U.S. DEPARTMENT OF ENERGY | Office of Science

Climate Resilience Centers Awards

Summary of projects awarded in 2023 under Funding Opportunity Announcement DE-FOA-0002915

Biological and Environmental Research Program ***science.osti.gov/ber***

Projects

- The Climate Resilience Center in Piedmont Triad of North Carolina
- California Community and Earth-System Integrated Climate Resilience Center
- Southwest Climate Resilience Center
- Center for Climate Adaptation and Resilience in Baltimore
- San Joaquin Valley Climate Resilience Center: Informing Equitable Climate Outcomes Through Collaborative and Interdisciplinary Science
- Center for Climate-Driven Hazard Adaptation, Resilience, and Mitigation in Great Lakes Rural Communities

Understanding fine-scale, local, and community impacts of climate change across America is a critical gap in climate research and analysis today. Climate change disproportionately impacts people in disadvantaged communities due to increased exposure and vulnerability.

Climate resilience is a community or region's ability to reach full recovery after being exposed to climate-induced stresses and damages using strategies that adjust its adaptive capacity at minimal impact to natural, socioeconomic, infrastructure, and financial systems. A key component of climate resilience involves using high-fidelity models to predict climate change–induced stresses and damages to systems.

The U.S. Department of Energy's (DOE) Office of Science's Biological and Environmental Research (BER) program selected six projects in fiscal year 2023 to increase the use and utility of DOE research to improve climate resilience, particularly in vulnerable communities.

Climate Resilience Centers (CRCs) will empower local universities to use DOE climate science to help tackle problems posed by a changing climate. CRCs will build and enable future scientists, engineers, and technicians to use DOE climate science and capabilities at national laboratories, scientific user facilities, and universities and translate research results into practice among community stakeholders for improved local climate resilience.

CRCs will extend DOE climate science, capabilities, and research by supporting Historically Black Colleges and Universities, non-R1 Minority-Serving Institutions, and Emerging Research Institutions to address regional resilience needs and impacts on natural, socioeconomic, and built systems and their intersections.

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The Climate Resilience Center in Piedmont Triad of North Carolina

Principal Investigator: Solomon Bililign
North Carolina A&T State University

Temperatures in North Carolina have been increasing during the last two to three decades and are projected to follow the upward trend well into the middle and end of this century. North Carolina urban areas have expanded substantially at the expense of suburban and rural landscapes. Natural emissions from forests, emissions from fossil-fuel use and wildfires, and chemical processes that lead to aerosol formation will likely impact the region's air quality and climate. Accurately predicting urban-atmospheric composition in a changing climate requires understanding the environmental drivers and climatic impact of these emissions. The burden of air pollution and climate change impacts in the United States is not evenly shared, with underrepresented community members and socioeconomically disadvantaged people impacted the most.

The North Carolina Piedmont Triad CRC will investigate links between the effects of changing climate on air quality and urban heat and the subsequent undue burden on marginalized communities in major cities across Piedmont North Carolina (e.g., Greensboro, Winston-Salem, and Charlotte).

In collaboration with Pacific Northwest National Laboratory scientists, experimental and modeling studies will investigate the chemistry leading to formation of secondary organic aerosols and their impact on health and climate in the region.

Community engagement projects will assess impacts on vulnerable neighborhoods by defining metrics for impacts and resilience and integrating scientific and resident understanding. This research will address environmental-equity concerns focused on climate resilience and the compounding effects of climate changes such as urban air quality and heat by working closely with the Greensboro Community Sustainability Council.

The CRC will develop tools to inform city-planning decisions based on citizen science and crowdsourcing projects that rely on community participants and professionals working together. The project will address the challenge of building and sustaining trust between scientific professionals, policymakers, and the community, which will create opportunities for resident participation. The project will work closely with City of Greensboro planners to address climate resiliency by conducting community outreach and focus-group meetings with community members.

Education and training will focus on the next generation of climate scientists to increase diversity, equity, and inclusion of minorities in modeling, instrument selection and deployment, and data analysis. The CRC will develop culturally and socially relevant activities that promote student engagement, agency, and social responsibility.

