CISA
CAROLINAS INTEGRATED SCIENCES & ASSESSMENTS

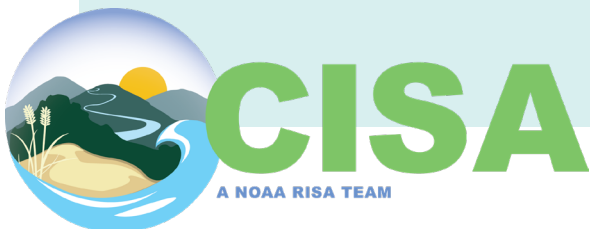Photo Courtesy Jacob Ramthun

2018-2019 ANNUAL REPORT
JUNE 1, 2018 - MAY 31, 2019 / NOAA AWARD NA16OAR4310163

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CISA
A NOAA RISA TEAM

RISA
Regional Integrated Sciences
and Assessments

Meet Our Team

executive team

Kirstin Dow, Lead PI
University of South Carolina

Amanda Farris, Program Manager
University of South Carolina

Kerry Guiseppe, Program Coordinator
University of South Carolina

Greg Carbone, PI
University of South Carolina

Chip Konrad, PI
The University of North Carolina at Chapel Hill
and NOAA Southeast Regional Climate Center

Kirsten Lackstrom, PI
University of South Carolina

Ashley Ward, Outreach and Extension Specialist
The University of North Carolina at Chapel Hill

Sarah Watson, Coastal Climate Extension Specialist
CISA and South Carolina Sea Grant Consortium

research staff

Research Associates
Karen Beidel, Peng Gao, Jordan McLeod, Lauren Rouen

Research Assistants
Ekaterina Altman, Elijah Charette*, Jordan Clark, Eleanor Davis, Montana Eck*, Emily Foster*, Anisha Gupta*, Junyu Lu, Yates McConnell*, Leah Moore, Stafford Mullin*, Aashka Patel, Jacob Ramthun*, Haley Schanne*, Kristin Sherlock*, Hunter Spitzer*, Yuqin Jiang*, and Rachel Woodul

collaborating investigators

Jeff Allen, SC Water Resources Center, Clemson University

Tanner Arrington, SC Department of Natural Resources*

Randy Byrd, University of North Carolina at Chapel Hill, American Indian Center*

Tim Callahan, College of Charleston*

Michelle Covi, Virginia Sea Grant and Old Dominion University

Corey Davis, State Climate Office of North Carolina

William Jefferson Davis, The Citadel

Rick DeVoe, SC Sea Grant Consortium

Jason Evans, Stetson University

Jill Gambill, Georgia Sea Grant*

Simon Ghanat, The Citadel

Melissa Griffin, South Carolina State Climatology Office*

Ashley Hiatt, State Climate Office of North Carolina*

Jennifer Helgeson, National Institute of Standards and Technology*

Shana Jones, Carl Vinson Institute of Government, University of Georgia

Landon Knapp, SC Sea Grant Consortium and College of Charleston *

Norm Levine, College of Charleston

Bryan McCloskey, USGS St. Petersburg Coastal and Marine Science Center *

Hope Mizzell, South Carolina State Climatology Office

James Nolan, University of Georgia, Carl Vinson Institute of Government

Matt Petkewich, USGS South Atlantic Water Science Center*

Scott Pippen, Carl Vinson Institute of Government

Henry Reges, Colorado State University, Colorado Climate Center

Jennifer Runkle, North Carolina State University*

Thomas Ruppert, Florida Sea Grant

Lisa Schivanato, California Sea Grant

Kelly Smith, National Drought Mitigation Center, University of Nebraska

Maggie Sugg, Appalachian State University*

Rebecca Ward, State Climate Office of North Carolina

Jessica Whitehead, North Carolina Sea Grant

Richard Young, USGS South Atlantic Water Science Center*

advisory committee

Jeff Allen, South Carolina Water Resources Center at Clemson University

Frank Alsheimer, NOAA National Weather Service Columbia, SC

Dan Burger, SC Dept. of Health & Environmental Control, Ocean and Coastal Resource Management

M. Richard (Rick) DeVoe, South Carolina Sea Grant Consortium

Liz Fly, The Nature Conservancy, South Carolina Chapter

Emily Forth, DOI Southeast Climate Adaptation Science Center*

Dana Haine, Institute for the Environment, University of North Carolina at Chapel Hill*

Suzanne Lea, Department of Public Health, East Carolina University *

Steve McNulty, USDA Southeast Regional Climate Hub

Ellen Mecray, NOAA Regional Climate Services

Tancred Miller, NC Department of Environmental Quality, Division of Coastal Management

Linda Rimer, EPA Region 4

Gregory Sprouse, Central Midlands Council of Governments

Adam Stein, NOAA Office for Coastal Management, Stewardship Division

Susan White, NC Sea Grant and Water Resources Research Institute

* Indicates new team members, project partners, and advisory committee members.

