
>> **Learn more about how humans are changing the carbon cycle**

H. While some of these human-caused carbon dioxide emissions are absorbed quickly by the ocean and forests, much of the carbon dioxide will remain in the atmosphere before it is absorbed by the ocean over thousands of years.

I. As concentrations of carbon dioxide and other greenhouse gases increase, Earth's average temperature rises in response. This rise in temperature causes a significant change in the climate averages and extremes that people and the natural environment experience.
>> **Learn more about carbon dioxide's role in Earth's climate**

ESSENTIAL PRINCIPLE 3

CAUSES

Burning fossil fuels and other human activities are causing the planet to warm.

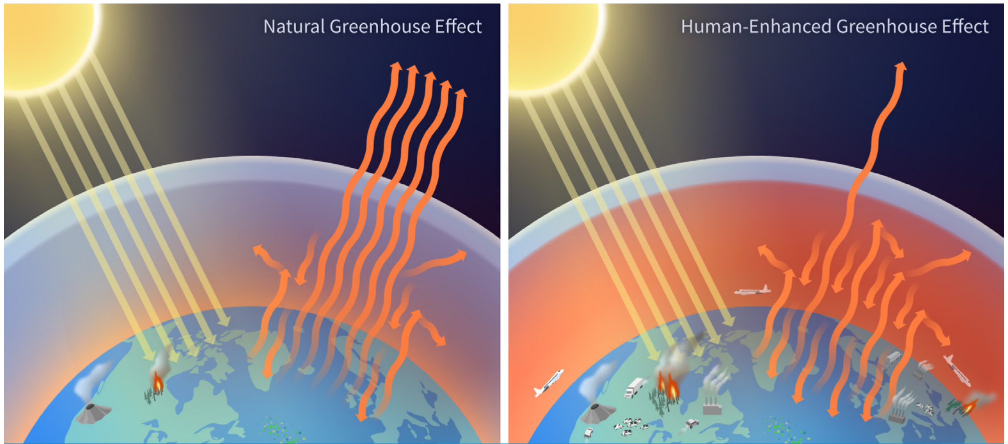
A. Human activities have unequivocally caused the global warming observed over the **industrial era** by increasing the levels of carbon dioxide and other greenhouse gases in the atmosphere.
>> Learn more about how human activities cause global warming

B. Three-quarters of all greenhouse gases emitted by human activities come from the use of fossil fuels, primarily coal, oil, and natural gas, for transportation and energy. The rest come from industrial processes, agriculture, landfills, and land-use changes such as deforestation.
>> Learn more about sources of greenhouse gas emissions

C. **Social systems**—including institutions, policies, practices, values, and behaviors—determine the amount of greenhouse gases emitted. Social systems also inequitably distribute the economic benefits of energy consumption and the impacts of greenhouse gas emissions and climate change.
>> Learn more about how social systems drive climate change

D. The global climate will continue to warm in the future. How much it warms depends primarily on current and future emissions of greenhouse gases from human activities. By far the biggest **uncertainty** in terms of future climate change is the human factor—how much action global society will take to limit greenhouse gas emissions.
>> Learn more about future climate change

E. Many of the human activities that produce greenhouse gases also produce small airborne particles called **aerosols**. Aerosols generally cool the planet by reflecting sunlight back into space, and by seeding clouds that reflect sunlight. This cooling effect is currently not big enough to fully counteract human-caused warming. Most



Human-produced greenhouse gases have intensified Earth's natural greenhouse effect by changing the balance between the amount of sunlight that reaches the surface and the amount of heat that escapes the atmosphere.
CREDIT: NOAA Climate Program Office, Graphic by Anna Eshelman

human-produced aerosols, such as smoke from power plants and biomass burning, also have negative effects on air quality and human health.
>> [Learn more about climate change and air quality]

F. Human activities continue to increase the levels of greenhouse gases in the atmosphere, although contributions vary across regions, sectors, and populations.
>> [Learn more about global greenhouse gas contributions]

G. Carbon dioxide remains in the atmosphere for centuries or longer. This means that carbon dioxide emitted decades ago continues to contribute to climate change today. Among countries, the United States is the largest emitter of the carbon dioxide that has accumulated in the atmosphere since the Industrial Revolution. From 1850 to 2021, total emissions from the United States are estimated to have caused around 17% of global warming, China 12%, European Union 10%, and the 47 least-developed countries collectively 6%.

Artist's statement: "Originally trained as a landscape architect, I rework abandoned sites, invasive species zones and decaying ruins as a way of navigating human folly. Individual works juxtapose something highly artificial with something organic, and/or something jarring with something reassuring. Forged from multiple medium format images, this scene of industry in a forested, mountainous area combines landscape visualization techniques (infrared sensors) with more traditional light photography (dodge/burn, compositing) to bring out atmospheric details and place the manmade and vegetation in high contrast."
CREDIT: Casey Lance Brown, Art x Climate, Jackson County Industry (2022, infrared photography composite)

Cause and effect are represented here in southern Delaware, where temperatures rose to triple digits in a period of excessive heat due in large part to emissions from transportation and energy use and production.
CREDIT: NOAA Climate Program Office, Photo by Katy Perrault

H. Annual U.S. greenhouse gas emissions have been slowly declining since 2007, while emissions have increased rapidly in China, India, and other nations with rapidly industrializing economies. China is currently the top annual emitter as a nation.
>> **Learn more about global greenhouse gas emissions**

I. Reducing emissions of greenhouse gases can limit future global warming and its impacts. Parties to the 2015 Paris Agreement set a goal of holding the global average temperature to well below 2°C (3.6°F) above preindustrial levels, and pursuing efforts to limit warming to 1.5°C (2.7°F).
>> **Learn more about the Paris Agreement**

J. The Paris Agreement also sets an aim to make financial flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. However, public and private financial systems continue to support investment in fossil fuels. Currently, global spending on fossil fuels outweighs investments in adaptation and mitigation. Current investments in reducing greenhouse gas emissions are not large enough to keep warming below 2°C (3.6°F).

Essential Principles for Understanding and Addressing Climate Change

ESSENTIAL PRINCIPLE 4

IMPACTS

Rapid warming and other large-scale climate changes threaten human and ecological systems.

A. As of 2021, Earth had warmed by about 1.1°C (2°F) above pre-industrial levels. Most of this warming has occurred since 1980. The current rate of warming is roughly 30 times faster than the rate at which Earth warmed as it emerged from the last ice age.

