

# CISA

CAROLINAS INTEGRATED  
SCIENCES AND ASSESSMENTS

2020-2021 ANNUAL REPORT  
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Photo Source: John Platt

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# Meet Our Team

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**Adam Stein**, NOAA Office for Coastal Management  
**Susannah Tuttle**, NC Interfaith Power & Light  
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Left to Right: CISA Team Members - Jory Fleming, Peng Gao, Amanda Farris, Ellie Davis Pierel, Kirstin Dow, Karen Beidel, Greg Carbone, Donovan Zimmerman (Paperhand Puppet Intervention), Kirsten Lackstrom, Jordan Clark Not Pictured: Elijah Charette, Chip Konrad, Stafford Mullin, Sarah Watson Photo Source: Kirstin Dow.

# The CISA Program

Established in 2003, the [Carolinas Integrated Sciences & Assessments](#) (CISA) is 1 of 11 [NOAA Regional Integrated Sciences & Assessments](#) (RISA) teams. RISAs are interdisciplinary research teams that work to expand and build the nation's capacity to prepare for and adapt to climate impacts by addressing science questions facing decision makers.

Working at the intersection of climate with water, coasts, and health, the CISA team creates, tailors, and integrates climate information to advance equitable planning and management approaches to support healthy and resilient communities and environments for all in the Carolinas. Our portfolio of projects and engagement activities reflects key information needs of the stakeholders we serve in the region. We continue to expand on long-term partnerships with federal, state, and local government agencies, resource managers, non-governmental organizations, and the private sector, engaging more diverse communities and the professionals on which they rely. As a trusted source of climate information in the Carolinas for over 18 years, we support state and local climate adaptation through direct stakeholder engagements as well as reaching broader audiences by sharing regionally-relevant, actionable climate science, information, and news with a network of over 3,000 individuals.

## Adapting Our Approach During the Pandemic

Over the past year, COVID-19 created substantial interruptions to our collaborative work, stakeholder engagements, on-line tool development, and staffing. Travel bans across our universities as well as the agencies and organizations with whom we work limited our ability to host in-person meetings. We introduced new web-based tools and offered training on effective methods for on-line engagement. While that worked well for some situations and will be continued, it was an imperfect substitute in many cases, and no help in others. Testing and validation of the Wet Bulb Globe Temperature (WBGT) forecast tool was not possible because high school athletics, the primary audience for the tool, were canceled during the 2020 heat season. Plans to expand the Hazard Extremes for Risk Assessment (HERA) tool to the Southeast were delayed because public health officials, the target audience for this resource, were solely focused on the pandemic. Meeting members of rural, underserved communities in Beaufort County and elsewhere was blocked by both the travel ban and the lack of broadband service in many rural areas. Efforts to transfer IT support for tools from the State Climate Office of North Carolina (SCONC) to our partner, the Southeast Regional Climate Center, were delayed as UNC

Chapel Hill IT staff were overwhelmed with meeting IT needs to support virtual teaching and other COVID-related disruptions. University hiring freezes also prevented any efforts to replace our Climate and Health Integration and Outreach Specialist. Despite these disruptions and delays, we continued to make substantial progress to advance adaptive capacity in the region. We learned new engagement strategies by thinking creatively and utilizing a variety of virtual platforms and shared these with our network of project partners during monthly team calls. Planned engagements with the Town of Edisto Beach, SC, were converted to virtual meetings as we began to explore flooding impacts due to sea level rise and heavy rainfall events on the island. Similarly, meetings of the Beaufort County Sea Level Rise Task Force were held virtually while the team worked to draft the Beaufort County Long-Term Resilience Plan. The Carolinas Climate Resilience Conference, originally scheduled for October 2020, was converted to a hybrid event, and successfully hosted May 10-12, 2021, with over 300 virtual and in-person participants. More information about the hybrid format can be found in the Case Studies section on [page 20](#). Other projects and partnerships outlined in the annual report also demonstrate an expansion of the CISA network and our footprint in the region.



Photo Source: Sarah Watson

# Highlighted Accomplishment

## Supporting Coastal Climate Adaptation at the Community Level

In partnership with the S.C. Sea Grant Consortium, CISA funds a Coastal Climate Extension Specialist who unites the expertise of CISA research on climate science with the outreach expertise of the NOAA Sea Grant program. Sarah Watson currently holds this position and works with coastal communities in the South Carolina Lowcountry to improve understanding of the risks they face due to coastal climate hazards, including sea level rise, and assist stakeholders and decision makers to develop equitable adaptation strategies. Until recently, few communities have wanted to be seen as leaders in climate change adaptation or take on the added work of piloting innovative approaches. Below are two examples of models for community adaptation made possible by the CISA and S.C. Sea Grant Consortium collaboration.

**Our long-term investment and relationship building has supported these communities in piloting efforts that are now models for other coastal communities that are becoming more interested in addressing climate change and resilience. Our community partners have developed local plans and ordinances to address risks and are contributing to an expanding network of local leaders working together to integrate climate resilience into planning and resource management.**

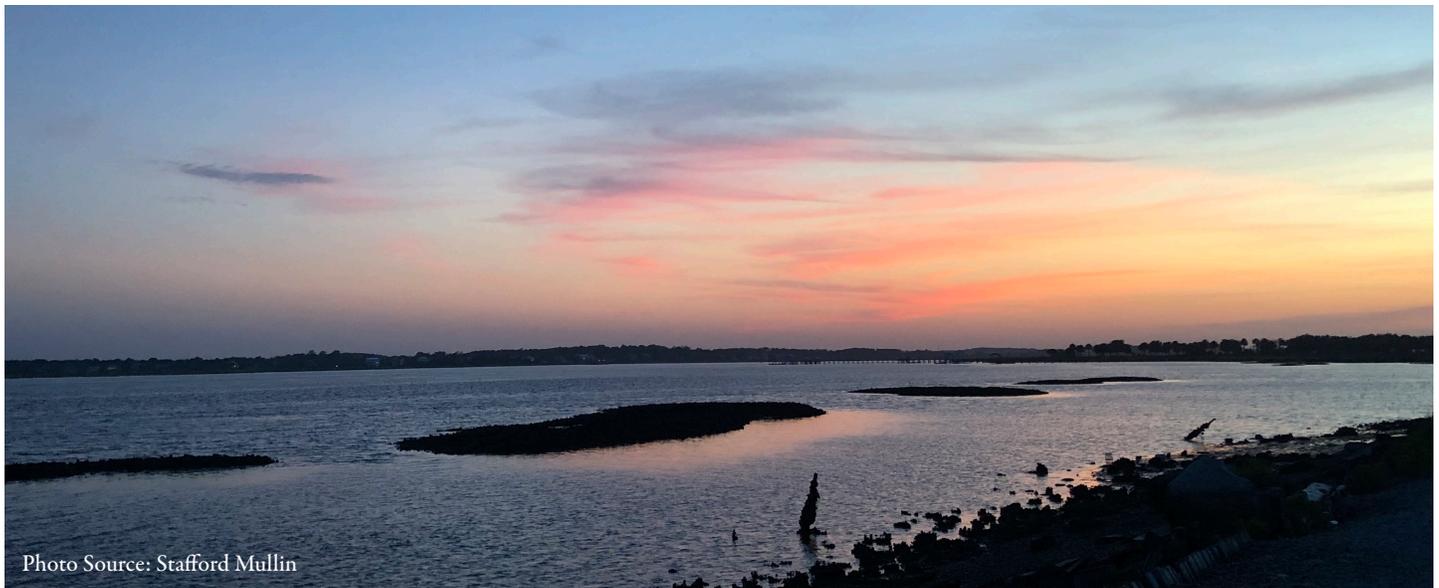


Photo Source: Stafford Mullin

## Sea Level Rise Adaptation Planning in Beaufort County, SC

We have worked with Beaufort County, SC, since 2012 when we first conducted a [Vulnerability, Consequences, and Adaptation Planning Scenarios](#) (VCAPS) exercise with community leaders and used the information to develop the first [Beaufort County Sea Level Rise Action Plan](#). The 23 recommendations in the plan were integrated into the County's 2015 comprehensive plan update and the Stormwater Department implemented requirements that stormwater pond outfalls account for sea level rise in their design. Consecutive years of land-falling hurricanes and tropical storms between 2016 and 2018 left little time for staff to continue the work, but a growing recognition of the urgency to do so.

In 2019 the County's Community Development Deputy Director, Rob Merchant, requested assistance in exploring a no-fill ordinance and a sea level rise overlay ordinance. As discussions progressed with community leaders, the County decided to establish a county-wide sea level rise task force to inform the 2021 comprehensive plan update and revise the 2015 sea level rise action plan. The task force includes members from all municipalities within the County representing a variety of departments and stakeholder interests.

Over the last year, Watson and Merchant have worked with the task force to draft a **Beaufort County Long-Term Resilience Plan**, with a focus on identifying recommendations with feasible steps for implementation. The County's comprehensive planning consultant, Design Workshop, folded in multiple recommendations from the Resilience Plan into the draft Comprehensive Plan as core components of county goals and policies. The Comprehensive Plan went out for public comment in April 2021 and has received substantial feedback from County residents and stakeholders. The Resilience Plan is expected to be completed by the end of summer 2021. Additional plans for public engagement and improved understanding of groundwater dynamics, recommendations included in the Resilience Plan, are the foundation for a recently funded NOAA Adaptation Science grant. Members of the Gullah/Geechee and other underserved communities are a primary target audience for these engagements as they are among the most heavily impacted by groundwater rise and flooding. Additionally, through connections with the College of Charleston, the County received funds from the American Shore and Beach Preservation Association to install three low-cost tide sensors to better characterize current tidal conditions.

**This work exemplifies the importance of long-term relationship and trust building in communities where RISAs work to transform multi-layered planning goals into implementable adaptation strategies. Discussions with community leaders have evolved over the years as have perspectives within the communities. With continued engagement on the topic, the hazards these communities face are now addressed in a deeper, more meaningful way, and the policy goals have become more substantive with concrete implementation strategies. These efforts are shared as models for other communities in the Carolinas.**

## Investigating Climate Vulnerabilities in Edisto Beach, SC

The Town of Edisto Beach is located on a small barrier island that is highly vulnerable to storm surge, flooding due to heavy rainfall, and sea level rise. The Town contacted Watson in early 2020 to request assistance in exploring their vulnerabilities to flooding after learning about our work in Beaufort County. During initial engagements with Town officials, results of flood modeling completed by the College of Charleston were shared to better understand the Town's challenges and information needs.

On August 11, 2020, the CISA team facilitated the first VCAPS exercise virtually. The session helped Town officials and elected leaders better understand the impacts of flooding they already experience. They discussed challenges related to a rising groundwater table resulting in long-lasting street flooding, failed septic systems due to heavy rain events, and corroding underground infrastructure and service vehicles. The session highlighted how community infrastructure systems are beginning to fail because of sea level rise and frequent heavy rainfall. They are the first community to come forward with this combination of emerging issues.



Flooding on Edisto Island, SC  
Flooding Photo Source: SC National Guard, Flickr Creative Commons

The second virtual VCAPS exercise was held December 11, 2020, to further explore impacts to the Town's road infrastructure and clarify previous findings. Town officials also discussed goals moving forward, including developing impact-based timelines, or in academic jargon, dynamic adaptive pathways, and translating what these impacts mean for residents and maintenance of municipal infrastructure. We look forward to working with them to introduce and tailor this planning approach with an eye to learning transferable lessons about timelines and thresholds for coastal resilience efforts. A first draft of an **Edisto Beach Vulnerability and Resilience report** was sent to the Town for review. Public engagements will be held in summer 2021 to discuss the draft report and residents' experiences with flooding. The final report will be submitted to Town Council in fall 2021 for adoption.

# Expanding Our Reach

## Expanding Support for Heat Health in the Carolinas

We are expanding our network of partners beyond our initial target audience (i.e., high school athletics), to develop, test, and use the [Wet Bulb Globe Temperature \(WBGT\) forecasting tool](#) and other heat health risk reduction strategies. The newly formed Carolinas Heat Health Coalition currently includes 30 members representing a wide variety of agencies and organizations ranging from the North Carolina Department of Labor to organizations serving public housing and disabled farmworkers. This group will help to inform and enable the expansion of the WBGT forecasting tool to heat-vulnerable groups, such as outdoor workers, the military, and underserved communities. We will conduct new field testing and forecast validation of the tool in the Charleston, SC region in summer 2021 in collaboration with the Charleston Medical District and City of Charleston. More information about these efforts can be found in the Case Studies section on [page 19](#).