Our Program

Photo Courtesy: Kirsten Lackstrom

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. A key component of the RISA program is working at the regional level to address significant and timely climate issues of concern.

Working at the intersection of climate with water, coasts, and health, the CISA team creates, tailors, and provides climate information to improve planning and management approaches that build healthier, safer communities in the Carolinas. CISA has established long-term partnerships with federal, state, and local government agencies, resource managers, non-governmental organizations, and the private sector. As a trusted source of climate information for the Carolinas, CISA supports state and local climate adaptation through project-specific engagements as well as reaching broader audiences with other communications and outreach efforts, such as the biennial Carolinas Climate Resilience Conference.

Level of Engagement

Most Extensive
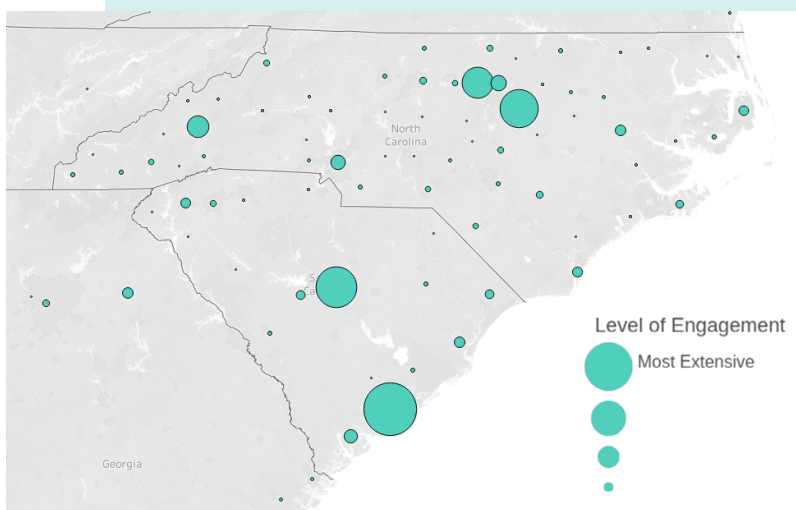
CISA works with partners throughout the Carolinas and the Southeast. Figure 1 (left) represents the location of CISA team members, partners, and individuals who participated in CISA-organized projects and events over the last year. The placement of the symbols represents the county location of individuals' organizations. The size of the circle reflects the number of participants and weighted participation values, used to represent the extent to which individuals participated in particular projects or events. For example, participation in a year-long research project received a greater weight than attendance at a one-day workshop. This analysis is part of CISA's ongoing Network Analysis and evaluation.

Photo Courtesy Jeremy Taylor, Flickr Creative Commons

2018 - 2019 HIGHLIGHTED ACCOMPLISHMENT
SHAPING THE FUTURE OF FOLLY BEACH, SC THROUGH SEA LEVEL RISE ADAPTATION

The City of Folly Beach is a small, barrier island facing a variety of coastal hazards, including the threat of sea level rise from both the ocean and marsh sides of the island. Referred to by local residents as "The Edge of America," Folly Beach is also a major tourist destination in South Carolina, making the maintenance of its beachfront properties and shoreline a top priority. The City first approached CISA in 2015 to request technical assistance to analyze the future impacts of sea level rise. CISA continued to partner with the City as they developed a Sea Level Rise Adaptation Report. In June, 2017, City Council voted unanimously to adopt the plan and the recommendations, including design of a marsh management plan. Building on that effort, there has been a new focus on creating policy recommendations to increase the resilience of waterfront properties.

City Council voted unanimously in May 2018 for a six-month moratorium on beach and marshfront development to investigate how to most effectively implement report recommendations. During this time, key stakeholders identified needs and policy recommendations for future-thinking development requirements. The City discussed a suite of land use, zoning, and building code ordinances that would improve resilience in the near and long term. There were multiple public hearings and discussions about the proposed ordinances. In January 2019, the ordinances were formally introduced and went into effect during the adoption process that was finalized in April 2019. Among the ordinances approved was a hotly contested increase to required **waterfront/marshfront set-backs for all new construction**. The **increase from 10 feet to 15 feet, including a 10-foot vegetated buffer**, was the result of months of discussion and recognition that any set-back larger than 15 feet would create dozens to hundreds of non-conforming properties.

