Vision: The ACE Research Program will provide information critical to improve air quality; reduce the impacts of air pollution and climate change on human health and ecosystems; reduce environmental and health inequities; and respond to impacts of climate change, transformations of the energy and transportation infrastructure, and other emerging risks to our environment from atmospheric pollution.

Approach: ACE will address current and future interrelated environmental challenges through a solutions-driven research framework employing integrated, interdisciplinary research areas to identify and characterize problems and develop solutions that address technical, social, and economic dimensions. This approach builds on the fundamental research that has been the foundation of the ACE program, and recognizes the existential risks posed by climate change, the disproportionate burdens faced by low-income and minority communities and tribes and how these challenges intersect with air quality risk management in all its forms, including consideration of criteria air pollutants, air toxics, wildland fires, and the transformation of the Nation's energy and transportation systems. The Program will place an increased emphasis on developing and evaluating science-based solutions that can be used to support decision-making by EPA partners, states, tribes, and local agencies. In addition, ACE will expand the development and evaluation of science-based interventions that can be applied by individuals, communities, and governmental organizations to decrease adverse public health and environmental impacts. By integrating social and natural sciences, ACE will inform science-based solutions that incorporate technological, social, cultural, and economic factors and provide evidence of their effectiveness in real-world settings.
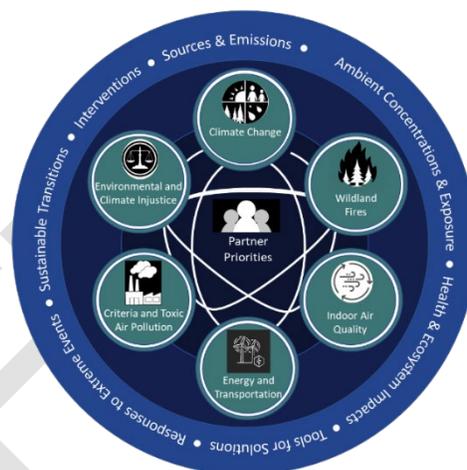

Multiple connections exist across partner priorities addressed by the ACE program.

Identification and evaluation of solutions will rest on a foundation of understanding the impacts of air pollution and climate change on human health and ecosystems. In order to understand the composition of the air pollution mixture, the program will continue to advance research on air quality measurement and modeling with additional work to improve capabilities that consider impacts of a changing climate and an increased focus on finer spatial and temporal resolution needed to inform decision making at the community level. This is linked to research on how humans and ecosystems are exposed to pollutants at multiple scales. Finally, research into the impacts of air pollution and climate on ecosystems will continue with an expanded emphasis on climate adaptation, resilience, and mitigation of greenhouse gas (GHG) emissions. In addition to continued research related to air pollution exposures, health research will increase focus on the effects of climate change on human health impacts and disparities in health and longevity in communities with environmental justice and equity concerns. Research activities and capacity will be expanded to address the Administrator's priorities of climate change and environmental justice, while increasing emphasis on specific challenges that are of emerging importance to the Agency, states, and tribes, such as wildfires, per- and polyfluoroalkyl substances (PFAS), and ethylene oxide (EtO). Long-term, innovative, and multidisciplinary research is needed to make progress on the complex issues of climate change and environmental disparities and to develop the knowledge needed to support a sustainable pathway to solving these challenges.

Organization: The ACE program will be organized around two topics with research areas designed to promote systems-based science activities to address the key priority challenges identified by EPA program and region, state, and tribal partners. These challenges include climate change, environmental and climate injustice, public health and environmental impacts of criteria air pollutants, air toxics (including emerging contaminants, such as PFAS), and wildland fires, indoor air pollution, and transformations of the Nation's energy and transportation systems.