## Supporting Resilient Congregations with the Southeast Faith Leaders Network

The [Southeast Faith Leaders Network](#) (SFLN) is a working group under the Southeast Climate & Energy Network, a collection of NGOs and environmental justice organizations. The group's activities focus on climate advocacy and environmental justice and how faith communities can move towards climate resilience in their congregations and communities. The group has a large contingent of faith leaders from underserved communities. Its mission is to provide a support network for problem solving, sharing information, and informal education. In 2021, CISA's Climate Solutions Specialist, Jory Fleming, served as co-chair of the group, supporting monthly meetings, and developing informational resources including an emergency response guide for churches. Over the next year we will investigate opportunities to support the group's Resilient Congregations initiatives.

## Informing Hazard Vulnerability Assessments for Public Health Organizations

The [Hazardous Extremes for Risk Assessments](#) (HERA) tool was developed to assist public health organizations, such as hospices and public health coalitions, develop their annual hazard vulnerability assessments and emergency preparedness plans. HERA provides historical climate data and information to help users understand their risks and the types of hazards for which they should plan at the county level. In 2020, we received funding from the NOAA Climate Program Office to expand the tool from the Carolinas to the broader Southeast. Over the next year, we will launch the expanded version of the tool and conduct engagements in six additional states (AL, FL, GA, KY, MS, and TN).

## Communicating Climate to Financial Institutions

In early 2021, we made an initial connection with the [Federal Reserve Bank of Richmond](#), which has a growing interest and awareness of climate change impacts on economic growth and financial stability in the bank's geography. Our conversation identified potential ways to collaborate to advance the Reserve's goals to integrate climate information into their long-term plans and communicate regional climate impacts to the financial institutions who are their stakeholders. We will continue to pursue this collaboration as it raises understanding of the economic dimensions of climate impacts for the multiple actors in the Carolinas that work with or rely on the Reserve.

## Collaboration with the American Planning Association

The *South Carolina Revolving Fund Act 2020* created a new requirement that communities include resilience planning in their local government comprehensive plans. Following our participation in the 2019 South Carolina American Planning Association (APA) annual conference, their executive leadership requested our support in training members on how to successfully accomplish this new goal, which will also contribute to new climate continuing education requirements for certified planners (AICP). We plan to leverage our collaborative work with the Great Lakes and Mid-Atlantic RISAs on the development of a new hazard mitigation planning support tool to integrate climate information into this type of long-term planning. As the comprehensive plans establish the vision for more specialized local plans, we see integrating climate into comprehensive plans as a first step towards climate resilient community planning.

# Research to Advance Understanding of Climate and Its Impacts

## Enhanced Understanding of Wet Bulb Globe Temperature

As the number of dangerously hot days continues to increase in the Southeast, so too does our need for improved measures of heat stress on individuals exposed to these events to develop adaptive risk reduction measures. CISA team members at the Southeast Regional Climate Center (SERCC) have developed, tested, and refined a method for estimating Wet Bulb Globe Temperature (WBGT) from measurements of air temperature, humidity, solar radiation, and wind speed. By accounting for all these variables, WBGT provides the best estimate of human heat stress, especially in local environments where radiation and air ventilation are exceptionally high or low. Using this method, we have constructed a [WBGT forecast tool](#), which translates gridded National Weather Service (NWS) temperature, humidity, wind, and cloud cover forecasts into an hourly WBGT forecast for the next 5 days. Testing and validation of the tool reveals that WBGT is particularly sensitive to wind speed, especially on hot sunny days. Consequently, wind speed variations across the landscape can significantly affect WBGT. For example, sheltered, sunlit areas with many buildings or trees can be especially dangerous when wind speeds are low.

The NWS recently added an experimental WBGT forecast to their gridded National Digital Forecast Database (NDFD) using a different method for estimating WBGT. In a white paper published in 2020<sup>1</sup> CISA team members Chip Konrad and Jordan Clark compared the two methods against measurements from a WBGT thermometer at two locations in North Carolina and estimated WBGT at ASOS/AWOS stations across the United States. Results reveal that the NWS WBGT forecast is, on average, 4-5°F cooler than the SERCC/CISA WBGT forecast. Further testing and validation of the SERCC/CISA method and forecast tool will be conducted in summer 2021 in Charleston, SC in collaboration with the Charleston Medical District.



Photo Source: Stafford Mullin



<sup>1</sup> Clark, J. and C.E. Konrad. 2020. [Accuracy Assessment of Experimental Wet Bulb Globe Temperature Forecasts Across North Carolina and the Continental United States](#). Chapel Hill, NC. 11 pp.

## Analysis of Heavy Precipitation Trends in the Carolinas

This research project investigates the intensity, duration, and frequency (IDF) of heavy precipitation events from 1910 to 2019 for 40 US Historical Climate Network stations in the Carolinas. We employed a variety of statistical tests to determine trends in expected heavy precipitation. We are particularly interested in assessing how differences in the length of historical record used (e.g., 50, 55, or 60 years) or different periods from the historical record (e.g., 1900 – 1950 vs. 1910 – 1960) influence recurrence intervals of annual maximum 24-hour rainfall events. This helped us to determine how heavy precipitation events over the past five years might have influenced the recurrence intervals.

Results reveal that eight stations in the Carolinas show an increasing trend in annual maximum 24-hour rainfall (see Figure 1). Four stations show an increasing trend in 100-year rainfall events, eight stations show an increasing trend in 10-year events, and nine stations show an increasing trend in 2-year events. Extraordinary events in the past five years, such as Hurricane Florence, have contributed to these increasing trends, although, the length of record and specific time period heavily influences the results.

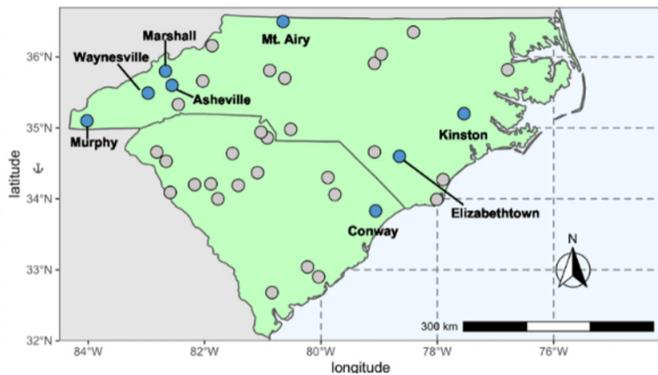


Figure 1: The blue dots represent the US Historical Climate Network stations with an increasing trend in annual maximum 24-hour rainfall (1910-2019). Gray dots represent analyzed stations with no change.

**Our continued work in this research area seeks to improve understanding of precipitation trends for the Carolinas and how best to tailor the information for diverse decisions and community planning. Our findings will support a growing number of decision makers who need information to understand how extreme precipitation may alter ecosystems, lead to flooding events, or influence infrastructure design and investment. Understanding the role of extreme events in historical versus modeled projections of extremes can inform guidance on how to use these analyses.**

## Innovating Approaches to Drought Communications

As a slowly evolving, long-lasting, and geographically expansive hazard, droughts are a complex and difficult-to-communicate phenomena. Unlike recent literature examining risk communications for hazards such as hurricanes, floods, and sea level rise, limited guidance exists about how to communicate drought to non-experts. In this project to develop and evaluate new informational resources with drought-affected sectors in North Carolina (agriculture, forestry, water resources), we found that drought monitoring processes are opaque to those outside the process and that key products (for example, the US Drought Monitor map) lack sufficient context to be useful for decisions. **By documenting the characteristics that contributed to the new resources' usefulness and usability, we sought to generate broader insights applicable to other drought communication efforts.**

Web-based portals, for example, are often the default method of drought information dissemination by information providers. We found that, in practice, drought information disseminates through a distributed network of sector-based communication chains. Understanding how and when different sectors use social media, leverage trusted messengers, and provide easily shareable products (e.g., infographics, factsheets) can help to facilitate the exchange and use of the resources produced. We found that impact-based icons and narratives are more informative and understandable for users than technical indicators and indices or other visuals (maps) that require more time and skill to interpret. Furthermore, existing drought products are often retrospective and/or only publicized after a drought has emerged. We found that information users desired the broader "climate context," that is, a combination of historic climatologies, current conditions, and future outlooks to understand how recent weather and climate conditions have affected, or may affect, their area's drought status. Receiving drought-related information even during "normal" or "wet" periods is needed to help on-the-ground decision makers anticipate future conditions and make operational decisions. More details about this project, deliverables produced, and the impact it has had on drought communications in the Carolinas can be found on [page 16](#).

# Climate Communications and Outreach

## CISA's Communication Avenues

Through our communications and outreach products, we support a climate-informed network in the Carolinas and connect communities working to tackle similar climate-related impacts. We have two core communications – a [quarterly newsletter](#) focused on CISA activities and the [Carolinas Climate Listserv](#), which disseminates Carolinas-relevant climate news every 1-2 weeks. Our listserv and newsletter reach 450 and 2,558 subscribers, respectively, as of June 2021. We circulated 32 listserv posts in 2021, with an above average open rate for our sector (education). Our most recent listserv's open rate reached 40% with a click rate of 43%. We updated our [website](#) in early 2021, giving our stakeholders a current view of projects and ongoing work. We also added a [resource page on equitable adaptation](#) and a [statement of diversity, equity, and inclusion](#). The website reached 9,500 users during the reporting period. Social media accounts are used to promote CISA events, such as the Carolinas Climate Resilience Conference, and to share research findings or resources from our partners. We have 751 [Twitter](#) followers and 286 [Facebook](#) followers.

## Development of a Southeast Region Information Hub for the Climate Resilience Toolkit

A team of partners from federal agencies, academic institutions, and public, private, and non-profit organizations collaborated to create a [Southeast Region Information Hub](#) within the [U.S. Climate Resilience Toolkit](#) (CRT). It gathers regionally relevant resources and provides an approachable overview to climate change and its impacts in the Southeast. The CRT aims to educate the public and easily link to tools which can turn new knowledge into actions to build resilience.

Our Climate Solutions Specialist, Jory Fleming, was a lead author on the landing page, helping to develop key messages and creating maps to convey complex data and information about climate in the region. He also helped develop the [Building Resilience in the Southeast](#) page which provides multiple examples of work to increase resilience in different communities and at different scales. The [new pages were released on June 24, 2021](#), with additional content to be added as new resources and case studies become available.

## Convergence of Climate Health-Vulnerabilities

In working with public health offices in rural and underserved communities, such as Blandon County, NC, we learned that local staff were lacking key resources. The [Convergence](#) website was designed to meet their needs by providing a platform for educational information, current research findings, and decision-tools specifically related to climate impacts on human health and vulnerable communities in the Carolinas. Through awareness of climate-health hazards, visitors to the website receive education in the short-term, which may lead to behavioral change, mitigation efforts, and adaptation actions in the long-term.

In 2020 Spanish language versions of [heat-health and climate communication](#) infographics were added. In addition to direct translation of the documents, some content was modified to make the information relevant to Spanish-speaking communities. We have received several requests for these Spanish language materials from organizations and have shared these resources with Durham, NC, another NIHHS Heat Mapping community. [Story maps](#) which explore drought, extreme heat, hurricanes, winter weather, and other severe weather in the Carolinas have also been added. The story maps provide information about past events as well as future climate change projections. In the main story map, each event type is outlined and links to another story map which delves into more detail. A climate-public health literature review is also in development, to be added to the site in summer 2021.

# Building a Network of Climate Adaptation Practitioners

The CISA team continues to support the development of a broad network of climate adaptation researchers and practitioners in the Carolinas and throughout the Southeast. We are considered not only a trusted source of climate information but also a key convener of those working to increase the region's climate resilience.

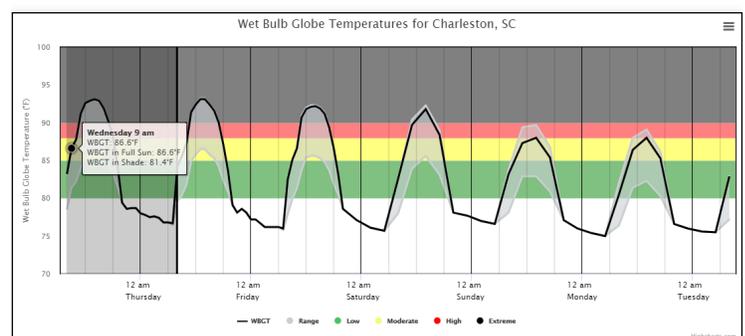
We host monthly calls with a core set of project partners in North Carolina and South Carolina and our [Advisory Committee](#) members, providing opportunities to share updates and to present relevant work to advance thinking around different climate-related topics impacting the region. We also hosted a broader Southeast Regional Climate Coordination Call from January 2020 to June 2021. This group of primarily federal agency partners (e.g., EPA, US Army Corps of Engineers, US Department of Agriculture, Southeast Climate Adaptation Science Center, US National Park Service) was originally convened by the EPA Region IV Climate Liaison, Linda Rimer. Upon her retirement we assumed leadership of the calls to advance coordination across federal agencies in the region.