B. The last time the amount of carbon dioxide in the atmosphere was as high as it is today was about 3.2 million years ago, when the world was significantly warmer and sea levels were between 18 and 63 feet (5.5 to 19 meters) higher than today.
>> Learn more about past climate

C. Human societies developed over the past 10,000 years during a very stable period in Earth's climate history. The rapid rise in temperatures and resulting climate changes since 1980 mean that the economic, transportation, agricultural, and social systems we rely on are **vulnerable**.
>> Learn more about climate change impacts on social systems

D. Climate change is already increasing the severity, geographic scale, and frequency of **extreme events**, such as **heatwaves**, floods, strong storms, droughts, and wildfires around the United States and the world. As the world warms, these events will become even more extreme, worsening existing social inequalities and leading to greater health, resource, and **migration** challenges. Existing societal challenges, intensified by increasing climate change, will exacerbate the drivers of instability and threaten both national and global security. To deal with the direct effects of extreme events, as well as the increased instability resulting from them, the need for humanitarian assistance will increase worldwide.
>> Learn more about changes to extreme events

E. Globally, a warmer atmosphere holds more total water vapor, and some areas will get wetter. Warmer air with more water vapor also causes heavier rainfall during storms, which can lead to flooding. However, over many regions, temperature changes will outpace the effects of increases in humidity, making dry places even drier and droughts more intense.

F. Changing precipitation and snowmelt patterns are altering the distribution of Earth's freshwater and the timing of runoff. Droughts are becoming more frequent and severe in many regions, while, at the same time, extreme precipitation events are becoming more frequent and intense in other regions. Some regions are experiencing both—more frequent or severe droughts in the summer, and more extreme precipitation events in the winter. These and other climate change impacts threaten the quality and reliability of water supplies.
>> **Learn more about the changing water cycle**

G. Global warming is causing the global average sea level to rise. As ocean water warms, it expands, taking up more space. Water from melting land ice is also being added to the ocean, raising sea levels. As the **sea level rises**, salt water contaminates coastal freshwater sources, damages coastal homes and infrastructure, harms coastal ecosystems, and inundates islands and low-lying land. Sea level rise also increases the risk of damage to buildings and infrastructure from **high tide flooding** and **storm surge**.
>> **Learn more about the impacts of climate change on coastal communities**

H. The ocean has slowed climate change by absorbing huge amounts of heat and carbon. About 90% of the warming caused by greenhouse gas emissions has been absorbed by the ocean, altering its global **circulation** patterns and threatening marine

Warming temperatures and changes in light and nutrients cause coral to expel their colorful symbiotic algae in a process called coral bleaching, leaving them without a major food source and vulnerable to disease.
CREDIT: Daniela Macaya, Ghost Reefs

A firefighter goes to work in a smoke-filled environment at the Pioneer Fire in Washington State. Wildfires have increased in frequency and intensity due to human activity.
CREDIT: U.S. Forest Service

life. The ocean has also taken up 25% of all carbon dioxide produced by human activities, making it more acidic and leading to harmful impacts on marine species, **food webs**, and coastal economies. As climate change continues, the ocean's capacity to store heat and carbon is likely to weaken, reducing its ability to buffer the effects of greenhouse gas emissions.

>> Learn more about the ocean and climate change

I. All species, including humans, survive within specific ranges of temperature, precipitation, humidity, sunlight, and other climate conditions. Organisms exposed to climate conditions outside their normal ranges must adapt or move elsewhere, or they may face negative health impacts. If climate conditions sufficiently alter a species' habitat, consequences can include extinction. Changes to the abundance of different species can threaten the stability and survival of their ecosystems.

>> Learn more about ecosystem changes

J. As local climate conditions change, many organisms, including animals, plants, and microbes, are attempting to move to areas with more favorable conditions. However, their movement can be limited or prevented by natural barriers such as mountains, human-built infrastructure such as roads, or competition with other species. The timings of blooms, migrations, and hibernations have changed and will continue to change, sometimes dramatically, potentially altering food webs and spreading infectious diseases. These processes disrupt existing ecosystems and can threaten the survival of entire species, biomes, and human livelihoods.

>> Learn more about ecosystem impacts

K. The impacts of climate change and other stressors may drive people to leave their homes temporarily or permanently, either within the same country or across a border. For example, rising temperatures and shifting rainfall could lead to increased crop failures, compelling farmers to seek more reliable livelihoods in nearby cities or neighboring regions. Climate migration is one type of human migration, which can have many complex causes and impacts. If migration is sudden and unplanned, it may increase demand for scarce resources and potentially exacerbate tension between migrants and local communities. Governments may also struggle to provide adequate services amid large-scale displacement.

>> Learn more about climate change and migration

L. Climate change negatively impacts human health through more frequent and severe **extreme heat** and other extreme events; increased transmission of infectious and vector-borne diseases; declines in food and water security; and degraded air and water quality. Exposure to extreme events can result in feelings of **vulnerability**, uncertainty, and anxiety or depression, with negative impacts on mental health. **Marginalized** and low-income populations tend to be more exposed to climate hazards and associated health impacts than other groups.

>> Learn more about climate change and human health

M. Climate change can harm businesses, governments, and economies through costly disruptions to services and supply chains, damage to infrastructure, and lost productivity. At the same time, climate solutions will create new economic opportunities for organizations.

>> Learn more about climate change and the economy

Ecogenia, the first NGO in Greece to promote sustainability through civic service, is working to mobilize young people to accelerate localized climate action. Inspired in part by AmeriCorps, collaboration with the California Conservation Corps enabled both programs to build capacity for increased climate action.
CREDIT: Ecogenia

ESSENTIAL PRINCIPLE 5

EQUITY

Climate justice is possible if climate actions are equitable.

A. With careful planning and execution, actions to reduce greenhouse gas emissions and adapt to climate risks can be carried out in ways that promote climate justice in the United States, which involves ensuring benefits from climate action are shared equitably and fairly. Achieving sustainable outcomes that promote **equity** in the United States, rather than exacerbate inequities, involves understanding how the impacts of and responses to climate change affect different groups of people, including those who have been marginalized and **underserved**. Including affected communities in decision-making can help reduce risks and distribute benefits equitably.
>> Learn more about climate justice

B. Climate change is both a product of society and a force that is shaping it. Its effects both reflect and exacerbate existing social inequities, with some people and communities suffering disproportionate harm. Societies can help address these issues by acknowledging the intersections between climate change and key social challenges, such as those relating to racial, economic, and gender **inequity**; rural communities; public health; migration; and ecosystem health.
>> Learn more about intersecting challenges

C. Although climate change affects everyone, marginalized and underserved communities are more likely to experience harmful impacts. The long-lasting effects of discriminatory investment practices, unequal distribution of resources, and exclusionary laws have pushed Indigenous communities, communities of color, and low-income communities into locations where they are more vulnerable to climate change. These communities are often **overburdened**, experiencing one or more types of **environmental injustice** in the form of disproportionate health-related impacts from fossil fuel-based energy systems, reduced capacity to prepare for and recover from extreme events, settlement in hotter or more flood-prone areas, or lower-quality infrastructure and services.

>> [Learn more about inequitable climate impacts](#)

D. Certain groups of people are at higher risk of negative health impacts from climate change. Those likely to experience elevated health impacts include the very young, the very old, people with disabilities or chronic health conditions, low-income individuals and communities, and other marginalized communities.