> *Thank you so much for your guidance during this moratorium period on Folly Beach. It is very difficult for civilians - particularly myself, who is accustomed to black and white answers - to wrap their heads around sea level rise and how to prepare for it. Your guidance has been so helpful not only by way of the science but also in the area of how to speak to people about sea level rise and flooding. This experience may in fact change the course of my career and the rest of my life.*
> *~ Lisa Strauss, Folly Beach Planning Commissioner*

Additionally, the City requested **CISA's assistance with developing the marshfront management plan**, the first of its kind in South Carolina. The plan is a key recommendation in the SLR report because the marsh side of the island is the most vulnerable to tidal flooding and, while the City knew a great deal about the beachfront, it did not know as much about the marshfront. Throughout much of the process, we have been on-hand to assist with research involving living shorelines, sea level rise projections, and conversations about how the barrier island could buy time and space for the long-term. The next stage for this work will be to discuss planning efforts and new flood modeling with the City's residents in July 2019.

Providing Climate Information and Services through New Projects and Partnerships

ASSESSING BUSINESS IMPACTS OF HURRICANES AND FLOODING IN THE CHARLESTON, SC REGION

According to the U.S. Small Business Administration, 99.9% of businesses are small or medium-sized. These businesses play a critical role in the local and national economy, creating job growth and stability. However, recent hurricanes have caused revenue losses and business closures. **The College of Charleston estimates that Charleston-area businesses lost $111.3 million due to Hurricane Florence (2018) and Hurricane Irma (2017) and Hurricane Matthew (2016) had similar impacts.**

Working with leadership in the NOAA Climate Program Office, CISA established a partnership with researchers at the National Institute of Standards and Technology (NIST) to survey impacted businesses in Charleston, SC. The study seeks to better understand the true cost of hurricanes and identify strategies to make local economies more resilient. Early findings reveal that Hurricane Irma was a catalyst for businesses to not only create hurricane plans, but also to flood-proof their buildings. Of the businesses surveyed to date (n=29), 52% noted that they have a hurricane or severe weather plan in place and that these plans help with faster recovery. However, businesses are limited in their recovery efforts due to flood-prone locations and supply chain disruptions. Suggestions by business owners to improve their capacity to recover include additional resources for flood proofing their buildings, a business hotline for reliable information, rent assistance due to loss of revenue, and expedited small business loans after an event.

Next Steps

In addition to the Charleston region, NIST is conducting similar surveys in Maryland, North Carolina, Puerto Rico, and Texas. Surveys will be completed by the end of 2019. Researchers in the different locations will collaborate with each other and business owners to develop communications materials and guidance documents to better prepare for future events.

INNOVATING DROUGHT COMMUNICATIONS WITH NORTH CAROLINA DECISION MAKERS

In the aftermath of recent droughts in North Carolina decision makers across the state articulated needs for enhancing information and communications resources. With support from the NOAA Sectoral Applications Research Program (SARP), we are working with partners from the State Climate Office of North Carolina to improve the usability of drought information for the agriculture, forestry, and water resources sectors. Dubbed Project Nighthawk after the common nighthawk, a drought-resilient bird species native to NC, the project was designed as an iterative process that engages decision makers through various stages of product development, evaluation, refinement, and implementation. Feedback from groups such as the North Carolina Drought Management Advisory Council (DMAC), Cooperative Extension agents, and public water system managers is guiding refinements to communications materials and outreach strategies. Through early engagements, we learned that approximately half of survey respondents (n=140) were unaware of the NC drought monitoring process, the NC Drought Map, and/or the US Drought Monitor. Approximately half of respondents consider the NC and US Drought Monitor maps only moderately accurate or are unsure of their accuracy. The most useful types of information would clearly convey current and anticipated conditions, including 1-2 week and seasonal time frames, and place drought into local geographic and management contexts. More information about the results of the feedback survey and webinar can be found in the Phase 1 Summary Report. This feedback has been used to develop prototypes of communications materials tailored for each sector.

The NC DMAC and NC Division of Water Resources have been enthusiastic supporters of the project. NC DWR has begun posting the new drought information prototypes to their website. They also plan to revise and update the ncdrought.org website, using feedback from and new content developed through Project Nighthawk.