A growing demand for information and resources about the impacts of high heat in the Carolinas led to the establishment of the Carolinas Heat Health Coalition in 2020. The CHHC quickly grew to 30 members representing athletes, emergency managers, first responders, low-income earners, older adults, outdoor workers, persons with disabilities, prisoners, soldiers, tourists, and youth in less than a year. The group will continue to meet bi-monthly to share resources, identify opportunities for collaboration, and support further development of the WBGT forecast tool.

In fall 2020, a small, private consulting firm, [Climate Adaptation Partners](#), reached out to inquire about our heat-health work and begin to investigate ways we might help inform their work on site renovation plans for the Charleston Medical District (CMD) to integrate heat risk information and risk reduction strategies. Following a presentation to the CMD board, we initiated plans to conduct field work on site in summer 2021. As we continued to connect with stakeholders in the region, efforts coalesced around a proposal to support urban heat mapping that would improve understanding of heat exposure and risk throughout Charleston, with a focus on low-income communities of color. Future opportunities continue to arise around this pressing issue and rapidly growing network of stakeholders and project partners in the South Carolina Lowcountry.



Photo Source: Sarah Pack



Jordan Clark (left) measures wet bulb globe temperature (WBGT) in Charleston, SC. This field study will contribute to improvements in the [WBGT forecast tool](#) (above) and heat health risk reduction strategies for organizations we are engaging through the Carolinas Heat Health Coalition.

The [Carolinas Climate Resilience Conference](#) grew from a 200-person event in 2014 to over 320 participants in 2021. This year’s conference, held May 10-12, was hosted as a hybrid event to ensure safe participation for all as the COVID-19 pandemic slowly began to wane. The Conference continues to draw a more diverse group (Figure 2). More information about this hallmark event of the CISA program can be found on [page 20](#).

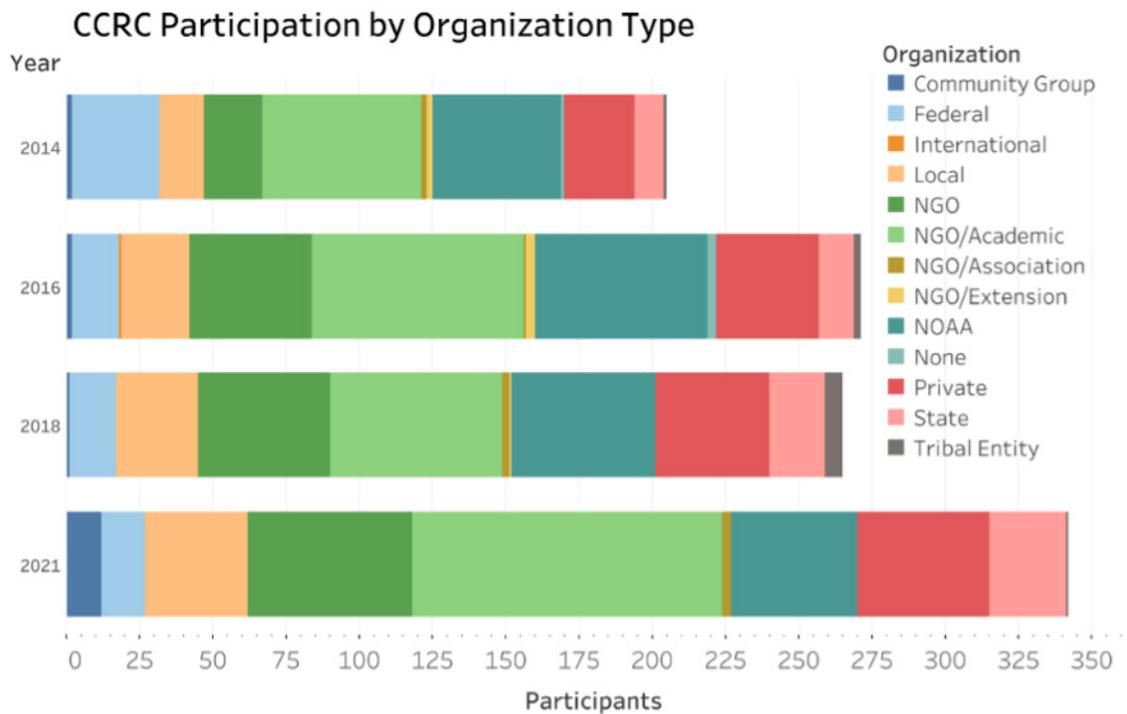


Figure 2: This figure shows the number of participants and the organizations they represented for each of the four Carolinas Climate Resilience Conferences

Representatives from NC Interfaith Power & Light attended the 2014 Carolinas Climate Resilience Conference (CCRC) to learn about climate change impacts in the region and who was working in the field. In 2016, the group reconvened at the CCRC, hosting a faith-based resilience workshop, and expanding their network. The discussion led to the creation of the Southeast Faith Leaders Network. With travel support from CISA, the group conducted a similar session at the 2017 National Adaptation Forum to connect more broadly. Now, the network has grown to 65 members, supports GIS research on climate impacts on churches, and is implementing a strategy to create Congregational Resilience Hubs in member communities.

**“I became aware of CISA at the first CISA-organized Carolinas Climate Resilience Conference in 2014.... The opportunity to partner with environmental justice leaders and lift up community-based climate solutions at the [National Adaptation Forum] helped foster the development of the Southeast Faith Leaders Network, and we are grateful for CISA’s role in making this happen.”**  
 ~ Susannah Tuttle, NC Interfaith Power & Light

# The CISA Footprint

We approach evaluation as an integrative activity that allows us to reflect on and learn from the individual projects and overarching approach through which we engage decision makers, assess our effectiveness in producing user-driven research and providing actionable information, and monitor the long-term impacts of our work. Throughout the nearly 20 years of the CISA program, we have adopted multiple approaches to monitor and evaluate our impact, including both quantitative metrics and qualitative analysis. Our overarching approach centers on four elements of building adaptive capacity which, in turn, guide our evaluation efforts. The Case Studies in the section that follows provides more information about several of our projects and how we have measured their success and societal impact.

## Research to Advance Understanding of Climate and Its Impacts

Based on stakeholder needs assessments, our physical science research focuses primarily on extreme heat and precipitation extremes in the region (both heavy rainfall and drought). In addition to quantitative metrics such as the number of publications, reports, and presentations developed to share key findings, we evaluate these efforts to understand the extent to which we have addressed decision makers' specific questions by soliciting feedback on how they use products or information such as the Wet Bulb Globe Temperature (WBGT) forecasting tool. We also monitor the extent to which we incorporate new findings and analysis into other CISA projects or use them to enhance others' climate-related understanding and work.

## Collaboration to Support Adaptation Implementation

Through our community-based projects, we provide one-on-one decision maker support to translate and integrate climate data and information and guide adaptation implementation strategies. We measure the success of this work by the number of communities for whom we provide technical assistance; the number of convenings of and sustained interactions with partners, decision makers, and other stakeholders; and the extent to which these communities are considering or including climate into specific planning or policy processes. We also consider transfer of knowledge from these pilot projects.

## Decision Support Services

We have developed several resources to help translate, tailor, and integrate climate science and information into different decision-making processes. These include the [Citizen Science Condition Monitoring](#) project, efforts to [improve drought communications products](#), development, and expansion of the [Coastal Salinity Index](#) (CSI), and creation of decision support tools including the [Climate and Hazard Mitigation Planning](#) (CHaMP) tool, the [Hazardous Extremes for Risk Assessment](#) (HERA) tool, the [Carolinas Climate Patterns & Probabilities Atlas](#), and the [Wet Bulb Globe Temperature](#) (WBGT) forecasting tool. We evaluate the effectiveness and impact of this work through project-specific evaluations which assess the processes through which we engage with stakeholders, as well as the use and usability of the information and products we provide. We measure the success of the resources based on the understandability of provided information, usability of the information, actual use of the resources, and feedback from decision makers who helped in resource development.

## Outreach and Engagement to Foster Climate Information Networks

As described in the communications and network building sections beginning on [page 10](#), we provide communications and outreach products and host engagement activities to support a regional network of climate adaptation practitioners. We measure the success of our outreach and communications materials, such as the listserv, newsletter, and social media accounts based on the number of people reached and the growth of our distribution lists over time. We measure the success of in-person and virtual engagements not only by the number and diversity of individuals and organizations who attend these events, but also through feedback from attendees about the content shared, the structure of the engagement, and the value of networking opportunities. Our program-wide network analysis also helps us to monitor the growth of the network over time and how the organizations with which we engage are evolving to meet regional needs.

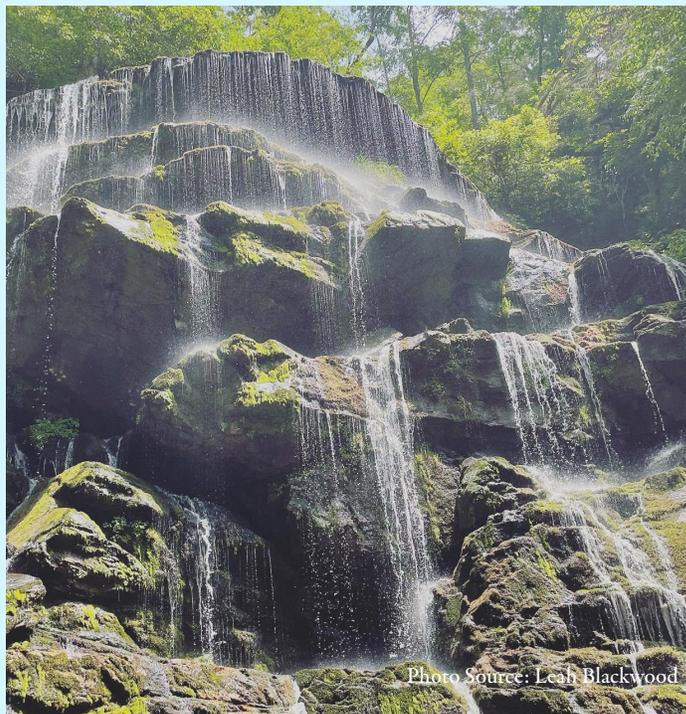


Photo Source: Leah Blackwood

# Case Studies in the Carolinas

## Support for Drought Planning and Preparedness

Working with partners to enhance the Carolinas' drought monitoring, planning, and communications capacity has been a key component of CISA's water focus area. Here we highlight three projects that concluded during this reporting period, featuring impacts and outcomes that have resulted from our long-term investments, stakeholder engagements, and capacity-building efforts. These projects have been supported through funding from CISA's RISA award, the National Integrated Drought Information System (NIDIS), the NOAA Sectoral Applications Research Program (SARP), and the U.S. Geological Survey.

### Condition Monitoring: Supporting CoCoRaHS Volunteers and Drought Monitoring in the Carolinas and Beyond

**Project Partners:** CoCoRaHS, State Climate Office of North Carolina, South Carolina State Climatology Office

From September 2013 until August 2020, we worked with the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network and their volunteer observers to enhance the reporting and use of drought impacts information. Observers provide regular condition reports to document the effects of weather and climate on their local environments and communities. Drought monitoring agencies use these reports to help identify local impacts and where conditions are changing. Our [final story map](#) documents this seven-year investment, which grew from a pilot in the Carolinas to an established national citizen science drought monitoring network permanently integrated into the CoCoRaHS network. **Between October 2016, when the project was launched nationally, and May 2021, 76,972 reports were submitted by 5,442 volunteers throughout Canada and the U.S., including Puerto Rico and the U.S. Virgin Islands.**

#### Climate Science and Translation to Support Decision Making

Over the last year, we developed [tailored guidance for observers](#) in other regions, including a Spanish translation for Puerto Rico and the U.S. Virgin Islands. We examined how the reports might be used for monitoring, reporting, and communicating about other types of significant weather events. We also analyzed the content of Condition Monitoring reports, as well as National Weather Service, Regional Climate Center, and state climate office reports, to see if and how Condition Monitoring report content might fit agencies' information needs. We worked with these agencies to use this information to create [Helpful Reporting Hints](#) to support volunteers in providing weather event information through different CoCoRaHS reports: significant weather reports, daily comments, and Condition Monitoring reports. A [story map](#) documents this portion of the research project and highlights the wealth of information provided by volunteer observers.