Topic 1: Understanding Air Pollution and Climate Change and Their Impacts on Human Health and Ecosystems.
This topic includes research to better understand and characterize air pollution and climate change and their individual and interrelated impacts on ecosystems and public health. It also includes research to understand inequities in exposures and impacts, which result in disproportionate burdens in communities with environmental justice and equity concerns. The design of the research areas follows the environmental and public health source to impacts paradigm to achieve the topic goal.
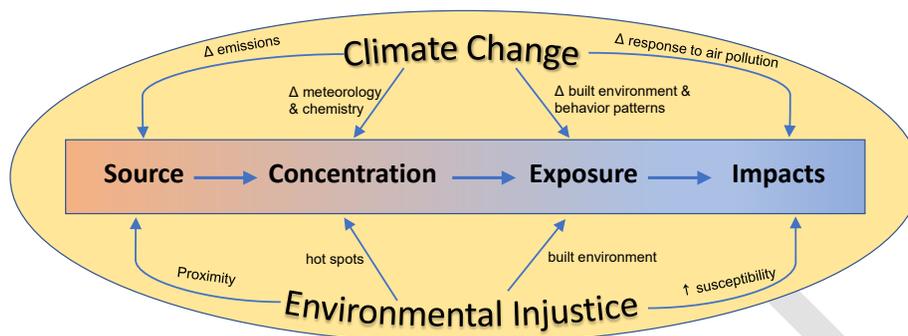
Climate change has direct impacts on human health and ecosystems. Climate change also affects emissions and ambient concentrations of air pollution, and how humans and ecosystems respond to air pollution. Environmental injustice impacts proximity to sources, concentrations in vulnerable communities, exposure pathways, and susceptibility to health and ecological impacts.

- *Research Area 1: Sources and Sinks of Air Pollution and Climate Forcers* (Short title: *Sources and Sinks*)
  - Develop and evaluate measurement methods to characterize sources of emissions of air pollutants and climate forcers including criteria pollutants, air toxics (PFAS, EtO), nitrogen, and climate forcers.
  - Characterize and compare the chemistry and bioactivity of emissions from fugitive, area, point, and mobile sources, including natural and manmade sources such as biomass burning, the oil and gas industry, vehicles, indoor and agricultural activities, as well as other novel and emerging sources.
  - Characterize natural and manmade sinks or deposition rates for air pollutants and climate forcers, such as PFAS, nitrogen species, CO_2, and others.
  - For various sources and conditions, develop well-characterized information on emissions composition for use in development of emissions inventories, health studies, and the broader research community.

- *Research Area 2: Air Quality Concentrations and Exposure Characterization: Measurements*
  (Short title: *Concentration and Exposure: Measurements*)
  - Develop and evaluate measurement methods and approaches to characterize ambient air composition for criteria pollutants and their precursors, air toxics, and climate forcers using sensors, regulatory methods, mobile and remote instruments.
  - Develop and evaluate measurement methods to characterize human and ecosystem exposures to chemical and non-chemical stressors to inform understanding of health and ecosystem impacts.
  - Investigate photochemical processing and atmospheric transformation of pollutant emissions to inform model development and health outcomes research.
  - Improve characterization of individual and population exposures using measurements and information on time-activity patterns, and other social, cultural, and economic determinants that affect exposures.

- *Research Area 3: Air Quality Concentrations and Exposure Characterization: Models* **(Short title: *Concentration and Exposure: Models*)**
  - Conduct air quality modeling activities, such as model development and evaluation across a range of geographic scales including local dispersion scale, fine- or community-scale, and regional to global scale.
  - Enhance the capabilities and application of models to provide air pollution concentrations at finer temporal and spatial scales to address a wide range of toxic air pollutants and better characterize air pollution at the neighborhood level.
  - Investigate and implement model updates and improvements, including methods for data fusion, updates to chemical and physical mechanisms, and representation of changing meteorology.
  - Improve individual and population level exposure estimates through data fusion, modeling of time/activity patterns, and consideration of indoor environments.

- *Research Area 4: Health Impacts of Air Pollution and Climate Change* **(Short title: *Health Impacts*)**
  - Explore air pollution and climate health impacts (e.g., thermal stress) within different lifestages and populations, including overburdened groups—assessing vulnerabilities to air pollution from chronic illnesses and sequelae from respiratory viruses, social determinants of health, and air pollution impacts resulting from different exposure time-activity patterns.
  - Explore linkages between animal and human biomarkers for different adverse outcome pathways and specific human individual and population health outcomes that can be quantified for use in climate and air pollution risk and benefits assessments, including for air toxics.
  - Investigate interactions between acute and chronic air pollution exposures on susceptibility to, and exacerbation of, illness caused by respiratory viruses such as SARS-CoV-2, and environmental influences on vaccine efficacy.
  - Investigate interactions between air pollution and climate change related stressors (e.g., heat, aeroallergens) that affect human health.