Next Steps

We will continue engagements with decision makers and stakeholder to refine the resources being developed through the project and to develop plans to support the dissemination of new products and their integration into decision making. We will disseminate a final survey to project participants and partner to further assess the effectiveness of the project in the final phase.

ASSESSING THE IMPACT OF CLIMATE CHANGE ON LONGLEAF PINE ECOSYSTEM MANAGEMENT

The longleaf pine ecosystem is iconic in the Southeast, but has been reduced to only a fraction of its previous acreage due to fire suppression, timber harvesting, and land conversion. In addition to urban growth, projected changes in temperature and precipitation patterns will continue to affect this ecosystem and the species that rely upon it. Through the Southeast Conservation Adaptation Strategy (SECAS), federal, state, nonprofit, and private organizations are seeking to coordinate conservation actions and investments to improve the health, function, and connectivity of regional ecosystems over the next 50 years. With support from the DOI Southeast Climate Adaptation Center, we are conducting research to better understand how decisions regarding longleaf pine prescribed burn planning and implementation are made across the Southeast region and how potential changes in climate and urban growth may influence the future use of prescribed burning as a management tool.

Next Steps

A survey will be circulated to fire managers in July 2019, to assess their current burn plans and practices and changes they foresee under future climate and urban growth scenarios. Managers' perceptions will be compared to work that our colleagues at the University of South Carolina, NC State University, and the Tall Timbers Research Station have already done which documents how climate change will narrow the window for optimal prescribed burning. We will tie these changes into management implications and possible adaptation strategies available to managers for prescribed fire activity.

CISA JOINS REGIONAL PARTNERS IN NEW COOPERATIVE INSTITUTE FOR CLIMATE AND SATELLITES

NOAA announced in May 2019 that the University of Maryland (UMD) was awarded the grant to host NOAA's Cooperative Institute for Satellite Earth System Studies (CISESS). CISESS is a consortium of both academic and nonprofit organizations that will be led by UMD and NC State University. CISA's role in the consortium stems for our experience in providing information about extremes to decision makers, such as that anticipated from improvements in seasonal to sub-seasonal forecasting. Our team consists of climatologists, who specialize in understanding the recurrence of climate extremes, and social scientists, who are experienced in increasing the accessibility of data through innovative communications methods. We will work with CISESS to extend their work on forecasting extremes to develop resources to help reduce the impacts of extreme events and support NOAA's efforts under the Weather Research and Forecasting Innovation Act of 2017.

Photo Courtesy Kirsten Lackstrom

Case Studies in the Carolinas
Projects to Increase Adaptive Capacity

SUPPORT FOR SOUTH CAROLINA'S DROUGHT RESPONSE PROGRAM

This project was initiated on the heels of an extreme drought and wildfire season in fall 2016. Through CISA's ongoing partnership with the SC State Climatology Office we have conducted a variety of research and engagement activities to enhance the State's Drought Response Program and improve drought preparedness and response.

» **The first South Carolina Drought Tabletop Exercise, co-hosted by CISA, the SC SCO, the SC Water Resources Center, and the SC Emergency Management Division (EMD) in September 2017, resulted in 23 appointments by the Governor's Office to fill vacancies on the South Carolina Drought Response Committee.**

Another major milestone for the collaboration was the creation of the scdrought.com website. CISA assisted the SC SCO with the development of new informational resources for this website, including several flyers (Drought Monitoring and Response in South Carolina, Water Conservation Tips, and How much water can you save?) and content on the Impacts page. The website has drawn more than 7,500 views over the past year, with nearly one third of page visits occurring in May 2019, with the onset of drought conditions in the state.

» **The scdrought.com website is used as the primary drought information portal for South Carolina. It is used by the SC SCO to display the State's drought status. The State Drought Response Committee members use the website to access the drought indicators and indices they are required to use for drought monitoring and determining drought levels for SC's 46 counties.**

The website was recognized as a "Notable State Document" by the SC State Library. This annual award, conferred by the SC State Library since 1991, recognizes state governmental publications of outstanding merit and usefulness to South Carolina.

"The Notable Documents Awards are presented every year to focus on the important value of information compiled and produced by state governmental agencies and to emphasize the importance of open and equal access to this information. The efforts of your agency are to be congratulated."