#### Stakeholder Engagement and Feedback

During the final year of the project, we continued to engage with both volunteers and the agencies who use Condition Monitoring reports. We supported observers in the Carolinas through regular communications via a monthly newsletter and publicly recognized the most consistent reporters. We solicited feedback from CoCoRaHS coordinators on the regional guidance documents and provided communications and outreach materials to help them promote Condition Monitoring with their volunteers. We iteratively developed the [Helpful Reporting Hints](#) in collaboration with the agencies who use the reports.



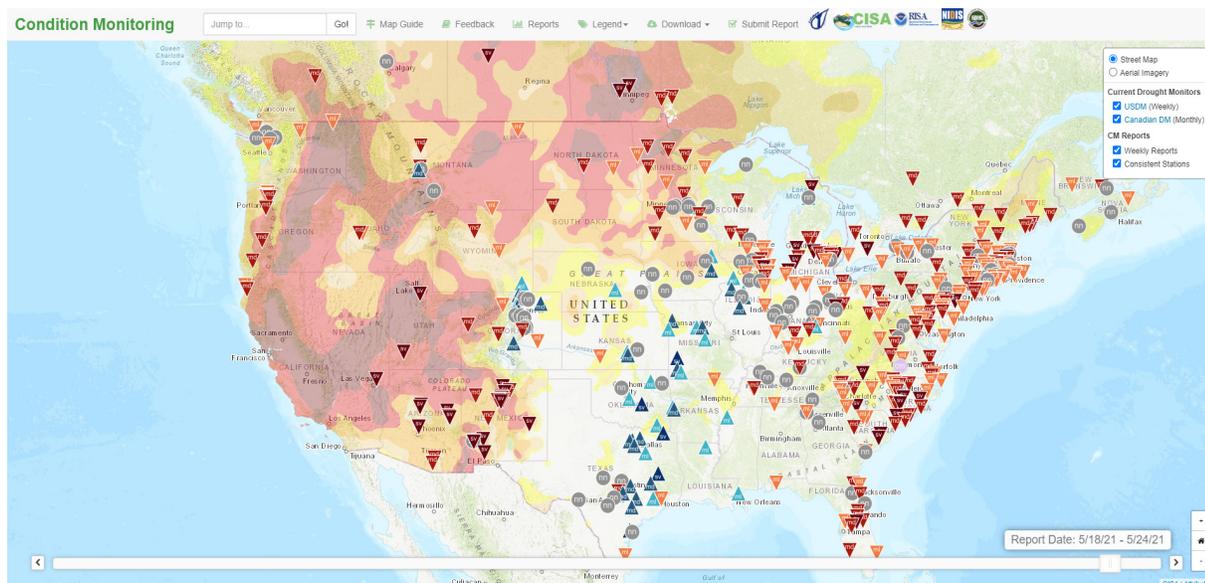
CoCoRaHS Condition Monitoring volunteers share consistent observations of their local environment to document change over time, such as these images of a creek bed in Nash County, North Carolina, photographed by Christopher Lumppp.

## Implementation and Impacts

CoCoRaHS Condition Monitoring evolved from a pilot project in the Carolinas to an established national program, available to over 20,000 citizen science volunteers and accessible by drought decision makers throughout the U.S. and Canada. The [Condition Monitoring web map](#) and [associated resources](#) are permanently housed on the CoCoRaHS website and maintained by the CoCoRaHS team.

National and state drought monitoring efforts regularly use this reporting. U.S. Drought Monitor (USDM) authors download the reports as a GIS layer to consider as they develop the national USDM map each week. The State Climate Office of North Carolina uses the reports in weekly North Carolina Drought Management Advisory Council (NC DMAC) calls. The South Carolina State Climatology Office and NWS offices use the reports to provide input to the U.S. Drought Monitor. We have also learned of other state CoCoRaHS coordinators and climate offices who use the information regularly to contribute to state and national drought designations, including in Florida and Minnesota.

Project partners at the National Drought Mitigation Center (NDMC), who helped develop CoCoRaHS Condition Monitoring, replicated the process in their online drought impacts reporting tool, [Condition Monitoring Observer Reports](#) (CMOR). Working through state partners, this tool expands the reach of Condition Monitoring to a broader audience of volunteer observers and report users. Since the tool was launched in 2018, 5,900 reports have been submitted.



The [CoCoRaHS Condition Monitoring Web Map](#) now includes the weekly Canadian Drought Monitor map in addition to the US Drought Monitor map to provide additional context for observers' condition monitoring reports.

**“Our NWS Weather Forecast Office, including myself and our hydrologist, look at the condition monitoring reports from CoCoRaHS observers. I send out posts on social media on occasion encouraging CoCoRaHS observers to send in condition monitoring reports to help gather feedback for the weekly drought monitor.”**

**~ Michelle Margraf, Meteorologist, NWS Twin Cities, MN**

The reports are also used by Environment Canada for the Canadian Drought Monitor, which is actively recruiting new CoCoRaHS volunteers to contribute to precipitation reporting and condition monitoring. The Canadian Drought Monitor map has been added to the Condition Monitoring web map.

**“The CoCoRaHS Conditions data are used to assist us in the assessment of drought conditions along with the AIR data and many more data sets for the Canadian Drought Monitor. The information provided by CoCoRaHS reporters assists in understanding local conditions and impacts.”**

**~ Trevor Hadwin, Agroclimate Specialist, Science and Technology Branch, Agriculture and Agri-Food Canada**

## Innovating Approaches to Drought Communications in North Carolina

**Project Partner:** State Climate Office of North Carolina

From 2018 through 2020, we partnered with the State Climate Office of North Carolina (SCONC) to improve the usability of drought-relevant information for North Carolina decision makers, particularly those in the agriculture, forestry, and water management sectors. The project was designed to support the NC Drought Management Advisory Council (DMAC) and NC's official statewide monitoring process by engaging different audiences to develop and evaluate new drought communications products..

### Climate Science and Translation to Support Decision Making

The project stemmed from needs articulated by the NC DMAC and constituents, such as NC Cooperative Extension agents and public water supply system managers. Specific needs included a better understanding of the drought monitoring process, climatic and environmental conditions that cause or worsen drought conditions, and drought impacts on various sectors and regions in the state. Through an iterative development and feedback process, the project team identified key elements necessary to ensure the usefulness of drought communications products as well as the most effective avenues for dissemination. Additional information about key findings can be found on [page 9](#). The [project website](#) provides an archive of the infographics, historical drought fact sheets, presentations, and other resources produced.

### Stakeholder Engagement and Feedback

Representatives from federal and state agencies, private sector reservoir managers, cooperative extension agents, fire environment committee members, and water utilities provided feedback on the drought communications materials developed by the project team. Feedback was solicited through online surveys, focus group discussions, and eye tracking studies. Key findings, such as a need for forward-looking information as well as historic and current conditions, were incorporated into updated versions of communications products.

### Implementation and Impacts

These new communications products are providing timely and actionable information for decision makers and have been integrated into existing monitoring processes. The SCONC produces the Weekly Drought Update (WDU) infographic to convey the reasoning behind the NC drought map designations and how conditions are changing from week to week. These are distributed through a listserv and posted on the [NC DMAC website](#). With funding support from the NC Forest Service, the SCONC produces the monthly Short-Range Outlook to convey short- to medium-range forecast information and potential effects on the formation, intensification, or amelioration of drought conditions.

Communications products have also been successfully transferred to South Carolina. The SC State Climatology Office has adapted the WDU infographic templates to describe conditions that drive SC's status on the US Drought Monitor map. SC's weekly update product is disseminated to the SC Drought Response Committee and other stakeholders via a listserv and posted on the [scdrought.com](#) website (accessible in the "archived graphics" dropdown menu in the "USDM of SC" thumbnail).

Through our interactions with stakeholders, the team also identified needs for a real-time, interactive tool for water utilities to monitor drought's effects on regional water supplies. In March 2020, we initiated a project with the Internet of Water (IoW), water utilities in the Triangle region of NC, and the NC Department of Environmental Quality (NCDEQ) to pilot a "[Water Supply Dashboard](#)." The dashboard integrates water data from a variety of federal, state, and local agency sources to help managers provide information to their staffs, boards, and customers about drought conditions and any risk reduction measures or decisions, such as water conservation. The use of free and open-source software increases the accessibility of this tool to a wider array of community water systems. Currently hosted by IoW, plans for the Dashboard include transferring the tool to NCDEQ, expanding its scope to utilities across the state, and integrating with existing NCDEQ reporting processes.



## Advancing the Development and Use of the Coastal Salinity Index

**Project Partner:** U.S. Geological Survey (USGS)

The [Coastal Salinity Index](#) (CSI) was developed to help characterize, monitor, and assess fluctuating salinity conditions in coastal surface waters caused by droughts and floods. It is one of the first drought indices to address coastal environments. Since 2014, we have collaborated with the USGS South Atlantic Water Science Center (SAWSC) to support the iterative development of the tool and provide CSI-related data and information to a variety of stakeholders and user groups.

### Climate Science and Translation to Support Decision Making

The CSI characterizes short- and long-term coastal drought using salinity values along the freshwater-saltwater interface and helps users understand the effects of changing salinities on freshwater and saltwater habitats, fisheries, and freshwater availability for municipal and industrial use. The first iteration of the CSI website was launched in 2019 to provide real-time CSI values using USGS gages in North Carolina, South Carolina, and Georgia. As of June 2021, the CSI website has had over 3,000 unique pageviews. In 2020, USGS received funding to expand real-time CSIs to all coastal states from Maine to Texas, integrate datasets from the National Estuarine Research Reserve System (NERRS) and Everglades National Park monitoring networks, and enhance the website.

### Stakeholder Engagement and Feedback

Stakeholder feedback, led by CISA PI Kirsten Lackstrom, has been an integral part of this project. From 2016 to 2019, a CSI user group, consisting of state and federal agencies, academics, and NGOs in the Carolinas, provided input on the CSI tool, its dissemination, and its applications for resource monitoring and management. During the 2020 CSI website expansion, Lackstrom led the user engagement and tool evaluation components of the project, to include designing and implementing an online survey and a user feedback webinar for the expanded geography. With USGS colleagues, we continue to familiarize new audiences with the CSI through in-person and virtual engagements. For example, the tool has been presented to a variety of NOAA and USGS programs and centers; the US Army Corps of Engineers; the Gulf of Mexico Alliance; and the National Academies of Sciences, Engineering, and Medicine Committee on Long Term Environmental Trends in the Gulf of Mexico.

### Implementation and Impacts

Motivated by decision makers in the Carolinas and fostered by NIDIS/Coastal Carolinas DEWS and CISA efforts, the CSI is a unique tool with broader applicability to other regions. There is continued interest in and support for its expansion. Work over the last year to support the geographic and agency/monitoring network expansion of the existing website made the CSI more widely available and applicable for users. Survey and feedback results helped improve website interactivity, functionality, data access, and content. The expanded availability of CSI data and other resources is supporting new analyses and case studies in the Gulf of Mexico and South Carolina to improve understanding of ecological responses to disturbance events and salinity dynamics. The USGS SAWSC is partnering with the Caribbean-Florida WSC to integrate the CSI into the [Florida Water Level and Salinity Analysis Mapper](#).