>> Learn more about climate change impacts on human health

E. Rural communities face unique challenges from climate change. Rural areas are often under-resourced and therefore less resilient to climate impacts. Climate change also worsens stressors they already face, including physical isolation, limited economic diversity, and higher poverty rates, combined with an aging population. At the same time, rural communities are key to many climate adaptation and mitigation efforts, from climate-smart agricultural practices, to new sources of **renewable energy**, to restoring critical habitats for wildlife.

F. Indigenous Peoples hold unique knowledges and experiences about how to live sustainably on their lands. Their ways of life are threatened as local climates change and the ecosystems they rely on are altered. Tribal education systems are engaged in building community **resilience** and supporting the next generation of climate leaders.

>> Learn more about how Indigenous leadership is guiding climate responses

Members of the San Carlos Apache Tribe, Klamath Tribe, and White Earth Nation, alongside a representative of the DOI-Bureau of Indian Affairs, collaborate on potential Tribal renewable energy projects at the National Renewable Energy Laboratory.
CREDIT: DOE, Photo by John De La Rosa (NREL)

Artist's statement: "Cheryl is a very real person in Milwaukee, Wisconsin. She works at a social services non-profit and is a member of our gay community. I painted her to show her confidence and triumph over urban challenges. This painting depicts the density of urban life and the spirit of the individual in it. The power of the individual, for climate change, social change, and personal change is embodied in this painting." CREDIT: Ellen Anderson, Art x Climate, Cheryl (2021, oil on canvas)

G. An equitable and sustainable U.S. response to climate change has the potential to reduce climate impacts while improving well-being, strengthening resilience, benefiting the economy, and, in part, redressing legacies of racism, injustice, and inequity within the nation.
>> **Learn more about just climate solutions**

H. Participatory research and planning processes can help reduce inequities and the chances of causing unintended harm through climate actions. Taking inclusive and equitable approaches to addressing climate change in the United States requires that the characteristics of a community, the factors that shaped them, and the interests of those affected are central to designing and implementing climate solutions. Approaches to decision-making that are based on broad and meaningful participation by all affected groups can build trust, promote social cohesion, and increase support, implementation, and efficacy for adaptation and mitigation strategies and plans.
>> **Learn more about how inclusivity improves climate responses**

I. A **just transition** within the United States is the process of responding to climate change with transformative actions that address the root causes of climate vulnerability while ensuring equitable access to **decent work** and quality jobs; affordable, low-carbon energy; environmental benefits such as reduced air pollution; and improved quality of life for all. This type of transition has the potential to enable more ambitious, effective, and lasting adaptation, resilience, and mitigation actions, including by creating good-paying jobs in renewable energy industries.
>> **Learn more about just transitions**

ESSENTIAL PRINCIPLE 6

ADAPTATION

Humans can adapt social, built, and natural environments to better withstand the impacts of climate change.

A. Adapting and building resilience to climate impacts in all aspects of society saves lives; reduces structural, environmental, and economic damage; protects natural resources; helps preserve cultures; and often results in improved quality of life.
>> **Learn more about climate adaptation**

B. Adaptation and mitigation are complementary strategies for reducing the risks of climate change. Taking actions to adapt and build resilience to current and future extreme events and other climate changes, while dramatically reducing emissions of greenhouse gases, will also reduce loss of life and property and limit damage to ecosystems and human health.

C. Adaptation will become more expensive and less effective as the planet warms. Building a costly seawall today, for example, will be insufficient if water levels rise above the height of the wall in the future. Without mitigation, there will come a time when the impacts of climate change overwhelm our capacity to adapt.

D. Current adaptation efforts and investments are insufficient to address today's risks and keep pace with future climate change. Adequate adaptation would involve not only scaling up efforts across a wider range of actors, sectors, and systems, but also more **transformative adaptation** involving profound shifts in our institutions, behaviors, values, or technologies. For example, transformative actions could shift housing development to less flood-prone areas to account for rising seas, or redesign buildings and cities to manage heat extremes.
>> **Learn more about transformative adaptation**

E. People may be able to adapt and reduce their vulnerability in different ways, depending on their circumstances. For example,

Artist's statement: "This piece was commissioned by the University of Washington Climate Impacts Group. Developed in collaboration with scientists and tribal representatives, the work acknowledges the inevitable while highlighting how we can cultivate good. From the urban West Coast to the shrubsteppe of eastern Washington, resiliency looks different in every landscape. True resiliency is not bound within the realm of science; social justice is equally as vital to every solution. The piece aims to make climate resiliency concepts more accessible. After all, before any goal can be accomplished, it must first be envisioned."
CREDIT: Claire Seaman, Art x Climate, Imagining Climate Resiliency in the Pacific Northwest (2021, oil on canvas)

some communities and individuals may move to higher ground to avoid flooding and rising sea levels, choose crops that will thrive under new climate conditions, develop **nature-based solutions** such as restoring vegetation to lessen storm impacts, and adopt new technologies or building standards suited for new weather extremes. However, the ability to adapt may be limited by the capacity of a community or individual to address changing conditions, or by a risk or hazard exposure that is too great to overcome.

F. There is no one-size-fits-all model for adaptation and improved resilience. Adaptation will look different in different communities because risks, judgments about risk, resources, and potential solutions differ across groups of people and the places where they live and work.

G. Actions that increase risks are called **maladaptation**. For example, maladaptation can occur if infrastructure (like a levee or roadway) or a disaster response program encourages continued development in hazardous areas, leading to higher losses in the event of future disasters. Most often, maladaptation is an unintended consequence.

H. A fair, democratic, and community-based approach to assessing risks and planning adaptation measures can reduce the chances of unintentionally causing more harm to natural systems and the people who are affected by these decisions.
>> **Learn more about equity in adaptation**

I. Adaptation often requires financial investment in new or enhanced technologies, infrastructure, and education. Investing in adaptation and resilience efforts undertaken by vulnerable populations can contribute to a more equitable future.
>> **Learn more about investments in adaptation**

ESSENTIAL PRINCIPLE 7

MITIGATION

Reducing emissions of greenhouse gases from human activities to net zero by 2050 can help limit global warming and climate change impacts.

A. Rapid, deep, and sustained reductions in global emissions of greenhouse gases can still limit global temperature changes to well below 2°C (3.6°F), consistent with the goals of the Paris Agreement.
>> Learn more about climate mitigation

B. Limiting global warming requires net-zero carbon dioxide emissions— where emissions fall to zero or remaining emissions are balanced by removal from the atmosphere. To keep warming to well below 2°C (3.6°F), global carbon dioxide emissions would need to reach net zero by 2050, along with substantial reductions in emissions of all greenhouse gases. Rapid and sustained reductions in methane emissions are one of the fastest ways to limit near-term warming.