CRC's goal is to educate, train, and sustain a world-class diverse workforce with climate-science skills and capacity in several areas relevant to the center's mission and success. Training for all groups includes:

- Interdisciplinary research skills involving atmospheric sciences, climate science, social and behavioral science, and the ability to translate research results to a level suitable for nonspecialists; and
- Communication and technical writing skills to disseminate research results to various audiences in public education, community outreach, conferences, and other academic settings.

This will ensure that the knowledge created by the CRC will impact diverse disciplines and communities.

California Community and Earth-System Integrated Climate Resilience Center

Principal Investigator: Minghui Diao
San José State University

California is home to 39 million people and is one of the most ethnically diverse states in the nation. California faces a multitude of threats from climate change (e.g., catastrophic wildfires, droughts, heat waves, storms, and flooding). An urgency exists to build a DOE CRC to examine, predict, and remediate climate-change impacts on all communities in the region.

The California Community and Earth-System Integrated (CalCEI) CRC is led by San José State University (SJSU), the largest minority-serving institution in the San Francisco Bay Area and the oldest public institution of higher education in the western states, partnering with Lawrence

Livermore National Laboratory, University of California–San Diego, and multiple stakeholders and community leaders. CRC's overarching goal is to examine and predict interactions between climate change and multiethnic communities.

This project will quantify how the disparity of various climate impacts will be exacerbated by a changing climate and will build metrics to quantify effectiveness and equity of potential solutions. This will be achieved through integrating field observations with an Earth system model and other applied science models such as epidemiological models. The CRC will build an integrated modeling framework to support decision-makers with adaptation and resilience planning.

The project is driven by three key scientific questions that aim to advance basic science to improve understanding, forecasting, and mitigation of climate change in California:

1. What are the added values of understanding spatial heterogeneity of physical processes and key meteorological conditions (e.g., temperature, humidity, aerosols, gases, and precipitation) at high resolution (3 km) for estimating climate impacts on communities in California?
2. What are the compounding effects of wildfire-smoke emissions and extreme heat on public health in the Bay Area in the past five years as studied through selective case studies?
3. How can the CRC build a modeling framework to translate resilience plans into quantifiable metrics such as public-health impacts? What are the health benefits of possible mitigation and adaptation plans (e.g., air conditioning and green spaces) in various communities in the next 50 years?

With increasing capabilities and spatial resolution of Earth system–modeling tools, it is critical to develop new capabilities to connect emerging high-resolution climate simulations with community-level activities for building climate resilience, particularly for high-risk populations. These capabilities will use climate simulations to support community-scale adaptation plans and decision-making activities.

In research led by co-investigator Tang, CalCEI will leverage new advancements in the DOE Energy Exascale Earth System Model (E3SM) regionally refined model (RRM) and atmospheric chemistry. The new RRM configuration, which became available in December 2022, allows high-resolution simulations at the storm-resolving scale (~3 km) over the entire state of California (~100 km elsewhere in the globe). It can perform multidecadal simulations with interactive atmospheric chemistry and aerosols at relatively low computational cost (roughly one simulation month per wall-clock day).

An integrated modeling framework will be built by linking E3SM model output with state-of-the-art epidemiological models (i.e., within community-matched design coupled with Bayesian hierarchical models) led by co-investigators Benmarhnia and Basu. The integrated modeling framework will showcase the capabilities of using high-resolution climate models to support communities. The CRC will then develop metrics to quantify the benefits of hypothetical mitigation and adaptation strategies and assess the potential inequalities for various communities.

This work will focus on three main tasks:

1. Developing a new modeling framework that fills critical gaps between Earth-system models and other applied-science models to quantify climate resilience,
2. Leveraging unique observational capabilities at the SJSU Wildfire Interdisciplinary Research Center to improve E3SM RRM simulations of wildfire smoke and support development of the next-generation E3SM, and
3. Quantifying compounding effects of various extreme events (e.g., wildfire smoke plus heat) and examining the effectiveness and equity of strategies from 2000 to 2070.

The CRC will ensure two-way engagement with stakeholders and community leaders through every step of project design and developmental process. CalCEI missions are reflected in its name. CalCEI will leverage the integration of multiscale modeling tools and observations to quantify effective and equitable solutions that will support all stakeholders and communities to build resilience towards a changing climate.

Southwest Climate Resilience Center

Principal Investigator: Peter Fulé
Northern Arizona University

The Southwestern Mountains Climate Resilience Center (SMCRC) will focus on fundamental and applied research needs of regional populations in highlands of the southwestern United States through a targeted set of research and outreach activities. These activities will leverage and build upon existing capabilities and partnerships

while also developing new collaborative partnerships with DOE BER scientists.