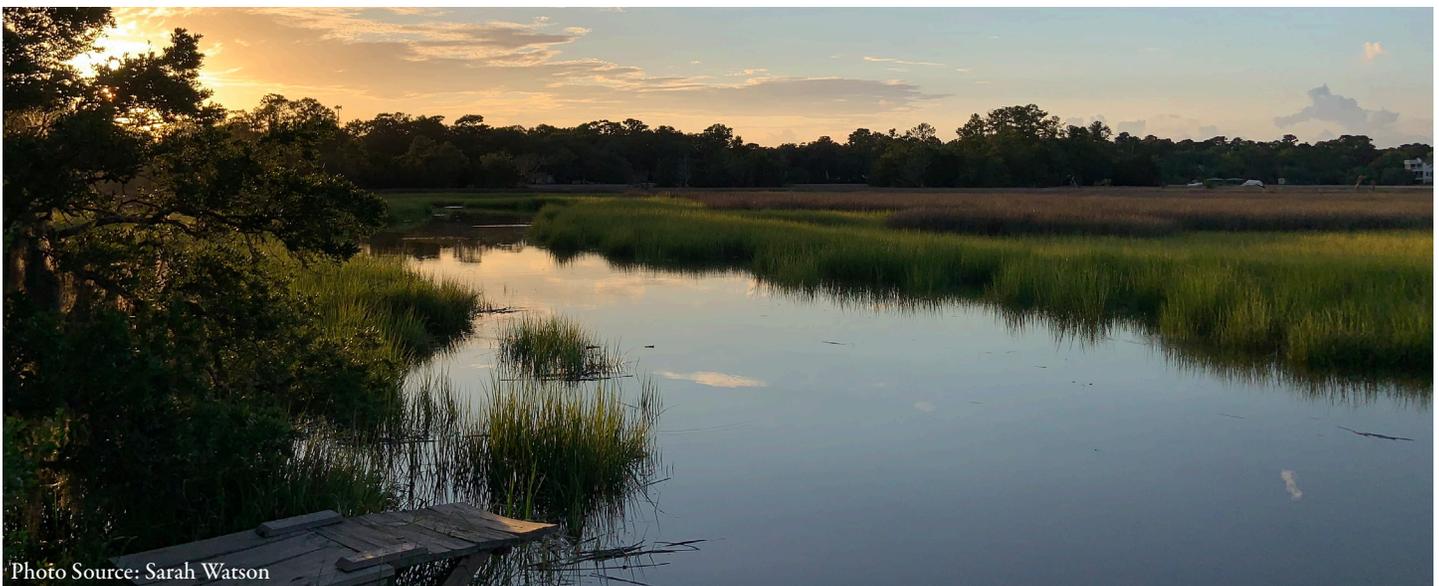
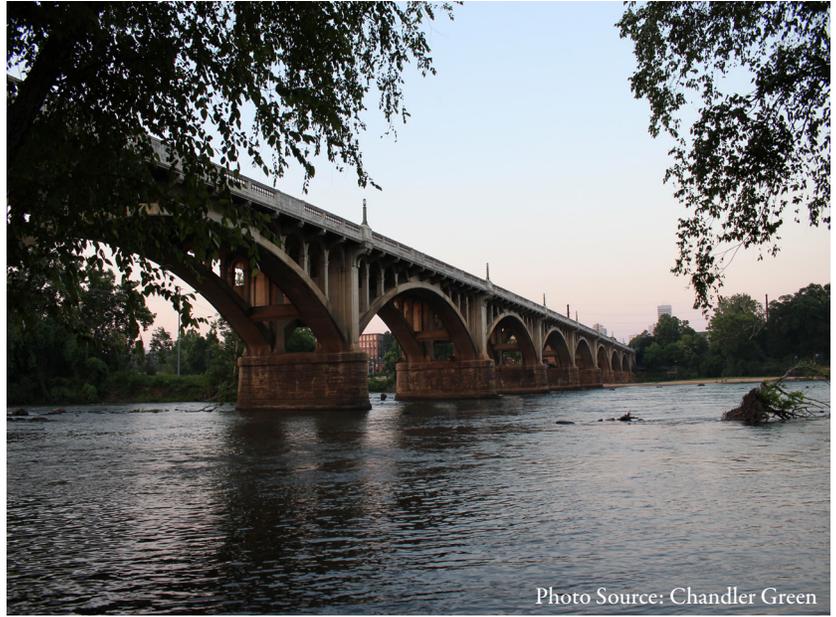


Photo Source: Sarah Watson

## Integrating Climate into Watershed Planning

**Project Partner:** McCormick Taylor, Central Midlands Council of Governments, SC DHEC

The Central Midlands Council of Governments (COG) is developing a watershed-based source water protection plan in partnership with the consulting firm McCormick Taylor for the Three Rivers Watershed, the confluence of the Broad, Saluda, and Congaree Rivers near downtown Columbia, SC. This is the first watershed-based source water protection plan in the state developed under new guidance requiring information on climate change. We are helping to develop a climate change sub-section of the plan and providing input on climate considerations in other aspects of the plan, including equitable adaptation strategies. The collaboration builds climate change data into a plan that will influence future governance decisions in the watershed.



### Climate Science and Translation to Support Decision Making

We distilled outputs from CMIP6 global climate models so future shifts in annual precipitation are reflected in the model behind the plan's recommendations. Model projections were combined with long term trends and relevant literature to build a future scenario to be used in the watershed treatment model. Results will be compared to watershed treatment model results which used historical data only. This will enable the COG to use both existing conditions and a climate-informed hypothetical future when considering best management practices and plan recommendations. We are also working with the COG to envision equitable adaptation and co-benefit frameworks for the plan, identifying ways in which a climate adaptation lens could be used to extend the utility of the watershed plan in the local community.

### Stakeholder Engagement and Feedback

Ongoing discussions with the COG and McCormick Taylor informed our approach to the development of the future climate scenario for the watershed treatment model as well as how climate data and information will be integrated into plan recommendations. We collaborated with the COG to identify priority areas in the plan where climate should be considered in long-term decision making. As we worked to develop the future climate scenario for the watershed treatment model, we shared possible scenarios with the COG and discussed the implications of each to determine the scenario which would be most useful in developing recommendations based on potential future impacts. Feedback to the watershed plan will also be provided by a stakeholder advisory group and eventually public comment, led by the COG, as the plan moves towards implementation.

### Implementation and Impacts

The Three Rivers Watershed Plan covers river segments in downtown Columbia, SC. In recent years, the city has focused development on the geographies surrounding the river, including creating a greenway and opening a riverfront business district. The river segments covered under the plan are actively used for recreation and serve as a drinking water source for over 450,000 residents.

The City of Columbia's 15-year economic development plan, *Columbia Compass: Envisioning 2036*, views the river district as key to the economic future of the city. The report recommends the city spend over \$1.5 million on public river access points and \$500,000 to \$1.5 million on sustainable development and protection of ecosystem services in the next 15 years. The watershed plan will help guide these investments to ensure the health and sustainability of the river system.

Based on this successful partnership, McCormick Taylor has invited us to participate in a similar process for the Caw Caw Watershed in Orangeburg, SC, over the next year. We are also coordinating with the SC Department of Health and Environmental Control (DHEC) Watersheds Program to provide support for other communities interested in applying for [watershed-based source water plan development grants](#). CISA is listed on the SC DHEC grant application page as a resource to help incorporate climate considerations into watershed planning.

## Advancing Heat Health in the Carolinas

**Project Partners:** Southeast Regional Climate Center, Carolinas Heat Health Coalition members, Climate Adaptation Partners, Charleston Medical District (Medical University of South Carolina, Johnson VA Medical Center, Roper-St. Francis Hospital), City of Charleston, SC

Wet bulb globe temperature (WBGT), which incorporates solar radiation and wind speed in addition to air temperature and humidity, has been deemed a more reliable measurement to monitor the impact of heat on human health. Since most weather stations do not measure WBGT, we have developed, tested, and refined a method for estimating WBGT from measurements of air temperature, humidity, solar radiation, and wind speed. Using this method, we, along with partners at the Southeast Regional Climate Center (SERCC), constructed [the WBGT forecast tool](#), a web-based application that translates gridded NWS temperature, humidity, wind, and cloud cover forecasts into an hourly forecast of WBGT for the next five days. Currently, the tool is designed to support high school athletic directors and coaches in understanding risk for their athletes. As we continue to refine our methods for calculating WBGT and integrating this information into the forecast tool, we are working with new agencies and organizations through the Carolinas Heat Health Coalition to consider how WBGT can provide a better estimate of heat stress and lead to risk reduction strategies for different vulnerable populations.

### Climate Science and Translation to Support Decision Making

The recently released [Charleston, SC All Hazards Vulnerability and Risk Assessment](#) has raised new awareness about the threat of high heat events and increasing temperatures across the region. A private consulting firm, Climate Adaptation Partners, is leading work for the Charleston Medical District (CMD) to integrate sea level rise and extreme heat into planning for the CMD campus. CISA team members presented our work on heat health and development of the WBGT forecasting tool to a group of CMD stakeholders in December 2020. This engagement led to plans for field work in summer 2021 to test the WBGT forecasting tool on site in conjunction with a pilot study to understand occupational heat exposure for outdoor workers. Results will be used to refine the model for estimating WBGT at local scales and inform the design of \$2 billion in future building investments for the three hospitals which make up the CMD.

### Stakeholder Engagement and Feedback

In partnership with Climate Adaptation Partners and the City of Charleston, CMD, The Citadel, and other stakeholders, we supported a successful application to conduct this mapping in [Charleston, SC](#) supported by the National Integrated Heat Health Information System. The mapping efforts are intended to raise awareness about heat risks throughout the city, from heavily touristed areas to underserved neighborhoods, and areas slated for further investments. Mapping results will also incorporate local perspectives and engage community members in developing strategies to reduce exposure. The City of Charleston is committed to using the results in its resilience planning. Mapping will also take place in Raleigh-Durham, NC, and we have discussed opportunities for sharing data and exposure reduction strategies. We launched the Carolinas Heat Health Coalition (CHHC) in 2020 to bring together diverse organizations and sectors around heat vulnerabilities in the region. The goal of the CHHC is to facilitate heat health awareness, prevention, warning, and information exchange, particularly for those most vulnerable to high heat. The 30 CHHC members represent athletes, emergency managers, first responders, low-income earners, older adults, outdoor workers (construction, farming), persons with disabilities, prisoners, soldiers, tourists, and youth. The CHHC meets every other month and serves as a forum where groups working with underserved and vulnerable populations can connect directly with state agencies and other resource providers. CHHC members will also help to test the WBGT forecast tool for different populations (e.g., outdoor workers) to support development of new sector-specific guidelines. The group will also provide feedback on training and communications materials under development to describe WBGT, the climatology of WBGT, variations in WBGT expected throughout the day, and how to use the forecast tool.

### Implementation and Impacts

An online video course was created for the Mid-Atlantic Trainers Association and accessed by sixty-nine athletic trainers from across the country to learn about heat-related vulnerabilities and how to use the WBGT forecasting tool. Participants saved an estimated \$500 each through virtual participation while earning professional development credits. The WBGT forecast tool was not widely utilized during the 2020 heat season because high school athletics were largely canceled due to the pandemic. The Convergence website hosts an updated version of the tool which has been expanded to include nine states across the Southeast. Engagements with the North Carolina High School Athletics Association and CHHC members are scheduled in summer 2021.

## The Carolinas Climate Resilience Conference

**Project Partners and Sponsors:** The CCRC is supported by many different partners in the region through participation on our [planning committees](#) and through [sponsorships](#).

The [Carolinas Climate Resilience Conference](#) (CCRC) is a regional convening of researchers and practitioners to share experiences and knowledge about climate impacts and adaptation strategies specific to the Carolinas. The conference was created to foster real-world solutions to the challenges we face in the region, and we actively solicit presentations beyond research findings. The 4th CCRC was hosted May 10-12, 2021, as a hybrid event with 323 virtual and in-person attendees from throughout the Carolinas and broader Southeast region.

The event has become synonymous with resilience in the face of unexpected events and adaptation to evolving circumstances. Following delay and rapid rescheduling of the 2018 CCRC caused by Hurricane Florence, the planning committee faced an even greater challenge for the fourth convening because of the COVID-19 pandemic. Recognizing a growing demand for climate information in the region and the importance of in-person connections, lead planners decided to embrace the challenge of hosting the conference in a hybrid format to ensure safe participation for anyone hoping to attend. In-person attendees gathered at the Durham Convention Center in downtown Durham, NC. Virtual participants joined live sessions, discussion, and networking events via the [Socio virtual conference platform](#).

### Climate and Adaptation Science to Support Decision Making

The 2021 CCRC program included 4 virtual pre-conference workshops. The 3 plenary sessions, 28 oral presentations, 22 lightning talks, 20 symposia, and 18 poster sessions were simultaneously held in-person and virtually. The program was organized around key [cross-cutting themes](#) relevant to stakeholders. Nearly 200 speakers shared work to advance climate adaptation through actionable climate science, climate resilience planning and recovery, communication and engagement, equitable adaptation, and more. The virtual conference platform allowed us to record all conference sessions. These recordings were made available to registered attendees for an additional three months after the conference.