C. Reaching and sustaining global net-zero greenhouse gas emissions will result in a gradual decline in warming. However, some long-term responses to warming that have already occurred will continue due to the long lifespan of some greenhouse gases in the atmosphere (for example, sea level rise, ice sheet losses, and ecosystem disruptions).
>> Learn more about the ways to reach net zero

D. Actively removing carbon dioxide from the atmosphere and using **natural climate solutions** to increase ecosystem **carbon sinks** can help reach net zero even faster. Scientists, entrepreneurs, and communities are working on ways to remove some of these greenhouse gases.
>> Learn more about carbon dioxide removal

E. Many countries, states, cities, and corporations have set climate mitigation goals and targets that are aligned with limiting warming to 1.5°C (2.7°F). However, current efforts to meet these goals and

Regional Administrator Jared Blumenfeld, Tribal Council Member and Environmental Director Tommy Siyuja, Sr., and Augie Hanna visit a new solar array at the Havasupai Tribal School. This array will help save the Tribe money and energy, prevent frequent outages, and reduce greenhouse gas emissions.
CREDIT: EPA

targets need to be scaled up and expanded to limit global warming, and it remains likely that warming will exceed 1.5°C (2.7°F) during the 21st century.
>> Learn more about climate mitigation at many scales

F. Technologies and approaches that are already available can dramatically reduce greenhouse gas emissions from the highest-emitting sectors. These include improvements in energy efficiency, electricity generation from solar and wind energy, electrification of transportation and heating, less emissions-intensive diets, and protection and restoration of forests and ecosystems.
>> Learn more about options to reduce emissions now

G. Some other greenhouse gas emissions, such as those from jet fuel, cement production, and certain industrial processes, cannot be avoided at a large scale with current technologies. To reach net-zero emissions, additional mitigation options and approaches, such as natural and engineered **carbon dioxide removal** and low-carbon fuels, may need to be explored.

H. Actions by governments, businesses, organizations, and individuals can support net-zero emissions goals.
>> Learn more about efforts to reduce emissions

This fully electric school bus is part of a new fleet in Virginia and a larger national plan to switch a substantial portion of the nation's 500,000 school buses to renewable energy.
CREDIT: EPA, Photo by Eric Vance

ESSENTIAL PRINCIPLE 8

HOPE & URGENCY

A livable and sustainable future for all is possible with rapid, just, and transformational climate action.

A. How quickly global carbon dioxide emissions reach net zero will largely determine how much warming can be limited. Every increment of warming that the world avoids reduces the risks and harmful impacts of climate change, including loss of life. Acting sooner on mitigation and adaptation will reduce future warming and associated impacts and produce environmental, economic, and social benefits.
>> Learn more about the choices that will determine the future

B. Parties to the Paris Agreement set a collective goal to limit global warming to well below 2°C (3.6°F) above preindustrial levels and to pursue efforts to limit warming to 1.5°C (2.7°F) above preindustrial levels. To meet this goal, countries, companies, communities, and organizations need to implement more ambitious mitigation actions.
>> Learn more about international climate goals

C. Even if the world rapidly reaches net-zero emissions, the United States will continue to face climate impacts and risks. Adequately addressing these risks involves longer-term inclusive planning, investments in transformative adaptation, and mitigation approaches that consider equity and justice.
>> Learn more about potential benefits of climate action

D. Inclusive, equitable, and just approaches to climate action in the United States can help reduce risks, improve outcomes, encourage ambitious mitigation, and create opportunities to overcome past environmental inequities. Supporting Indigenous and local knowledge holders and their practices can lead to more resilient and sustainable outcomes.
>> Learn more about just transitions

E. Human well-being is dependent on natural and managed ecosystems, which provide crucial functions and resources for nearly everything we eat, make, and do. Nature-based solutions can provide climate adaptation and mitigation benefits, protecting ecosystems and the services they provide while also benefiting people.

>> **[Learn more about ecosystems, ecosystem services, and biodiversity]**

F. Improving climate education, increasing access to information, and communicating effectively can improve people's understanding of risks and their ability to address them.

G. Taking constructive climate action together with other people helps reduce **eco-anxiety** and builds a stronger sense of community.

>> **[Learn more about climate change and mental health]**

H. Substantially reducing human-caused greenhouse gas emissions and taking actions to adapt and build resilience involves all levels of society. Actions by individuals, organizations, businesses, and governments can support adaptation and mitigation goals. In the United States, states, cities, Tribes, companies, and other organizations have adopted a range of climate actions and policies.

>> **[Learn more about mitigation and adaptation actions underway now]**

I. Millions of people all over the world are already working to make a safer, healthier, more prosperous, more just, and more stable world for all through climate action.

>> Learn more about how people are **[mitigating]** and **[adapting]** to climate change

Artist's statement: "In my art, I try to convey that we can help reverse the effects of climate change. One hand is erasing the pollution caused by industrialization the world over, and the other is redrawing actions to restore the Earth's beauty. I have always tried to help out the Earth, through stream clean ups and more. I hope people learn from my art that they can help change the world by just doing simple things like driving less, not littering, and maybe even setting up solar panels or wind turbines. The effects of climate change are only in our hands, so we should do whatever we can to help."
CREDIT: Ritika S., Art x Climate, Redrawing the Earth (2023, colored pencil)

Key Definitions

All definitions are from the Fifth National Climate Assessment Glossary, unless another source is cited.

Adaptation In human systems, the process of adjustment to actual or expected climate and its effects to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects. Human intervention may facilitate adjustment to expected climate and its effects.

Aerosols A suspension of airborne solid or liquid particles, with typical particle size in the range of a few nanometers to several tens of micrometers. Aerosols have both natural and human-caused sources. Overall, they tend to produce cooling by scattering incoming radiation and by affecting cloud cover, although some aerosols can cause warming directly by absorbing radiation and indirectly through their interactions with clouds.

Biodiversity The variety of life, including the number of plant and animal species, other life forms, genetic types, habitats, and biomes in an ecosystem.

Carbon cycle The series of processes by which carbon compounds flow among reservoirs in the environment, such as the incorporation of carbon dioxide into living tissue by photosynthesis and its return to the atmosphere through respiration, the decay of dead organisms, and the burning of fossil fuels. In the carbon cycle, carbon flow or output from one reservoir transfers carbon to other reservoir(s) of carbon dioxide into living tissue by photosynthesis and its return to the atmosphere through respiration, the decay of dead organisms, and the burning of fossil fuels. In the carbon cycle, carbon flow or output from one reservoir transfers carbon to other reservoir(s).

Carbon dioxide (CO_2) A naturally occurring gas, as well as a by-product of burning fossil fuels from fossil carbon deposits, burning biomass, land-use changes, and industrial processes (e.g., cement production). CO_2 is the principal anthropogenic greenhouse gas that affects Earth's radiative balance. As the reference gas against which the radiative forcing of other greenhouse gases are measured, it has a global warming potential of 1.

Carbon dioxide removal A set of techniques that aim to remove and/or sequester carbon dioxide (CO_2) directly from the atmosphere by either increasing natural carbon sinks or using chemical engineering to remove the CO_2.