- *Research Area 5: Ecosystem Impacts of Air Pollution and Climate Change* **(Short title: *Ecosystem Impacts*)**
  - Assess air pollution impacts on ecosystems, such as critical loads, and vulnerabilities attributable to changes in climate, energy, ecosystems, and infrastructure.
  - Evaluate ecosystem-mediated effects on human health in response to climate change and air pollution including wildland fire.
  - Investigate impacts on ecosystem resilience and capacity to sequester and store carbon from changes in air pollution, critical loads, temperature and precipitation patterns, wildland fires, and other consequences of climate and global change.

Topic 2: Responding to Risks and Impacts and Preparing for the Future. While work throughout the ACE program includes consideration of the changing climate, changing energy infrastructure, and disproportionately impacted communities, this topic focuses on research needed to take action to address these concerns now and into the future. *The research areas in this topic cut across those that are addressed in the first topic area.*

- *Research Area 6: Scientific Support for Climate Change and Air Quality Policy Solutions* **(Short title: *Solutions*)**
  - Quantify public health and ecosystem service benefits (and co-benefits) to inform air quality management and climate change response actions, as well as mitigation and adaptation strategies at multiple government levels.
  - Develop and expand research activities to assess health and ecosystem impacts arising from changes in air quality and changes in the climate.
  - Develop data, models, scientific knowledge, and tools to inform climate policies, regulations, and decisions from local to state, federal, and international organizations.
  - Develop and evaluate strategies to reduce ecosystem impacts of a changing climate with consideration of ecosystem management strategies to preserve and increase carbon storage.

- *Research Area 7: Empowering Communities and Individuals to Improve Public and Ecosystem Health* **(Short title: *Empowering Communities*)**
  - Develop and evaluate the effectiveness of strategies that individuals and communities can use to reduce exposure and public health impacts of air pollution including technologies, risk communication and management, community preparedness, and infrastructure, with particular consideration of overburdened communities.
  - Evaluate health effects of individual and community level health protective interventions such as facemasks or portable air cleaners.
  - Develop and evaluate strategies to reduce ecosystem impacts of air pollution, including land management, modification of ecosystems, and other best practices.
  - Engage stakeholders in developing science-based solutions to specific problems at the individual and community level with a focus on improving communication, accessibility, and usability of data and information for individuals with less technical expertise.

- *Research Area 8: Responding to Risks of Fires, Floods, and Other Extreme Events* **(Short title: *Fires, Floods, and Extreme Events*)**
  - Improve ability to evaluate the resilience of communities, especially overburdened communities, to extreme events such as wildland fires, floods, and drought.
  - Develop and assess interventions to reduce adverse ecosystem, water quality, and health risks from wildland fires and acute and chronic exposure to smoke.
  - Develop evidence-based approaches that can increase resilience by enabling communities to recover from extreme events more quickly.
  - Address exposures to contaminants following climate-related events, such as mold resulting from flooding.
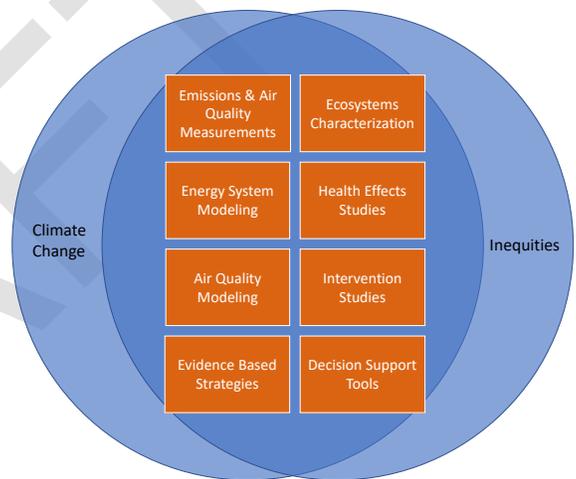
Research studies within the ACE program occur within the context of climate change and environmental inequities.

- *Research Area 9: Transitions to a Sustainable Future* **(Short title: *Sustainable Transitions*)**
  - Identify and evaluate transitions to sustainability in sectors such as energy, transportation, and buildings due to the transformational impacts and responses that will result from climate change.
  - Investigate and develop information on broad community, societal, and sectoral transformations that result from the changing climate and climate mitigation options.
  - Improve understanding of the health and environmental consequences of future energy and climate scenarios, including multi-pollutant, multi-sectoral approaches for mitigation options and responses.