~ Leesa Aiken, SC State Library Director

ENGAGING CITIZEN SCIENTISTS IN DROUGHT MONITORING AND REPORTING

CISA is working with volunteers throughout the Carolinas to improve our understanding of how drought impacts ecosystems and communities. Using tools developed by the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network these citizen scientists take daily rainfall measurements and submit weekly condition monitoring reports to share information about how recent rainfall, or a lack thereof, has affected their community and environment. Regular reporting helps to identify expected seasonal changes versus changes caused by unseasonal wet or dry weather conditions. Reports can also reveal the onset, intensification, or recovery from wetter or drier than normal conditions.

Condition Monitoring began as a pilot project in the Carolinas in September 2013. It has now transitioned to a national program, engaging thousands of citizen scientists throughout the United States.

» **14,789 condition monitoring reports were submitted during the reporting period (June 2018 – May 2019) by 4,119 observers. These reports are used to inform state and national-level drought designations, which, in turn, are used to assist sectors experiencing the most severe impacts of drought.**

» **The NC Drought Management Advisory Council incorporates report information into the weekly state drought map.**

» **National Weather Service Forecast Offices use the reports to recommend the drought status in their county warning areas and for other forecasts (e.g., fire weather warnings).**

» **US Drought Monitor map authors download the reports weekly as a GIS layer to review as part of their "convergence of evidence" in drought designation.**

Based on recommendations from report users, a "Consistent Stations" layer was added to the national web map, which only displays observers who have submitted at least 20 reports in the last twelve months (about once every two weeks). Because these observers consistently submit reports about local conditions, web map users have a better understanding of the timescale of changes observers report.

Over the next year, we will continue to conduct activities that foster and build the network of observers in the Carolinas. We are developing regional guidance to reflect drought impacts in other geographies and climates throughout the U.S. And we are working with decision makers, particularly those in National Weather Service Forecast Offices, to assess additional ways report information might be used (e.g., frost/freeze warnings, fire weather forecasts, etc.).

TRANSFERRING CLIMATE ADAPTATION KNOWLEDGE AND TOOLS FROM NEW ENGLAND TO GEORGETOWN, SC

Georgetown, SC has experienced consecutive years of major storms and increased chronic flooding. This has led to disruptions in lives and jobs, damage to homes and health, and loss of revenue, among other impacts. A project team with members from CISA, the North Inlet-Winyah Bay NERR, and Coastal Carolina University worked with The Consensus Building Institute to transfer the New England Climate Adaptation Project (NECAP), a role play scenario process for community engagement, to Georgetown.

The project used South Carolina-specific climate projections provided by CISA in community engagement sessions to teach decision makers how to effectively use the projections for planning and resources management. CISA's role in producing climate change scenarios involved use of the newest generation of climate model simulations under the framework of Coupled Model Intercomparison Project Phase 5 (CMIP5) of the World Climate Research Programme (IPCC 2013). We used the downscaled daily minimum temperature, daily maximum temperature, and daily precipitation outputs from 20 general circulation models to produce projections for the short-term (2010-2039), medium-term (2040-2069), and long-term (2070-2099), relative to the historical baseline period (1976-2005).

> » **Partners with the North Inlet-Winyah Bay NERR and Coastal Carolina led three** stakeholder engagements **to share these future climate projections and consider impacts and adaptation strategies for Georgetown.**

The engagements were conducted as role play simulations in order to allow people to explore different viewpoints, take risks, and consider options they normally might not. Participants were asked to review the background of a fictitious community, their role, and climate projections in preparation for the role play. During the engagements, participants were challenged to reach a consensus on "shovel-ready" projects to reduce flooding impacts in the community.

As a next step, partners with the North Inlet-Winyah Bay NERR plan to further utilize the future climate scenarios in conversations with local government leaders in Georgetown County. Partners will encourage local government to consider some of the adaptation strategies discussed during the engagements and how those might be incorporated into a Sea Level Rise Adaptation Strategy for the community.

Photo Courtesy Kirsten Lackstrom

NEW PARTNERSHIPS IN MT. PLEASANT AND NORTH CHARLESTON, SC

Working through a NOAA Regional Coastal Resilience grant, CISA along with partners at the S.C. Sea Grant Consortium, College of Charleston, and The Citadel are engaging stakeholders in the Charleston region to improve understanding of flood risk and strategies to increase resilience. A high resolution, parcel-level flood model was created to incorporate tidal and stormwater flooding and provide a more realistic view of what happens during storms or other flooding events. CISA project members produced future precipitation scenarios based on dynamically downscaled precipitation data, which were incorporated into this parcel-level flood model. A core part of the project is to take draft model output to representative neighborhoods in the Charleston metro area to ground truth the data as well as provide flood education and engagement with residents. These engagements have led to new connections with local government in the region.