Carbon sink Any process, activity, or mechanism that removes carbon from the atmosphere. A carbon sink may also refer to a physical location, defined area, or geological or biological element of Earth's system (e.g., the ocean, a country, biomass) that stores acquired carbon from the atmosphere for a specified period of time.

Circulation (ocean) The large-scale movement of waters in the ocean basin. It is a key regulator of climate by storing and transporting heat, carbon, nutrients and freshwater all around the world. (NASA, 2020)

Climate Climate, in a narrow sense, is usually defined as the average weather or, more rigorously, as the statistical description in terms of the average and variability of defining factors over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate, in a wider sense, is the state, including a statistical description, of the climate system.

Climate change Changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changes in frequency and location of severe weather events, and changes to other features of the climate system.

Climate justice Within the United States, the recognition of diverse values and past and ongoing harms, equitable distribution of benefits and risks, and the procedural inclusion of affected communities in decision-making processes. (Adapted from USGCRP, 2023: Ch. 20)

Climate literacy An understanding of how the climate system works, how human actions influence the climate, and how the climate influences people and other parts of the Earth system.

A climate-literate person:

- understands the essential principles of Earth's climate system and the options to address human-caused climate change, which are summarized in this guide;
- recognizes credible information about climate change and knows where to find it;
- communicates about climate change in accurate and effective ways; and
- is able to make informed decisions related to climate change.

Climate model A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of components, a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions; the extent to which physical, chemical, or biological processes are explicitly represented; or the level at which empirical parameterizations are involved. Climate models are applied as a research tool to study and simulate long-term climate projections (decadal or longer) and operationally used to create shorter climate predictions (seasonal, annual, interannual).

Climate system The matter, energy, and processes involved in interactions among Earth's atmosphere, hydrosphere, cryosphere, lithosphere, biosphere, and Earth-Sun interactions. (USGCRP, 2009)

Climate variability Deviations of climate variables from a given average state, including the occurrence of extremes, at all spatial and temporal scales beyond that of individual weather events. Variability may be intrinsic, due to fluctuations of processes internal to the climate system (i.e., internal variability), or extrinsic, due to variations in natural or anthropogenic external forcing (i.e., forced variability).

Coproduction (of knowledge) The integration of different knowledge systems and methodologies to systematically understand phenomena, systems, and processes.

Decent work Productive work for people in conditions of freedom, equity, security, and human dignity. (European Commission, 2022) (ILO, 2024)

Discrimination The differential treatment of an individual or group of people on the basis of, for example, their race, color, national origin, religion, sex (including pregnancy and gender identity), age, marital and parental status, disability, sexual orientation, or genetic information.

Drought An exceptional period of water shortage for existing ecosystems and the human population (due to low rainfall, high temperature and/or wind).

Earth system Earth functions as a system of interdependent parts. These parts include the physical, chemical, and biological processes that all interact to shape our planet and the organisms on it.

Eco-anxiety Also known as climate anxiety, a chronic fear of environmental doom.

Ecosystem A functional unit consisting of living organisms, their non-living environment, and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined. In some cases, ecosystem boundaries are relatively sharp, while in others they are diffuse, and they can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms, or they are influenced by the effects of human activities in their environment.

Emissions The release of climate-altering gases and aerosols into the atmosphere from human and natural sources.

Environmental injustice Environmental actions, behaviors, laws, and policies that have not been fair, that have limited meaningful involvement in environmental decision-making, or have unjustly allocated the risks and benefits of environmental action across communities, most often based on race, color, national origin, income, and gender identity, among others.

Equity The principle of being fair and impartial and a basis for understanding how the impacts and responses to climate change, including costs and benefits, are distributed in and by society in more or less equal ways. Often aligned with ideas of equality, fairness, and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society, generations, and gender, and in the sense of who participates and controls the processes of decision-making.

Extreme events A weather event that is rare at a particular place and time of year, including, for example, heatwaves, cold waves, heavy rains, periods of drought and flooding, and severe storms. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10% or 90% probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense.

Extreme heat Temperatures that are much hotter and/or humid than average. Because some places are hotter than others, this depends on what is considered average for a particular location at that time of year.

Flooding The overflowing of the normal confines of a stream or other water body or the accumulation of water over areas that are not normally submerged.

Food web A diagram of the links among species in an ecosystem—essentially who eats what. A food chain shows only the organisms that contribute to the diet of the top consumer. (USGS, 2003)

Fossil fuels Carbon-based fuels from fossil hydrocarbon deposits, including coal, oil, and natural gas.

Global warming The increase in global surface temperature relative to a baseline reference period, averaging over a period sufficient to remove interannual variations (e.g., 20 or 30 years). A common choice for the baseline is 1850-1900 (the earliest period of reliable observations with sufficient geographic coverage), with more modern baselines used depending on the application.

Greenhouse effect The process through which heat is trapped near the Earth's surface by substances known as greenhouse gases. (NASA, 2024)

Greenhouse gas (GHG) Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of radiation emitted by Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor, carbon dioxide, nitrous oxide, methane, and ozone are the primary GHGs in Earth's atmosphere. Other GHGs include sulfur hexafluoride, hydrofluorocarbons, chlorofluorocarbons, and perfluorocarbons; several of these are also ozone-depleting (and are regulated under the Montreal Protocol).

Hazard The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Heatwave A period of abnormally hot weather, often defined with reference to a relative temperature threshold, lasting from two days to months. Heatwaves and warm spells have various and, in some cases, overlapping definitions.

High tide flooding Occurs when sea level rise combines with local factors to push water levels above the normal high tide mark. Changes in prevailing winds, shifts in ocean currents, and strong tidal forces (which occur during full or new moons) can all cause high tide flooding, inundating streets and other infrastructure even on sunny days.

Ice sheet An ice body originating on land that covers an area of continental size, generally defined as covering > 19,000 mi^2 (>50,000 km^2), and that has formed over thousands of years through accumulation and compaction of snow.

Impact (climate) The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health, and well-being; ecosystems and species; economic, social, and cultural assets; services (including ecosystem services); and infrastructure.

Indigenous Knowledges (IK); also, Traditional Knowledges/ Traditional Ecological Knowledges (TEK) Bodies of dynamic and experiential knowledges gained over time by Indigenous Peoples, often associated with a specific place. IK includes observations, oral and written knowledge, innovations, practices, rituals, and beliefs; some IK is considered sacred and secret to a group or individuals. IK is inherently heterogeneous due to the cultural and geographic contexts from which it is derived. Also known as Native Science, Traditional Knowledges, Traditional Ecological Knowledges, or Indigenous Ways of Knowing.

Industrial era The multicentury period from the onset of large-scale industrial activity around 1750 to the present day. The reference period c. 1850-1900 is used to approximate preindustrial global average surface temperature.

Inequity An unfair or unjust difference in the distribution, allocation, management, or use of a resource, benefit, or burden between groups of people.