This region includes the highest density of Native American populations and tribal lands in the United States as well as extensive rural populations with a high proportion of Hispanic residents. Northern Arizona University (NAU), the lead institution, is an R2 Hispanic-serving institution with high Indigenous student enrollment. SMCRC's objectives are to:

1. Integrate research tools in dynamics of forests, disturbances, climate, carbon, and hydrology that provide informative practical examples for climate-resilient management of public and tribal lands;
2. Develop an outreach program for science translation reaching K-12 and adult populations through online materials and a network of Native-serving teachers;
3. Foster training and science translation of multidisciplinary climate scientists through work with a community college, tribal college, the national-scale Institute for Tribal Environmental Professionals, and the Southwest Fire Science Consortium; and
4. Partner with DOE scientists to develop and communicate relevant science in two-way interactions with southwestern communities.

The research approach of Objective 1 focuses on bringing together the diverse modeling approaches and results associated with future projections of forest attributes in southwestern mountains to provide detailed, practical information to resource managers and model developers. The research design involves literature review, interaction with managers and researchers, quantitative comparison of outputs from multiple models, and new measurements of key variables common among these models. These approaches are directly relevant to ongoing and planned work by national laboratory scientists examining decadal trends in remotely sensed proxies for forest health.

Under Objectives 2 and 3, the SMCRC team will develop and present materials related to climate change in a culturally responsive framework, drawing upon existing educational networks for K-12 Native-service educators and tribal and Hispanic-serving colleges (e.g., Diné College, Coconino Community College). SMCRC will also develop appropriate technical materials for professional audiences including tribal and other natural resource managers across multiple disciplines such as forestry, wildlife, hydrology, and fire in partnership with organizations such as the Southwest Fire Science Consortium and Institute for Tribal Environmental Professionals.

Under Objective 4, Lawrence Berkeley National Laboratory scientists will work with the NAU team and stakeholder groups to promote transferability of novel methodological approaches to advance resiliency research and planning in the SMCRC. These partnership activities are explicitly designed to integrate, communicate, share, and learn. The CRC is a unique opportunity to integrate research with real-world concerns of managers and communities. This provides a conduit of communication between DOE research and the communities it ultimately wishes to serve, fulfills the university's role of learning and sharing, and provides benefits to tribes and other stakeholders.

Center for Climate Adaptation and Resilience in Baltimore

Principal Investigator: Xiaowen Li
Morgan State University

Baltimore is facing climate challenges common to many coastal cities: extreme heat stress during the summer, poor air quality, flooding, drought, coastal storm surge, and erosion. Unique to Baltimore are its highly heterogeneous neighborhoods with contrasting racial demographics, incomes, housing types, and amounts of green space. Climate challenges mean widely different things for different communities.

Morgan State University (MSU), a Historically Black College and University and Maryland's preeminent public urban research university located inside the city, is uniquely positioned to address climate adaptation and resilience issues in Baltimore.

The Center for Climate Adaptation and Resilience in Baltimore (CCARB) will serve as the nexus of MSU's multidisciplinary climate research and collaborate closely with the DOE-supported urban integrated field laboratory in Baltimore (Baltimore Social-Environmental Collaborative) and Pacific Northwest National Laboratory's climate modeling community.

CCARB's goal is to build MSU's climate-research capacity, laying a solid foundation for a multidisciplinary, community-rooted climate research and adaptation center capable of serving as the host of cutting-edge scientific knowledge and extensive community ties gained through collaborations with DOE-supported projects. New urban

climate modeling activities and a climate science certificate program will be established as results of the project.

San Joaquin Valley Climate Resilience Center: Informing Equitable Climate Outcomes Through Collaborative and Interdisciplinary Science

Principal Investigator: Samuel Markolf
University of California–Merced

The San Joaquin Valley CRC has two goals:

1. Gain a deeper understanding of how environmental and climate hazards, such as air pollution and extreme heat, vary spatially and temporally across urban environments; and
2. Contextualize the effectiveness and unintended consequences of adaptation strategies for reducing the impacts of air pollution and extreme heat.

Emphasis will be placed on identifying specific urban environmental conditions and adaptation strategies that disproportionately affect certain locations or groups.