Photo Source: Sarah Watson

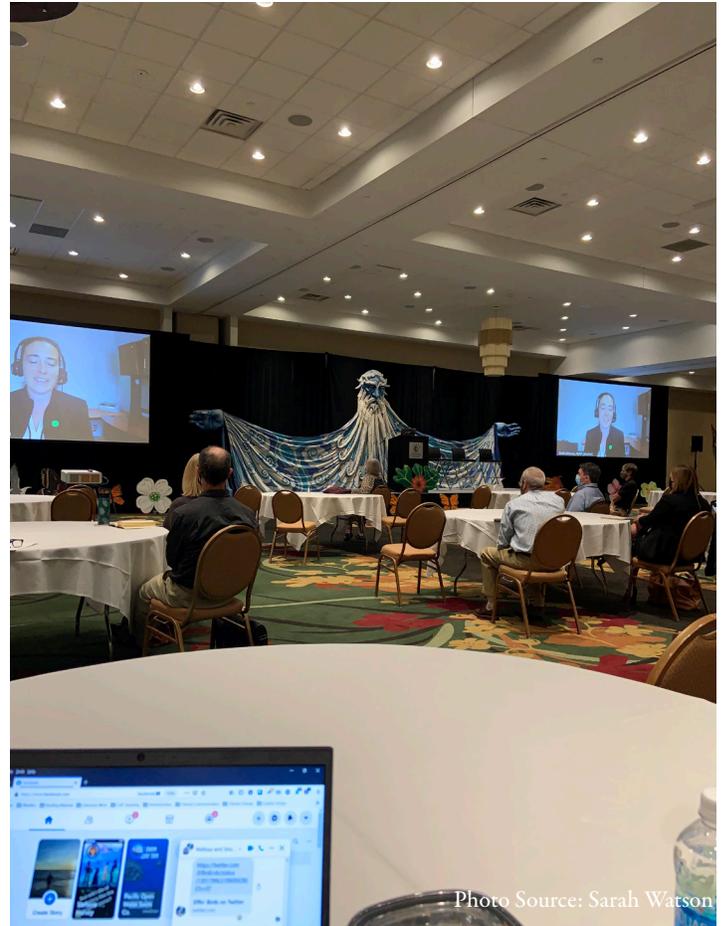


Photo Source: Sarah Watson

## Stakeholder Engagement

The 323 attendees represented federal, state, local, and tribal government, academia, NGOs, community organizations, and the private sector. Most attendees were from the Carolinas. There was also representation from 18 other states throughout the U.S. We offered travel support to 30 community leaders, including 5 youth advocates who spoke about their experiences during the “Empowering Youth to Contribute to Climate Resilience Efforts in their Communities” session. This financial support, including registration and hotel accommodations for those attending in-person, totaled \$9,950.

## Impacts in the Region

We once again collaborated with the American Society of Adaptation Professionals (ASAP) to award the [Carolinas Regional Adaptation Leadership Award](#). Queen Quet, Chiefess of the Gullah/Geechee Nation & Founder of the Gullah/Geechee Sea Island Coalition, winner of the 2020 Carolinas RALA, was recognized in a virtual ceremony during the opening plenary along with the other award nominees.

We provided up to 12 continuing education credits to certified floodplain managers, licensed engineers and surveyors, and planners free of charge. Although rates vary depending on the number of hours and type of credits, these CEUs had the potential to save attendees several hundred dollars in training fees. For instance, a 1-hour webinar training hosted by the Association of State Floodplain Managers (ASFPM) averages \$45<sup>2</sup>, providing an estimated \$540 savings for an ASFPM member who received 12 credit hours for attending the CCRC. We provided CEUs to 15 attendees.

Evaluation results were overwhelmingly positive and point to the value of this conference to enhance adaptive capacity in the region. Respondent feedback indicates:

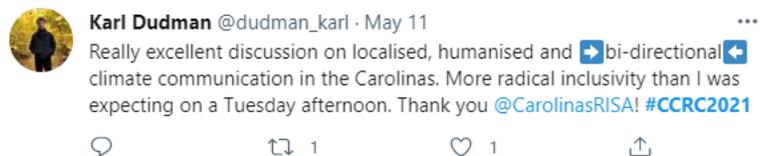
- 93% acquired new knowledge.
- 91% learned about resources and/or tools that could be used in their work.
- 67% met other participants with whom they hope to collaborate in future.
- 76% plan to share examples of climate resilience activities with co-workers or colleagues.



**“I came away with a much clearer understanding of the landscape of work being done in our region on climate resilience and who I can reach out to when I need support or have questions as I do my own work.”**

**“It was inspiring to see the evolution of climate adaptation work that has gone on over the last number of years. An amazing group of people in this space. I’m honored to work alongside them.”**

**“It was very successful as a hybrid event and probably the best we could do with COVID. The Socio platform helped make it successful and was easy to use. What I did miss was the in-person networking that proved so valuable at past CCRC conferences.”**



<sup>2</sup><https://www.floods.org/training-education/online-training/asfpm-webinars/>

# Overview of Ongoing Projects

## Contributions to the NIDIS Drought Early Warning System for the Coastal Carolinas

### Citizen Science Condition Monitoring Project

**Team Members:** Lackstrom, Farris, Blackwood, Charette, Mullin, Ward

**Overview:** This project engages citizen scientists and the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network to promote drought impacts monitoring. Observers provide regular condition reports to document local effects of weather and climate. Since the project began in 2016, 76,972 total reports have been submitted from the U.S. (incl. Puerto Rico and U.S. Virgin Islands) and Canada. This project addresses a need for improved understanding of drought impacts and for impacts information to facilitate decision making.

**Activities:** In the last phase of this project (January 2018 – August 2020), CISA continued to engage with both the volunteers, agencies, and organizations who use the condition monitoring reports. CISA supported observers via a monthly newsletter and tailored guidance and examined reports for research significance in understanding and evaluating extreme weather. CISA produced research and communications products to support Carolinas stakeholders.

**Deliverables:**

- CISA led pilot project initiated in the Carolinas has become a national program
- [Citizen Science Condition Monitoring: Phase 3 Report \(January 2018 – August 2020\)](#)
- [Story Map: CoCoRaHS Condition Monitoring](#)
- [Story Map: More than Drought, Condition Monitoring for Weather of All Types](#)
- [Helpful Reporting Hints for CoCoRaHS Observers](#)
- Multiple presentations (See Appendix: CISA Deliverables)

**Data Management:** All CoCoRaHS Condition Monitoring Reports are publicly available on the CoCoRaHS website: [www.cocorahs.org](http://www.cocorahs.org). Agency reports from the state climate offices, Southeast Regional Climate Center, and NCEI Storm Database that were used in project analysis are publicly available via each institution's website. Questions about project data can be directed to Amanda Farris ([afarris@sc.edu](mailto:afarris@sc.edu)).

### Innovating Approaches to Drought Communications with North Carolina Decision Makers

**Team Members:** Lackstrom, Ward, Davis

**Overview:** This collaborative project between the State Climate Office of North Carolina (SCONC) and CISA aimed to improve the usability of drought-relevant information for NC decision makers, particularly those in the agriculture, forestry, and water management sectors. It was designed to support the NC Drought Management Advisory Council (DMAC) and NC's official statewide monitoring process by engaging different audiences to develop and evaluate new drought communications products. The project team received over 475 feedback inputs through online surveys, focus group discussions, and eye tracking studies.

**Activities:** The SCONC continues to produce the Weekly Drought Update (WDU) infographic and a Short-Range Outlook for NC DMAC and other stakeholders. These materials were shared with the SC State Climatology Office, which is developing comparable products. The project conclusion has opened new opportunities for future resource development with the Internet of Water.

**Deliverables:**

- [Communications with North Carolina Decision Makers: "Project Nighthawk" Final Project Report](#). Raleigh, NC: State Climate Office of North Carolina. 41 pp.
- Ward, R., C. Davis, and K. Lackstrom. 2020. [Innovating Approaches to Drought Communications with North Carolina Decision Makers: Final Project Summary](#). Raleigh, NC: State Climate Office of North Carolina. 4 pp.

**Data Management:** The project [website](#) provides an archive of the infographics, historical drought fact sheets, presentations, and other resources produced throughout the project. Questions about project data can be directed to Kirsten Lackstrom ([lackstro@mailbox.sc.edu](mailto:lackstro@mailbox.sc.edu)).

### Advancing the Development and Use of the Coastal Salinity Index

**Team Members:** Lackstrom, Petkewich

**Overview:** The Coastal Salinity Index (CSI) was developed to help users characterize, monitor, and assess fluctuating salinity conditions in coastal surface water bodies due to events such as droughts and floods. Since 2017, CISA has collaborated with the USGS South Atlantic Water Science Center (SAWSC) to provide CSI-related data and information to a variety of stakeholders and user group.

**Activities:** In 2020, the USGS received new funding to expand the availability of real-time CSIs to a larger geographic area (Maine to Texas), integrate new datasets, and enhance the existing website and user interface. CISA led the user engagement and tool evaluation components of this project. Survey results and user feedback informed enhancements to the website, to include improved interactivity, functionality, data access, and content.

**Deliverables:**

- Expanded [Coastal Salinity Index website](#), released in summer 2021
- Lackstrom, K. 2021. Real-time Coastal Salinity Index for monitoring coastal drought and ecological response to changing salinity values: Report on user engagement methods and results. Columbia, SC: Carolinas Integrated Sciences and Assessments (CISA). 32 pp.

**Data Management:** All CSI products (data release, Open-File Report, real-time CSIs on the CSI website) are reviewed, approved, and managed by the USGS, following USGS data management requirements. Questions should be directed to Matthew Petkewich from USGS ([mdpetkew@usgs.gov](mailto:mdpetkew@usgs.gov)).

## Research to Advance Understanding of Climate & Related Impacts in the Region

### Heavy Precipitation Analysis

**Team Members:** Carbone, Hibbs

**Overview:** This project investigates Intensity-Duration-Frequency (IDF) values of heavy precipitation from 1910 to present for ~40 US historical climate network stations in the Carolinas. The project is interested in determining sensitivity of these measures to recent extreme weather events.

**Activities:** Data analyses and comparisons of a wide suite of measures commonly used for heavy precipitation trends. See the Research Highlights section for additional details.

**Deliverables:**

- Moraglia, G. 2021. Analysis of the pluviometric regime in North and South Carolina. (Unpublished master's thesis) University of Bologna, Bologna, Italy.
- Preliminary results shared on May 2021 RISA Call

**Data Management:** All data and programs used for its processing, as well as statistical results associated with the precipitation intensity research are stored on a networked hard drive maintained by the College of Arts and Sciences at the University of South Carolina. Questions should be directed to Greg Carbone (carbone@mailbox.sc.edu).

### Watershed-Based Planning - Central Midlands Council of Governments / Orangeburg Department of Public Utilities

**Team Members:** Carbone, Dow, Fleming, Ellis, Sprouse

**Overview:** The Central Midlands Council of Governments asked CISA to help incorporate climate change into a management plan for the three rivers watershed in Columbia, SC. CISA is providing technical support and research to support the climate change component of the Three Rivers Watershed plan in collaboration with the consulting firm McCormick Taylor. CISA is supporting Orangeburg, SC in a similar process for the Caw-Caw Watershed plan.

**Activities:** We have provided climate data and projections for watershed areas, research and literature reviews to aid in incorporating climate information and considerations into the planning document. We also aided McCormick Taylor in running a watershed model for a future climate scenario.

**Deliverables:** Contributions to Three Rivers Watershed Based Plan, led by McCormick Taylor and the Central Midlands Council of Governments. Plan set to be completed Summer 2021.

**Data Management:** Steps in analyzing data will be detailed in relevant reports and reproducible. Intermittent steps are stored on a network drive maintained by the College of Arts and Sciences at the University of South Carolina. Contact Jory Fleming (jory.fleming@sc.edu).

### Small Businesses and Community Resilience

**Team Members:** Dow, Davis, Helgeson

**Overview:** The project examines the relationship between businesses and community resilience, one which has become increasingly apparent as initiatives to shop local or support essential employees have gained traction. By understanding business' role in this support structure in comparison to hurricane support, we may be able to better conceptualize networks of community resilience during diverse types of events.

**Activities:** Research expected to result in 3 manuscripts and a better understanding of small businesses and community resilience.

**Deliverables:**

- J.F. Helgeson, E.D. Pierel, and K. Dow. 2020. "NIST-NOAA Survey Instrument for Business Disruption and Recovery Associated with Extreme Events: General Instrument Applied to the Greater Charleston, SC Small- and Medium-Sized Business Community Post-Hurricane Irma." NIST Data Collection Instruments 001. Gaithersburg, MD. National Institute of Standards and Technology, US Department of Commerce. <https://doi.org/10.6028/NIST.DCI.001>

**Data Management:** The Business Disruption data collected under the UofSC Aspire Grant is not published due to IRB best management practices. For questions about this dataset, contact Kirstin Dow (KDow@sc.edu). The data collected by Alignable.com is under their management and they may be reached through their website [Alignable.com](https://www.alignable.com).