Intergovernmental Panel on Climate Change Created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the objective of the Intergovernmental Panel on Climate Change (IPCC) is to provide governments at all levels with scientific information that they can use to develop climate policies. The IPCC provides regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. IPCC reports are also a key input into international climate change negotiations. (IPCC, 2024)

Just transition A set of principles, processes and practices that aim to ensure that no people, workers, places, sectors, countries, or regions are left behind in the transition from a high-carbon to a low-carbon economy. It stresses the need for targeted and proactive measures from governments, agencies, and authorities to ensure that any negative social, environmental, or economic impacts of economy-wide transitions are minimized, while benefits are maximized for those disproportionately affected. Key principles of just transitions include respect and dignity for vulnerable groups, fairness in energy access and use, social dialogue and democratic consultation with relevant stakeholders, the creation of decent jobs, social protection, and rights at work. Just transitions could include fairness in energy, land use, and climate planning and decision-making processes; economic diversification based on low-carbon investments; realistic training/retraining programs that lead to decent work; gender-specific policies that promote equitable outcomes; the fostering of international cooperation and coordinated multilateral actions; and the eradication of poverty. Lastly, just transitions may embody the redressing of past harms and perceived injustices.

Maladaptation (climate) Occurs when actions are taken that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence.

Marginalized population/Marginalized community Community excluded from mainstream social, economic, educational, and/or cultural life. Examples of marginalized populations include, but are not limited to, groups excluded due to race, gender identity, sexual orientation, age, physical ability, language, and/or immigration status.

Migration (human) Movement of a person or a group of persons either across an international border or within a nation. It is a population movement encompassing any kind of movement of people, whatever its length, composition, and causes; it includes migration of refugees, displaced persons, economic migrants, and persons moving for other purposes, including family reunification.

Mitigation Measures to reduce the amount and rate of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.

National Climate Assessment (NCA) The U.S. Global Change Research Program (USGCRP) was established by Presidential initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990. Its mandate is to develop and coordinate "a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." The GCRA mandates that USGCRP prepare and submit to the President and the Congress a quadrennial assessment, referred to as the National Climate Assessment (NCA). (USGCRP, 2023)

Natural climate solutions Actions to protect, sustainably manage, and restore natural or modified ecosystems for the purpose of climate change mitigation. (USAID, 2022)

Nature-based solutions Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

Net-zero carbon dioxide emissions Condition in which anthropogenic carbon dioxide (CO_2) emissions are balanced by anthropogenic CO_2 removals over a specified period.

Ocean acidification The process by which the pH measurement of ocean water moves toward more acidic levels due to the absorption of carbon dioxide, which interacts with ocean water to form carbonic acid, thereby lowering the pH. Increased acidity reduces the ability of plankton and shelled animals to form and maintain carbonate-containing body parts such as shells.

Overburdened community Population or geographic location in the United States that experiences disproportionate environmental and climatic harms and risks. This disproportionality can be a result of greater vulnerability to environmental hazards, lack of opportunity for public participation, or other factors. Increased vulnerability may be attributable to an accumulation of negative or lack of positive environmental, health, economic, or social conditions within these populations or places. The term describes situations where multiple factors, including both environmental and socioeconomic stressors, may act cumulatively to affect health and the environment and contribute to persistent environmental health disparities.

Paris Agreement An international climate agreement adopted in 2015, which entered into force in 2016, with the central goal of holding the global average temperature rise to well below 2°C above preindustrial levels and pursuing efforts to limit the temperature increase even further to 1.5°C. Under this agreement, each party must, among other things, submit a "nationally determined contribution" (NDC)—that is, a greenhouse gas emissions target and/or mitigation policies and measures—every five years and regularly report on progress made in implementing and achieving its NDC. The agreement also addresses efforts to adapt to the adverse effects of climate change and certain support for developing country Parties, such as financial support for mitigation and adaptation.

Participatory processes Approaches to research and planning in which those most directly impacted by the outcomes become active participants in the process. (Adapted from National Academies of Sciences, Engineering, and Medicine, 2023)

Renewable energy Any form of energy that is replenished by natural processes at a rate that equals or exceeds its rate of use.

Resilience (climate) The capacity of interconnected social, economic, and ecological systems to cope with a climate change event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure. Climate resilience is a subset of resilience against climate-induced or climate-related impacts.

Risk Threats to life, health, and safety, the environment, economic well-being, and other things of value. Risks are evaluated in terms of how likely they are to occur (probability) and the damages that would result if they did happen (consequences).

Sea level rise Increase to the height of sea level, both globally and locally (relative sea level change) due to a change in ocean volume as a result of a change in the mass of water in the ocean (e.g., due to melt of glaciers and ice sheets), changes in ocean volume as a result of changes in ocean water density (e.g., expansion under warmer conditions), changes in the shape of the ocean basins, and changes in Earth's gravitational and rotational fields, as well as local subsidence or uplift of the land. Sea level change refers to sea level rise or sea level fall.

Social systems The institutions, policies, programs, practices, values, and behaviors that shape drivers, risks, impacts, and understanding of climate change. (Adapted from USGCRP, 2023: Ch. 20)

Storm surge The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). Storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.

Transformative adaptation Adaptation that changes the fundamental attributes of a social-ecological system, often involving persistent, novel, and significant changes to institutions, behaviors, values, and/or technology in anticipation of climate change and its impacts.

Tipping point The point at which a change in the climate triggers a significant environmental event, which may be permanent, such as widespread bleaching of corals or the melting of very large ice sheets.

Uncertainty (statistical) An expression of the degree to which a quantity or process is unknown. In statistics, a term used to describe the range of possible values around a best estimate, sometimes expressed in terms of probability or likelihood. Uncertainty about the future climate arises from the complexity of the climate system and the ability of models to represent it, as well as the inability to predict the decisions that society will make. There also is uncertainty about how climate change, in combination with other stressors, will affect people and natural systems.

Underserved community A community who, due to continuous systemic discrimination, under- or disinvestments, and limited access to efficient, healthy, and affordable services and infrastructure, experiences disproportionate environmental and climatic harms and risks and lack access to adequate resources to mitigate, respond to, and recover from impacts. Increased vulnerability may be attributable to harmful environmental, health, economic, or social conditions—or to a lack of support for positive conditions—within these populations or places. The term describes situations where disproportionate vulnerability is often due to discrimination based on geography; access to authority or representation in governance; or social identities, including race, ethnicity, gender, culture, economic status, or ability.

U.S. Global Change Research Program A federal interagency research program established by Congress in the Global Change Research Act of 1990. Its mandate is to develop and coordinate "a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." (USGCRP, 2024)

United Nations Framework Convention on Climate Change (UNFCCC) An international climate agreement adopted in 1992, which entered into force in 1994. The objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Vector (disease) An organism, such as an insect, that transmits disease-causing microorganisms such as viruses or bacteria. Vector-borne diseases include, for example, malaria, Lyme disease, Zika, and chikungunya.