Each of these goals corresponds to a research focus area (RFA). RFA1 will investigate urban-scale variability of heat and air quality under different conditions and scenarios. Additionally, RFA1 will investigate the influence of interactions between climate, urban ecosystems, and air pollutants on localized air quality and extreme heat conditions. Performance of RFA1 entails a variety of methods including climate models and projections, Earth-systems models, statistical analysis, air sampling and modeling, and integration of satellite observations (e.g., dust properties) with ground-based measurements (e.g., surface temperature and humidity).

RFA2 will identify, analyze, and compare solutions for addressing climate and environmental risks at various temporal and geographic scales under different scenarios. These objectives will be achieved through a combination of approaches including integration of different environmental (e.g., California Heat Assessment Tool) and sociodemographic datasets (e.g., U.S. Census data, U.S. Environmental Protection Agency's environmental justice screening and mapping tool), scientific summarization and translation, data and geospatial analysis (e.g., hazard and risk maps), decision analysis, and collaborative engagement with local stakeholders (e.g., surveys, workshops, scenario visioning activities).

The project's anticipated outcomes include:

- Estimates of environmental and climate hazards at geographic and temporal scales pertinent to communities in the San Joaquin Valley;
- Improved understanding of interactions between soil and the atmosphere and their effect on air quality and local temperatures;
- Scientific support for ecological and nature-based climate solutions; and
- Decision-support framework for equitably assessing and addressing climate-induced impacts.

Ultimately, this project will advance fundamental knowledge of urban environmental systems in the context of climate change, embed community perspectives in scientific processes and outcomes, inform actionable and novel climate solutions, and catalyze development of a network of local expertise for addressing environmental, climate, and equity challenges.

Center for Climate-Driven Hazard Adaptation, Resilience, and Mitigation in Great Lakes Rural Communities

Principal Investigator: Pengfei Xue
Michigan Technological University

Climate change and climate-induced hazards are among the greatest threats facing the world today, and rural communities are especially vulnerable to the impacts of changing climate and economic systems.

The Great Lakes region encompasses vast rural communities, including Indigenous communities and post-industrial communities, which rely on natural resources and have limited adaptation capacity. Accordingly, the Center for Climate-Driven Hazard Adaptation, Resilience, and Mitigation (C-CHARM) in Great Lakes Rural Communities works with community partners to understand rural vulnerabilities and enhance rural resilience to natural hazards and electrical power disruptions in the face of climate change and energy-system transitions.

The pilot study region is the western upper peninsula of Michigan, an area facing numerous climate-related hazards and community-resilience challenges due to its remote location, varied terrain, long winters, and unique environmental features. The area includes rural, small urban, and tribal communities whose economies have

experienced decline due to the historical importance of industries such as shipping, mining, and logging.

To ensure research benefits these communities, C-CHARM brings together experts in climate science, engineering, data science, and social sciences while forging partnerships with local and regional governments, nonprofit organizations, and other community stakeholders. Team efforts are organized into four focus areas and integrated into the open-access toolkit for application and community engagement. The focus areas include:

1. Local-scale climate simulations for historical and future periods using an atmosphere-land-lake model developed by the C-CHARM team;
2. Severe weather, flood, and landslide risk assessment and visualization in an open-access toolkit;
3. Expansion of the toolkit to include current and future energy-infrastructure scenarios; and
4. Evaluation of the economic impacts of energy system transitions and geohazard risk mitigation.

A community engagement plan encompasses all research activities to ensure coproduction and application of project results in community decision-making. Through fostering mutual trust, collaboration, and knowledge sharing, the C-CHARM team will enhance climate resilience, equity, and sustainability in rural communities. Specifically, C-CHARM will expand climate research supported by DOE at universities and national laboratories and translate this research to address challenges in the Great Lakes region. In doing so, the project will build capacity at local scales by connecting with affected communities and empowering local talent and expertise to address resilience challenges and inform equitable solutions. Information will be incorporated into hazard-mitigation planning, tailored for climate-education programs, and used as training resources to help local communities assess their climate risks and implement adaptation measures.

Finally, this project will inform climate resilience for rural America beyond the immediate study region and identify future research priorities. Project findings will be disseminated through open-access publications; presentations at local, regional, and national conferences; and targeted outreach to community members, policymakers, and the media.