> » **Maps from the model output have been presented in two neighborhoods in the Charleston region with plans for three additional engagements. Once further refinements to the model are complete, decision-makers and residents throughout the region will be able to access the model to explore risks to their community and property as well as have the decision-making tools for discussions on how to reduce risks in the future.**
>
> » **The North Charleston event was the first of its kind for the City and helped springboard local leaders to begin focusing on larger flooding issues. The Mayor mentioned the event and the City's collaboration with CISA in the State of the City address in January 2019. A new flood resilience task force was also formed. City officials credit this event as the catalyst for the task force's creation.**

The first two of five engagements were held in the Town of Mt. Pleasant and City of North Charleston in July and November 2018, respectively. The engagements incorporated over 30 staff members from each municipality and were attended by nearly 100 residents. These engagements are designed as inclusive, service-focused events where residents are not just providing information, but also receiving knowledge and building relationships with municipal staff and their own neighbors. We worked closely with the College of Charleston team to help them create mapping products that incorporate sound risk communication science practices and build connections for municipalities to use these products for decision-making. We also incorporated a resident survey to understand what actions citizens are already taking to reduce flooding risks at home.

INFORMING PUBLIC HEALTH PREPAREDNESS WITH THE HAZARDOUS EXTREMES RISK ASSESSMENT TOOL

The Hazardous Extremes Risk Assessment (HERA) tool is a decision support tool designed to assist community agencies in planning and preparedness for extreme events. HERA was developed to provide information for a variety of often small entities, such as hospices, which receive funding from the U.S. Center for Medicaid and Medicare Services (CMMS). As a condition of funding, these entities are required to have emergency preparedness plans and provide staff trainings.

» **HERA provides decision support to inform these emergency preparedness plans through data visualizations; county-level data and information on extreme events including probabilities and recurrence intervals; comparisons across counties to state averages; and information on event-specific impacts.**

Based on feedback from decision makers, CISA team members at UNC Chapel Hill added new data layers to help organizations understand risks they perceive to be most relevant to their planning, including traffic accidents, heavy precipitation and flooding, and winter weather. Additional layers currently in development will include the percentage of county populations that live in a designated floodplain as well as the average value of county parcels within the floodplain. Researchers at the University of South Carolina are creating the datasets needed to launch the HERA tool in South Carolina as well.

FORECASTING WET BULB GLOBE TEMPERATURE FOR HIGH SCHOOL ATHLETICS

Current methods of estimating human heat stress (e.g. heat index & humidex) only account for air temperature and humidity; they do not consider the added burden of radiation (both solar and infrared from the surrounding surface) and lack of ventilation (i.e. low wind speed). National Weather Service (NWS) heat advisories and warnings solely utilize the heat index; they do not factor in these important influences on heat stress. Wet Bulb Globe Temperature (WBGT) accounts for these variables and therefore provides the best estimate of human heat stress, especially in local environments where radiation and air ventilation is exceptionally high or low. WBGT is becoming a required element for high school athletic coaches as they plan training. While very few weather stations include a WBGT thermometer, translator functions have

been developed to estimate WBGT from measurements of air temperature, humidity, solar radiation, and wind speed.

We have constructed the first version of a web-based application that provides an hourly forecast of WBGT for the next 5 days, updated twice a day. The application uses a translator function that converts gridded NWS forecasts of temperature, humidity, cloud cover, and wind speed to a WBGT value. The user simply provides their location, presses the "submit" button and a graphic is produced that shows not only the hourly forecast, but also the hourly WBGT values that were observed over the last 2 days. In addition, the graphic depicts the degree of danger (i.e. heat stress) for different values of WBGT.

Through collaboration with the NC High School Athletics Association, the WBGT tool will be piloted with 10 high schools across NC during summer 2019. We will document changes they make in the timing/nature of workouts in order to minimize heat stress (e.g. practicing in the shade, moving practice back an hour, moving workouts to a day in which the heat stress is predicted to be less, etc.). In addition, we will learn about the challenges of conveying the WBGT scale of heat stress in which danger levels begin at 80°F and are maximized at 90°F or greater.

CISA Research Assistant Jordan Clark demonstrates how to use a wet bulb globe thermometer with Carrie Powell, Athletics Director at Swain County High School in North Carolina.