Vulnerability (climate) The degree to which physical, biological, and socioeconomic systems are susceptible to and unable to cope with adverse impacts of climate change.

Weather The state of the atmosphere, mainly with respect to its effects on life and human activities. As distinguished from climate, weather consists of short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, humidity, precipitation, cloudiness, visibility, and wind.

Well-being (human) A state of existence that fulfills various human needs, including material living conditions and quality of life, as well as the ability to pursue one's goals, to thrive, and to feel satisfied with one's life.

Wildfire A wildland fire originating from an unplanned ignition, such as lightning, volcanos, unauthorized and accidental human-caused fires, and prescribed fires that are declared wildfires.

Literature Cited

Adroin, N.M., A.W. Bowers, and M. Wheaton, 2023: Leveraging collective action and environmental literacy to address complex sustainability challenges. *Ambio,* **52**, 30–44.
https://dx.doi.org/10.1007/s13280-022-01764-6

Collier, M. and S. Bansal, 2023: Climate Warming is Likely to Cause Large Increases in Wetland Methane Emissions. U.S. Geological Survey.
https://www.usgs.gov/news/featured-story/climate-warming-likely-cause-large-increases-wetland-methane-emissions

Di Liberto, T., 2024: What's in a number? The meaning of the 1.5-C climate threshold. National Oceanic and Atmospheric Administration.
https://www.climate.gov/news-features/features/whats-number-meaning-15-c-climate-threshold

DOS, 2023: Accelerating Fast Mitigation: Summit on Methane and Non-CO2 Greenhouse Gases. U.S. Department of State.
https://www.state.gov/accelerating-fast-mitigation-summit-on-methane-and-non-co2-greenhouse-gases/

EPA, 2024: Global Greenhouse Gas Overview. U.S. Environmental Protection Agency [Webpage].
https://www.epa.gov/ghgemissions/global-greenhouse-gas-overview

EPA, 2024: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022. EPA 430-R-24-004. U.S. Environmental Protection Agency.
www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

EPA, 2024: Understanding Global Warming Potentials. U.S. Environmental Protection Agency [Webpage].
https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

European Commission, 2022: What is decent work? [Webpage].
https://international-partnerships.ec.europa.eu/policies/sustainable-growth-and-jobs/employment-and-decent-work_en

IEA, 2022: Global Methane Tracker 2022. International Energy Agency, Paris, France.
https://www.iea.org/reports/global-methane-tracker-2022/methane-and-climate-change

ILO, 2024: Decent work. International Labour Organization [Webpage].
https://www.ilo.org/topics/decent-work

IPCC, 2014: *Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White, Eds. Cambridge University Press, Cambridge, UK and New York, NY, USA, 1-32.
https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf

IPCC, 2021: *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou, Eds. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3-32.
https://doi.org/10.1017/9781009157896.001

IPCC, 2022: *Summary for Policymakers In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama, Eds. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3-33.
https://doi.org/10.1017/9781009325844.001

IPCC, 2022: *Summary for Policymakers In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, Eds. Cambridge University Press, Cambridge, UK and New York, NY, USA.
https://doi.org/10.1017/9781009157926.001

IPCC, 2023: *Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Core Writing Team, H. Lee and J. Romero, Eds. IPCC, Geneva, Switzerland, 1-34.
https://doi.org/10.59327/IPCC/AR6-9789291691647.001

IPCC, 2024: *About the IPCC*.[Webpage].
https://www.ipcc.ch/about/

Lindsey, R., 2024: Climate Change: Atmospheric Carbon Dioxide. National Oceanic and Atmospheric Administration.
https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

Marcott, S.A, J.D. Shakun, P.U. Clark, and A.C. Mix, 2013: A Reconstruction of Regional and Global Temperature for the Past 11,300 Years. *Science*, **339**,1198-1201.
https://doi.org/10.1126/science.1228026

National Academies of Sciences, Engineering, and Medicine, 2023: *Strengthening Equitable Community Resilience: Criteria and Guiding Principles for the Gulf Research Program's Enhancing Community Resilience (EnCoRe) Initiative.* The National Academies Press, Washington, DC, USA, 96 pp.
https://doi.org/10.17226/26880

NASA, 2015: How Global Warming Stacks Up. National Aeronautics and Space Administration [Webpage].
https://svs.gsfc.nasa.gov/30615

NASA, 2022: Earth's Energy Budget. National Aeronautics and Space Administration [Webpage].
https://mynasadata.larc.nasa.gov/basic-page/earths-energy-budget

NASA, 2024: Climate Change Evidence. National Aeronautics and Space Administration [Webpage].
https://science.nasa.gov/climate-change/evidence/

NASA, 2020: Ocean Circulation. National Aeronautics and Space Administration, Physical Oceanography Distributed Active Archive Center [Webpage].
https://podaac.jpl.nasa.gov/OceanCurrentsCirculation

NASA, 2024: What is the greenhouse effect? National Aeronautics and Space Administration [Webpage].
https://science.nasa.gov/climate-change/faq/what-is-the-greenhouse-effect/

NASA Science Editorial Team, 2024: Steamy Relationships: How Water Vapor Amplifies Earth's Greenhouse Effect. National Aeronautics and Space Administration.
https://science.nasa.gov/earth/climate-change/steamy-relationships-how-atmospheric-water-vapor-amplifies-earths-greenhouse-effect/

NOAA, 2016: Study finds fossil fuel methane emissions greater than previously estimated. National Oceanic and Atmospheric Administration
https://www.noaa.gov/media-release/study-finds-fossil-fuel-methane-emissions-greater-than-previously-estimated

Osman, M.B., J.E. Tierney, J. Zhu, R. Tardif, G.J. Hakim, J. King, and C.J. Poulsen, 2021: Globally resolved surface temperatures since the Last Glacial Maximum. *Nature,* **599**, 239–244.
https://doi.org/10.1038/s41586-021-03984-4

Oziewicz, M., 2023: What Is Climate Literacy? *Climate Literacy in Education,* **1** (1), 34-38.
https://doi.org/10.24926/cle.v1i1.5240

Shakun, J., P. Clark, F. He, S.A. Marcott, A.C. Mix, Z. Liu, B. Otto-Bliesner, A. Schmittner, and E. Bard, 2012: Global warming preceded by increasing carbon dioxide concentrations during the last deglaciation. *Nature,* **484**, 49–54.
https://doi.org/10.1038/nature10915

Sill, T. E., J.R. Ayala, J. Rolf, S. Smith, and S. Dye, 2023: How Climate Literacy and Public Opinion Are the Driving Forces Behind Climate-Based Policy: A Student Perspective on COP27. *ACS Omega,* **8** (5), 4430-4435.
https://doi.org/10.1021/acsomega.2c07674