## Collaborations to Support Climate Adaptation in the Carolinas

### Carolinas Heat Health Coalition

**Team Members:** Konrad, McLeod, Cochran

**Overview:** CISA launched the Carolinas Heat Health Coalition (CHHC) in 2020 to bring together diverse organizations and sectors around heat vulnerabilities in the region. The goal of the CHHC is to facilitate heat health awareness, prevention, warning, and information exchange, particularly for those most vulnerable to high heat. The 30 CHHC members represent athletes, emergency managers, first responders, low-income earners, older adults, outdoor workers (construction, farming), persons with disabilities, prisoners, soldiers, tourists, and youth.

**Activities:** The CHHC meets every other month to hear from member organizations about ongoing work to address heat vulnerabilities. CHHC members will also help to test the WBGT forecast tool for different populations (e.g., outdoor workers) to support development of new sector-specific guidelines. The group will also provide feedback on training and communications materials under development to describe WBGT, the climatology of WBGT, variations in WBGT expected throughout the day, and how to use the forecast tool.

## Development of a Southeast Landing Page in the U.S. Climate Resilience Toolkit

**Team Members:** Fleming, Cochran

**Overview:** The U.S. Climate Resilience Toolkit serves as a public information resource and hub for data, tools, and resources to aid in climate resilience. CISA served as part of a working group to develop the Southeast portal in the toolkit.

**Activities:** Fleming served as a team lead in developing the landing page and regional sub-topic narratives, data analysis & visualization, and editing. Cochran contributed towards sub-topic narratives.

**Deliverables:** The Southeast region page is available online: <https://toolkit.climate.gov/regions/southeast>

**Data Management:** Service is maintained by NOAA / U.S. Climate Resilience Toolkit. Contact CRT Editor LuAnn Dahlman (luann.dahlman@noaa.gov)

## Support for the Southeast Faith Leaders Network

**Team Members:** Fleming

**Overview:** The Southeast Faith Leaders Network (SFLN) is a working group under the Southeast Climate & Energy Network (SCEN), a collection of NGOs and environmental justice organizations across the southeast. The SFLN convenes a monthly call and mini teams focused on climate advocacy and environmental justice, and how faith communities can move towards resilience in their congregations and communities.

**Activities:** CISA has aided in facilitating calls and worked individually with members to find climate data and contact government agencies for assistance.

**Deliverables:** Aided in facilitating group sessions for 65 members and developed a guide for Churches and Congregations in Contacting Government Agencies. Draft 2-pager, internal guidance / informal use.

**Data Management:** SFLN files are hosted in Google Drive and are owned and maintained by SCEN. Contact Dallas Conyers, SCEN DEI Fellow and SFLN Coordinator (dallas@scen-us.org)

## Urban Heat Mapping in Charleston, SC

**Team Members:** Dow, Clark, Konrad, Mullin

**Overview:** This partnership with the National Integrated Heat Health Information System (NIHHIS) is part of a network of urban heat mapping campaigns. CISA is partnering with the City of Charleston and other stakeholders to conduct a campaign in Charleston, SC in Summer 2021.

**Activities:** Community volunteers driving specified routes will map heat in the Charleston area, while CISA team members collect information on wet bulb globe temperature values, to increase the understanding of individual experiences of heat in the region in late July 2021 as part of a joint research and public awareness effort. Data collected as part of the Advancing Heat Health Resilience in the Charleston Medical District Study described below.

## Advancing Heat Health Resilience in the Charleston Medical District

**Team Members:** Dow, Konrad, Mullin

**Overview:** This partnership with the Medical University of South Carolina, Roper-St. Francis Hospital, and the Johnson VA Medical Center, Charleston Resilience Network, and Climate Adaptation Partners seeks to understand the links between extreme heat and occupational health hazards in the Charleston Medical District. Building an understanding of the total heat experience through wet bulb globe temperature monitoring and individual heat exposure via sensors of heat rates, temperature, and humidity will ground future building and design efforts around the Charleston Medical District. Analyses will also help build resilience and support local stakeholders via on-site research.

**Activities:** A study is set to be conducted in summer 2021 with workers in the district that are required to be outdoors, wearing trackers that will monitor both heat and health metrics while they work. The study findings will enable the hospital and other stakeholders to build heat health into their planning and procedures.

## Supporting Sea Level Rise Adaptation and Planning in Beaufort County, SC

**Team Members:** Watson, Knapp

**Overview:** Building on previous collaborations with Beaufort County, CISA is helping municipal leaders assess possible ordinances and sea level rise overlays that would inform an updated version of the 2015 Sea Level Rise Adaptation Plan and revisions to the County's comprehensive plan.

**Activities:** CISA aided the county in exploring ordinances and updates to the 2021 comprehensive plan from the 2015 SLR adaptation report. The county is now preparing a Beaufort County Long-Term Resilience Plan.

**Deliverables:** This worked informed a successful application for funding from the NOAA CPO Adaptation Sciences grant program and another grant-funded project from the American Shore and Beach Preservation Association

## Edisto Beach Sea Level Rise Vulnerability Assessment and Planning

**Team Members:** Watson, Dow, Farris, Fleming, Knapp

**Overview:** The Town of Edisto Beach is located on a tiny barrier island that is highly vulnerable to storm surge, extreme rainfall, and sea level rise. The town reached out to CISA to begin incorporating this knowledge into its planning. Initial work is focused on a vulnerability assessment and identifying steps to help the town prepare for sea level rise.

**Activities:** CISA facilitated two VCAPS exercises with town government officials and community leaders and delivered a draft report in 2021.

**Deliverables:** Sea Level Rise Vulnerability Assessment and Planning Report. Draft produced April 2021, currently undergoing review and comments from stakeholders.

## Building Resilience to Water-Related Hazards in the Charleston Region

**Team Members:** Watson, Dow, Carbone

**Overview:** CISA provided technical and engagement support to the Charleston Resilience Network as part of a NOAA Regional Coastal Resilience Grant, awarded in 2016. The project used a two-pronged approach to identifying current and future flood risk and effectively communicating those results to residents and decision makers.

**Activities:** CISA worked with research partners to submit a final project report to NOAA.

**Deliverables:** [Final Project Report](#) submitted to NOAA October 2020.

**Data Management:** Precipitation data were collected from the CORDEX-North America database for coastal South Carolina. These data, as well as historic annual precipitation maxima from them are stored on a hard drive maintained by Greg Carbone. Questions should be directed to Greg Carbone (carbone@mailbox.sc.edu).

## Support for South Carolina's Drought Response Program

**Team Members:** Lackstrom, Farris, Altman, Griffin, Mizzell, Mullin, Wickham

**Overview:** CISA initiated this collaborative project in 2017 with the South Carolina State Climatology Office (SC SCO). It has involved a variety of research and engagement activities to help the SC SCO enhance the State's Drought Response Program and improve drought preparedness and response across the State, including two statewide drought tabletop exercises in 2017 and 2019.

**Activities:** With new funding from the SC legislature, the SC SCO hired Elliot Wickham as the SC Water Resources Climatologist, where he leads drought monitoring and communications efforts. SC SCO and CISA are currently working to update the SC model drought plan and ordinance with a new drought planning guidance document tailored for the state's water utilities. This product will be available later in 2021.

## Providing Innovative Decision Support Services

### Convergence: Climate-Health Vulnerabilities Website

**Team Members:** Konrad, McLeod, Clark, Spitzer, McConnell, Dunston

**Overview:** The [Convergence website](#) provides a collection of resources to educate communities about the health impacts of climate and weather events. The project is rooted in a model of collaboration between experts and community stakeholders to foster public engagement and improve bidirectional communication and understanding of climate-health vulnerabilities.

**Activities:** Spanish language translations of [heat-health and climate communication infographics](#) were created to increase accessibility for audiences who may be more vulnerable to the impacts of high heat, such as outdoor workers and athletes. [Story maps](#) exploring climate extremes and weather hazards were developed to provide context and information about the extremes which impact health in the region. A climate and public health literature review will be added in Summer 2021.

**Deliverables:** 1,157 (967 unique) pageviews of the [Convergence website](#) between June 2020 and May 2021.

**Data Management:** All Convergence data is housed at and maintained by the University of North Carolina. Questions should be directed to Chip Konrad (cek@email.unc.edu).

### Hazardous Extremes for Risk Assessment (HERA) Tool

**Team Members:** Konrad, Yang, McLeod, Eck, Spitzer, McConnell, Dunston

**Overview:** The Hazardous Extremes Risk Assessment (HERA) Tool compiles and presents impact data on weather and climate related hazards in a centralized online resource, featuring maps and data visualizations.

**Activities:** CISA received additional funding through the NOAA Climate Program Office in 2020 to expand coverage to six additional states in the Southeast (AL, FL, GA, KY, MS, and TN). Engagements with public healthcare coalitions in these states is scheduled to resume in early 2022, post-COVID.

**Deliverables:** The HERA tool is available at <https://convergence.unc.edu/tools/hera/>

**Data Management:** All data for the HERA tool is publicly available. Data includes the NCEI storm database, death certifications, 100- and 500-year flood plain parcels, heavy precipitation events, heat, and agricultural damage. For more information about the datasets used in the tool contact Chip Konrad (cek@email.unc.edu).

## Wet Bulb Globe Temperature Forecast Tool

**Team Members:** Konrad, Clark, McLeod

**Overview:** Heat advisories in the Southeast typically rely on heat indices that do not account for radiation or ventilation. This project seeks to address these inadequacies by exploring methodologies to estimate wet bulb globe temperature (WBGT) in the absence of WBGT monitoring equipment. This includes creation of a tool that converts NWS gridded weather data into WBGT hourly forecast data.

**Activities:** The [WBGT forecast tool](#) has expanded its geographic footprint to the entire Southeast and focus is now shifting towards working with NOAA partners on methodology and community partners on use and implementation, especially athletic trainers in Carolinas schools.

**Deliverables:**

- Clark, J., & Konrad, C. E. (2020). [Accuracy Assessment of Experimental Wet Bulb Globe Temperature Forecasts Across North Carolina and the Continental United States](#). Chapel Hill, NC.

**Data Management:** Mortality data were obtained from NC Vital Records. Meteorological data were obtained through the NC State Climate Office CRONOS database. These data are freely downloadable with appropriate citation. Questions should be directed to Chip Konrad (cek@email.unc.edu).

## Cross-RISA Collaboration to Support Local Government Hazard Mitigation Planning

**Team Members:** Dow, Farris, Fleming

**Overview:** Planners often lack climate-informed hazard information for FEMA required hazard mitigation plans. This cross-RISA partnership with the Great Lakes and Mid-Atlantic RISAs and the Urban Sustainability Directors Network seeks to build a decision support tool that provides region-specific historical and projected data visualizations of climate-related metrics and impacts for use in these plans.

**Activities:** The RISA teams have built a beta version of the website to collect feedback from planners and stakeholders. CISA met with staff from the Central Midlands Council of Governments to review the Beta version.

**Data Management:** The tool is housed and managed by the NE Regional Climate Center. The tool pulls from the Applied Climate Information System and NCEI Databases. Contact Art Degaetano (atd2@cornell.edu).

# Appendix A: CISA Deliverables

## Advisory Committees

Carbone, G. SC Department of Health and Environmental Control Safe Yield Work Group.

Carbone, G. SC Department of Natural Resources Surface Water Technical Advisory Committee

Carbone, G. North Carolina State University Climate Change and Society Program, Advisory Board Member.

Dow, K. Outreach & Resilience Committee, Charleston Resilience Network.

Dow, K. Advisory Committee, Lt. Col. James B. Near Jr., USAF, '77, Center for Climate Studies, The Citadel.

Dow, K. Advisor, City of Columbia, Climate Protection Action Committee.

Dow, K. NOAA Climate Working Group supporting the Science Advisory Board, Co-Chair.

Farris, A. National Adaptation Forum Program Committee.

Farris, A. Southeast and Caribbean Disaster Resilience Partnership Winter Meeting Planning Committee.

Fleming, J. 2020 Carolinas Regional Adaptation Leadership Award, Selection Committee.

Lackstrom, K. Center for Oceans and Human Health and Climate Change Interactions (OHHC2I), University of South Carolina. Internal Advisory Committee member.

## Media Interviews

Carbone, G. (2020, December 9). "November 2020 had second-highest temperatures in SC, and set a record for the globe." The Post and Courier.