» **By preventing heat illness, the application, once refined, will reduce the number of emergency room visits, which average around $5300 per visit in North Carolina. In 2017, there were 3005 emergency department visits reported by the NCDPH for an estimated cost of $16.1 million. The use of the WBGT for targeted prevention of vulnerable groups in NC may reduce this financial burden.**

INCORPORATING CLIMATE PROJECTIONS INTO COMPREHENSIVE PLANNING

In October 2018 the City of Columbia, SC launched the Columbia Compass Envision 2036 campaign, part of the comprehensive planning process. As part of this effort, the City is conducting research about the community's population, natural resources, land use, transportation, housing, community facilities, cultural resources, and economy. The City is actively seeking public involvement in plan development through community meetings, online surveys, and other opportunities to share feedback. Members of the City's planning department met with the CISA team to discuss how current extremes and climate change might play a role in the City's future.

» **The City requested additional information about the number of high heat days, very warm nights, days below freezing, and observed heavy precipitation events. This information will be incorporated into various aspects of the City's comprehensive plan.**

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CISA's assistance has been invaluable as we work to update the City of Columbia's comprehensive plan. Our goal for this planning process, and for the City, is to develop a data-driven analytical approach to the issues we face now and expect to face in the future. We are truly grateful to have the opportunity to work with these leaders in their field to plan for a more resilient Columbia through identifying and implementing robust strategies for managing natural hazards and increased strains on resources, including consideration of climate change-related risks.

~ Leigh DeForth
City of Columbia, SC
Comprehensive Planner

Outreach & Engagement
Supporting Climate Information Networks in the Carolinas

COMMUNICATIONS AND OUTREACH MATERIALS

- The Carolinas Climate Connection newsletter is circulated quarterly to 3,238 subscribers. Topics this past year included project updates, event recaps, and reviews of local water and wildlife action plans, informational resources, stakeholder feedback requests, and funding opportunities.

- CISA leads communication efforts for the Southeast and Caribbean Climate Community of Practice including a webinar series, website, engagement and event emails, and social media (Facebook 46 followers)

- CISA maintains communication channels with its stakeholders using social media including Facebook (236 followers) and Twitter (625 followers).

- The Carolinas Climate Listserv is circulated to 382 subscribers once or twice a week bringing information about events, research, funding and local climate interests most relevant to the Carolinas.

- CISA communicates with Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) volunteers in the Carolinas through a monthly newsletter circulated to 2,507 citizen scientists. The newsletter offers insights into current climate and drought in the Carolinas, citizen science opportunities, and utilization of data submissions by decision makers.

CISA Hosts Third Carolinas Climate Resilience Conference

CISA hosted the third Carolinas Climate Resilience Conference on October 29 - 31, 2018 in Columbia, SC. Although the event had to be rescheduled due to Hurricane Florence, it drew 248 attendees from throughout the region. Members of federal, state, and local governments in addition to tribal, private, and other non-governmental organizations contributed to over 100 presentations and an atmosphere ripe with engagement and networking. Continuing education credits were provided to certified floodplain managers and licensed engineers and land surveyors at no additional cost to registrants. The conference was also certified carbon neutral in partnership with Greensboro, NC-based Urban Offsets. Former Charleston Mayor for 40 years, Joseph Riley was the keynote speaker during the closing session of the conference. Mayor Riley emphasized the importance of partnerships and working together as a society to create change. Other highlights included

- collaboration with the American Society of Adaptation Professionals to organize the "Accelerating Climate Action through Innovation and Technology" track and award the first Carolinas Regional Adaptation Leadership Award,
- a plenary session on flood mitigation and adaptation in the Carolinas during which speakers addressed the impacts of recurrent flooding events and sea level rise,
- and a panel discussion with representatives from Native American tribes about how they are coping with the impacts of climate change.

Learn more in the final conference report.

> *"I love that this conference brings scientists and decision makers together so that we can all interact and have meaningful conversations that translate to real-world changes. I met many great people at the conference, and it allowed me to make connections with those in my field."*
>
> ~ 2018 CCRC Attendee

Coastal Resilience Center @CoastalResilCtr — Following

Mark Wilbert, Chief Resilience Officer of @CityCharleston, talks about combatting sea level rise as "a small to medium-sized Southern city trying to battle an existential issue....with organic money." #CCRC2018

Dr. Jessica Whitehead @JCWclimate — Following

Sushma Masemore @NCDEQ gives #climate #resilience practitioners and researchers attending #CCRC2018 an overview of @NC_Governor Executive Order 80 on mitigation and adaptation in NC.