Tierney, J.E., J. Zhu, J. King, S.B. Malevich, G.J. Hakim, and C.J. Poulsen, 2020: Glacial cooling and climate sensitivity revisited. *Nature,* **584**, 569–573.
https://doi.org/10.1038/s41586-020-2617-x

UCAR, 2024: The Greenhouse Effect. University Corporation for Atmospheric Research Center for Science Education [Webpage].
https://scied.ucar.edu/learning-zone/how-climate-works/greenhouse-effect

UNFCCC, n.d.: The Paris Agreement. United Nations Framework Convention on Climate Change [Webpage].
https://unfccc.int/process-and-meetings/the-paris-agreement

USAID, 2022: USAID Climate Strategy 2022–2030. United States Agency for International Development.
https://www.usaid.gov/policy/climate-strategy

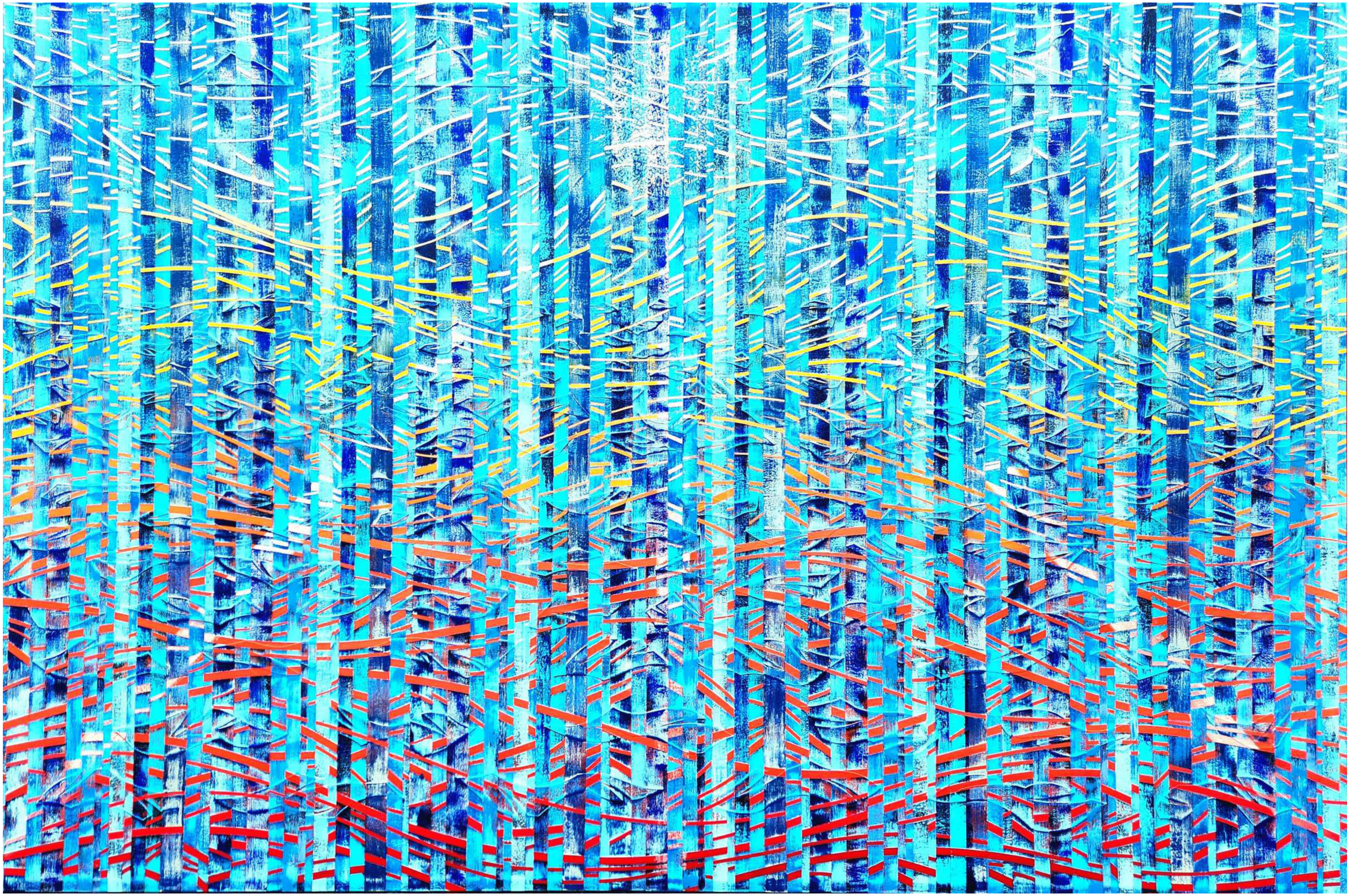
USGCRP, 2009: *Climate Literacy: The Essential Principles of Climate Science, A Guide for Individuals and Communities.* U.S. Global Change Research Program, Washington, DC, USA.
https://www.globalchange.gov/reports/climate-literacy-essential-principles-climate-science-0

USGCRP, 2018: Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu, Eds. U.S. Global Change Research Program, Washington, DC, USA, 878 pp.
https://doi.org/10.7930/SOCCR2.2018

USGCRP, 2023: *Fifth National Climate Assessment.* Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA.
https://doi.org/10.7930/NCA5.2023

USGCRP, 2024: About USGCRP. U.S. Global Change Research Program [Webpage].
https://www.globalchange.gov/about

USGS, 2003: What is a Food Web? U.S. Geological Survey [Webpage].
https://wwwrcamnl.wr.usgs.gov/isoig/projects/fingernails/foodweb/definition.html



Artist's statement: "This piece combines rigid, measured definitions of space with the lush organic movements of nature. The Reflections Series speaks to issues such as ocean awareness, threatened species, and water temperatures. Ultimately, the piece seeks to amplify today's contemporary landscapes in crisis."
CREDIT: Dodd Holsapple, Art x Climate, Reflections Series Blue Current (2022, mixed medium acrylic paint on canvas)

ABOUT THIS GUIDE

Climate Literacy: Essential Principles for Understanding and Addressing Climate Change presents information that is important for individuals and communities to know and understand about Earth's climate, the impacts of climate change, and solutions. Principles in the guide can serve as discussion-starters or launching points for learning about the climate crisis and what's being done to address it across the world. The guide aims to promote greater climate literacy by providing this educational and communication framework of principles and concepts.

To download this guide and related documents, see **globalchange.gov/reports/climate-literacy-guide-third-edition** and **climate.gov/climateliteracy**.

U.S. Global Change Research Program

For future revisions and changes to this document or to see documentation of the process used to develop this guide, please visit **globalchange.gov/our-work/interagency-groups/cec**.

FURTHER INFORMATION

For an up-to-date list of of science and educational organizations and institutions working to increase climate literacy and further information relating to climate literacy and climate resources, please refer to **climate.gov/teaching**.

U.S. Global Change Research Program
1800 G Street NW
Suite 9100
Washington, DC
20006 USA
globalchange.gov