Carbone, G. (2021, April). "Changes in average temperature and local climate since the first Earth Day in 1970." ABC News 4 Charleston.

Dow, K. (2020, October 22). "Coastal Flooding." WLTX Columbia.

Dow, K. (2021, April 15). Interviewed by Chloe Johnson, The Post and Courier. Heat Work. The Post and Courier.

Dow, K. (2021, January) "US Rejoins Paris Climate Agreement." News 19 Columbia.

Konrad, C. (2021, January 28) "The Science and Poetry of Snowflakes." The Well at UNC-Chapel Hill.

## Newsletters

Mullin, S. & Farris, A. CISA and CoCoRaHS Condition Monitoring Newsletter. 12 Monthly Issues, June 2020 – May 2021. Web.

Fleming, J., E. Charette, A. Farris, and S. Mullin. Carolinas Climate Connection. 2nd-4th Quarters 2020, 1st Quarter 2021. Web.

## Publications

Lu, J., G.J. Carbone, X. Huang, K. Lackstrom, and P. Gao. 2020. Mapping the sensitivity of agriculture to drought and estimating the effects of irrigation on the sensitivity in the United States, 1950-2016. *Agricultural and Forest Meteorology*, 292-293, 108124. <https://doi.org/10.1016/j.agrformet.2020.108124>

Hung, C.-L. J., L. A. James, G. J. Carbone, and J. M. Williams. 2020. Impacts of Combined Land-use and Climate Change on Streamflow in Two Nested Catchments in the Southeastern United States. *Ecological Engineering*, 143, 105665. <https://doi.org/10.1016/j.ecoleng.2019.105665>.

J.F. Helgeson, E.D. Pierel, and K. Dow. 2020. "NIST-NOAA Survey Instrument for Business Disruption and Recovery Associated with Extreme Events: General Instrument Applied to the Greater Charleston, SC Small- and Medium-Sized Business Community Post-Hurricane Irma." NIST Data Collection Instruments 001. Gaithersburg, MD. National Institute of Standards and Technology, US Department of Commerce. <https://doi.org/10.6028/NIST.DCI.001>

Eck, M., Murray, A., Ward, A., and C.E. Konrad. 2020: Influence of growing season temperature and precipitation anomalies on crop yield in the southeastern U.S. *Agricultural and Forest Meteorology* <http://doi.org/10.1016/j.agrformet.2020.108053>

## Presentations and Organized Conference Sessions

- Carbone, C., K. Dow, A. Farris, J. Fleming, C.E. Konrad, K. Lackstrom, S. Watson. (2021, May 3). Are You Ready for Climate? Planning for Extremes Using CISA Tools and Services. [organized session]. 2021 Carolinas Climate Resilience Conference.
- Dow, K. (2020, October 6). [presentation]. City of Columbia Climate Protection Action Committee (CPAC). Online.
- Dow, K. (2021, April 8). [presentation]. South Carolina, Solve Climate by 2030 webinar. Online.
- Dow, K. (2021, April 9). Addressing Heat Health Studies. [presentation]. Charleston Resilience Network Coffee Hour. Online.
- Dow, K. (2021, April 13). Reporting Local Climate Stories in South Carolina. [presentation]. Climate Matters in the Newsroom and Coastal Conservation League Workshop. Online.
- Dow, K. (2021, April 21). Community Resiliency in the Face of Coastal Hazards and the Renewable Energy Transition. [presentation]. Coastal and People Workshop. Online.
- Dow, K. (2021 April 30). Environmental Impacts of Climate Change. [presentation]. Fossil Free UofSC Divestment Webinar. Online.
- Farris, A., S. Bath, L. Fly, and G. Garte. (2021 January 28). Disaster Recovery and Resilience in the Private Sector. [organized session] Southeast and Caribbean Disaster Resilience Partnership Annual Workshop. Online.
- Farris, A. and K. Lackstrom. (2021 May 18). Condition Monitoring Update. [presentation]. CoCoRaHS Annual Meeting (WERA 1012: Managing and Utilizing Precipitation Observations from Volunteer Networks). Online.
- Fleming, J. (2020 December 11). Science for Environmental Justice Organizations. [presentation]. Southeast Climate and Energy Network meeting. Online.
- Konrad, C. (2021 May 25). [presentation]. Tools and Services Provided by the NOAA Southeast Regional Climate Center. Tennessee Climate Data Summit. Online.
- Konrad, C. (2020 July 27). Heat Vulnerability and Climate Change in the Carolinas. [presentation]. Columbia-Midlands SC Sierra Club. Online.
- Konrad, C. (2020 August 28). Heat-Related Illness and Climate Change. [presentation]. NC Climate and Health Symposium. Online.
- Konrad, C. (2020 August 11). Heat Vulnerability in the Southeast. [presentation]. NIDIS Southeast Climate Webinar. Online.
- Konrad, C. (2020 September 23). [presentation]. Perspective on Droughts across the Southeast U.S.: Focus on the 2016 Drought. Carolinas Drought Workshop. Online.
- Konrad, C. (2020 October 13). [presentation]. Fall Foliage Outlook. NIDIS Southeast Climate Webinar. Online
- Konrad, C. (2021 April 21). [presentation]. Validating the Skill of Wet Bulb Globe Temperature Forecasts: Challenges and Microscale Variations. 18th Annual Climate Predictions Workshop. Phoenix, AZ.
- Lackstrom, K. (2021 March 17). [presentation]. Ecological Drought: Impacts on Coastal Ecosystems. Ecological Drought National Webinar Series co-hosted by NIDIS and the USGS National Climate Adaptation Science Center. Online.
- Lackstrom, K. and A. Farris. (2020 December 8). Keys to Success: Assessing the Usefulness of Citizen Science Information in Drought-Related Decision Making. [presentation]. American Geophysical Union Fall Meeting. Online.
- Petkewich, M. and Lackstrom, K. (2020 July 28). Coastal Salinity Index (CSI). [presentation]. Apalachicola-Chattahoochee-Flint (ACF) Drought Assessment Webinar. Online.
- Petkewich, M. and Lackstrom, K. (2020 October 29). Coastal Salinity Index (CSI). [presentation]. NOAA Eastern Region Climate Services Webinar. Online.
- Petkewich, M., Lackstrom, K., Medenblik, A., McCloskey, B., Yurek, S. (2021 March 10). Real-time Coastal Salinity Index (CSI) for Monitoring Coastal Drought and Ecological Response to Changing Salinity Values along the Gulf of Mexico and the Eastern Atlantic Coasts. [presentation]. USGS Community for Integration. Online.
- Ward, R., Davis, C., and Lackstrom, K. (2020 September 29). Project Nighthawk. [presentation]. North Carolina Drought Management Advisory Council Annual Meeting. Online.
- Watson, S., R. Merchant, and K. Jones. (2021 May 11). Advancing Long-Term Climate Resilience in Beaufort County, SC. [organized session]. Carolinas Climate Resilience Conference. Durham, NC.

## Poster Presentations

- Farris, A., K. Lackstrom, R. Ward, and E. Charette. (2021 January 11). CoCoRaHS Condition Monitoring: Community Science Contributions to Drought Impacts Monitoring. [poster presentation]. American Meteorological Society Annual Meeting. Online.
- Lackstrom, K., R. Ward, and C. Davis. (2020 December 11). So Why Does the Drought Map Look Like That? Unpacking the Linkages Between the Transparency of Drought Monitoring Processes and Usability of Drought Communications Products. [poster presentation]. American Geophysical Union Fall Meeting. Online.
- Wooten, B., C.E. Konrad, and T. Houston. (2021 January 10). Human Heat Vulnerability: The Development of a Web-Based Tool for Predicting Heat Stress Among High School Athletes. [poster presentation]. American Meteorological Society Annual Meeting. Online.

## Project & Information Document

- Blackwood, L., E. Charette, A. Farris, K. Lackstrom, and S. Mullin. (2020). CoCoRaHS Condition Monitoring. [Story Map](#). Columbia, SC.
- Blackwood, L., E. Charette, A. Farris, K. Lackstrom, and S. Mullin. (2020). More than Drought: Condition Monitoring for Weather of All Types. [Story Map](#). Columbia, SC.
- Blackwood, L., A. Farris, and K. Lackstrom. (2020). Helpful Reporting Hints for CoCoRaHS Observers. Columbia, SC. 1 p. [https://cisa.sc.edu/PDFs/CoCoRaHS\\_ObserverGuidance\\_FINAL.pdf](https://cisa.sc.edu/PDFs/CoCoRaHS_ObserverGuidance_FINAL.pdf)
- Ward, R., C. Davis, and K. Lackstrom. 2020. Innovating Approaches to Drought Communications with North Carolina Decision Makers: Final Project Summary. Raleigh, NC. 4 pp. [https://climate.ncsu.edu/wp-content/uploads/2020/11/Nighthawk\\_FinalReport\\_short.pdf](https://climate.ncsu.edu/wp-content/uploads/2020/11/Nighthawk_FinalReport_short.pdf)

## Stakeholder Meetings, Trainings, and Workshops

- Watson, S. (2021, April 28). Planning for Long-Term Resilience. [presentation]. Charleston County Hazard Mitigation Planning Committee. 22 participants.
- Watson, S. (2020, December 15 and 18). Beaufort County Sea Level Rise Long-Term Resilience Planning. [virtual stakeholder engagement].
- Watson, S., K. Dow, A. Farris, and J. Fleming. (2020, December 10). Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) Exercise. Town of Edisto Beach, SC. [virtual stakeholder engagement]. 8 participants.
- Watson, S., K. Dow, A. Farris, and J. Fleming. (2020, August 11). Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) Exercise. Town of Edisto Beach, SC. [virtual stakeholder engagement]. 8 participants.
- Watson, S. and L. Knapp. (2020, July 8). Presentation of Flood Modeling Results. [virtual stakeholder engagement]. 7 participants.

## Reports

- Blackwood, L., E. Charette, A. Farris, K. Lackstrom, S. Mullin, E. Davis Pierel, and J. Ramthun. 2020. Citizen Science Condition Monitoring: Phase 3 Report (January 2018 through August 2020). Columbia, SC. 36 pp.
- Clark, J. and C.E. Konrad. 2020 Accuracy Assessment of Experimental Wet Bulb Glove Temperature Forecasts Across North Carolina and the Continental United States. Chapel Hill, NC.
- Fleming, J. and K. Dow. 2020 Carolinas Climate Needs Assessment Summary Report. Columbia, SC. 11 pp.
- Gvino, E. and F. Cochran. 2021. CISA Public Health Needs Assessment: Summary Report. Chapel Hill, NC. 33 pp.
- Lackstrom, K. 2021. Real-time Coastal Salinity Index for monitoring coastal drought and ecological response to changing salinity values: Report on user engagement methods and results. Columbia, SC. 32 pp.
- Ward, R., C. Davis, and K. Lackstrom. Communications with North Carolina Decision Makers: "Project Nighthawk" Final Project Report. Raleigh, NC. 41 pp.

## Student Deliverables

- Moraglia, G. 2021. Analysis of the pluviometric regime in North and South Carolina. (Unpublished master's thesis) University of Bologna, Bologna, Italy.

# Appendix B

## Collaborating Project Partners and Investigators

Kristen Baja, Urban Sustainability Directors Network  
Janice Barnes, Climate Adaptation Partners  
Lorin Bruckner, University of North Carolina Research Hub  
Ferdouz Cochran, The MITRE Corporation  
Dallas Conyers, Southeast Climate & Energy Network, Southeast Faith Leaders Network  
LuAnn Dahlman, NOAA Climate Program Office  
Corey Davis, State Climate Office of North Carolina  
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Benjamin Eck, Northeastern Regional Climate Center  
Kathryn Ellis, McCormick Taylor  
Ned Gardiner, NOAA Climate Program Office  
Omar Gates, Great Lakes RISA  
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Andy Grundstein, University of Georgia  
Jennifer Helgeson, National Institute of Standards and Technology  
Steve Hilberg, CoCoRaHS, Midwestern Regional Climate Center  
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Jenna Jorns, Great Lakes RISA  
Landon Knapp, S.C. Sea Grant Consortium, College of Charleston  
Debra Knopman, Mid-Atlantic RISA, RAND Corporation  
Maria Carmen Lemos, Great Lakes RISA  
Bryan McCloskey, USGS St. Petersburg Coastal and Marine Science Center  
Robert Merchant, Beaufort County, SC  
Michelle Miro, Mid-Atlantic RISA, RAND Corporation  
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Richard Young, USGS South Atlantic Water Science Center