NOAA Risk Communications Training

On January 15, 2019, Sarah Watson assisted the NOAA Office for Coastal Management in leading a Risk Communication Basics training in Mt. Pleasant, SC. This one-day training, co-developed by Watson and hosted by the ACE Basin and North Inlet-Winyah Bay NERRS, helps participants learn the basics about why people perceive things as they do, highly applicable methods for improving communication with all types of people, and practice applying those skills in role playing exercises. Multiple municipalities, including some of those Watson works with in the Charleston area, attended and reported using what they learned to improve how they communicate coastal risks to various constituencies.

Southeast & Caribbean Climate Community of Practice Workshop

CISA collaborated with NOAA and the Southeast Sea Grant programs to host the fourth Southeast & Caribbean Climate Community of Practice Workshop in Wrightsville Beach, NC on April 1 – 3, 2019. Sixty-seven attendees came from a diverse range of professional backgrounds and geographies. Discussions included strategies to prepare for, respond to, and recover from extreme events, how best to create frameworks to incorporate climate adaptation into local planning, and a review of current climate science in the Fourth National Climate Assessment. Barbara Doll, Water Protection and Restoration Specialist with NC Sea Grant, was the keynote speaker. She shared her experience helping rural communities in North Carolina assess their riverine flooding risk and identify viable solutions to address future impacts and increase resilience. Attendees also had the unique opportunity to meet with Captain Terry Bragg, Executive Director of the US Battleship North Carolina to learn about their new "Living with Water" campaign, which will incorporate living shorelines and restored wetlands to reduce the impacts of sea level rise at the battleship site. Access the final workshop report here.

"In 2016 I started working for the Town of Swansboro, NC. In preparing to update the CAMA Land Use Plan I was interested in learning more about the relationship of sea level rise and coastal adaptation planning. After attending the 2017 Southeast and Caribbean Climate Community of Practice meeting my understanding of sea level rise was greatly changed. I was able to tap into a community of professionals willing to help Swansboro. Being exposed to the community of practice has changed me from an AICP planner not so sure how sea level rise impacts my community to a convert sharing and working to help other small local governments undertake a VCAPs assessment. I very thankful for the experience and the opportunity at this year's 2019 Community of Practice workshop to share back Swansboro's experience and validation of our vulnerable location after Hurricane Florence. Thank you for the CISA scholarship enabling me to attend this year's meeting."

~ Andrea Correll, Planner, Town of Swansboro, NC

Captain Terry Bragg, Executive Director of the US Battleship North Carolina, discusses the impacts of recent hurricanes and sea level rise to the US Battleship North Carolina site in Wilmington, NC. Photo Courtesy Geno Olmi.

The CISA Footprint
Evaluating Our Impact in the Region

CISA's evaluation efforts seek to measure how effectively we are achieving our program goal of supporting and fostering the capacity of the Carolinas to respond to and prepare for climate variability and change and associated impacts on the region's resources and communities. We work to achieve this goal through four key program elements:

- Research to advance understanding of climate and its impacts in the Carolinas;
- Collaborations to support the implementation of climate adaptation strategies;
- Providing decision support services; and,
- Outreach and engagements to foster climate information networks throughout the region.

Throughout the life of the CISA program, we have adopted various approaches to monitor and evaluate our impact, including both quantitative metrics and qualitative analysis of individual projects and the program as a whole.

Individual projects, such as the Convergence website, the Hazardous Extremes Risk Assessment (HERA) tool, and Project Nighthawk, integrate evaluation questions and metrics into research and engagement activities. Direct stakeholder feedback helps us understand what types of information are most important and how stakeholders intend to use the information, which, in turn, informs resource and tool development through an iterative process. Evaluation requests are circulated to all workshop and conference attendees to improve future events and assess which content is most relevant and useful.

2018 PROGRAM EVALUATION

In 2018, CISA undertook a mid-grant program review to evaluate our regional impact and recommend adjustments to current projects and future directions. Three external reviewers attended the 2018 Carolinas Climate Resilience Conference (CCRC), where they interviewed CISA Advisory Committee members, PIs, and staff. By hosting them during the CCRC, evaluators were also able to participate in sessions during the conference and meet with collaborating researchers, stakeholders, and students to learn about their work with CISA team members. Reviewers returned recommendations encompassing our program areas of coasts, health, drought, engagement, and program management. We will incorporate their recommendations into the final two years of the current grant as well as plans for the next five-year proposal.

NETWORK ANALYSIS

As part of the 2018 program evaluation, we also undertook a network analysis to assess progress towards our overarching goal of "fostering climate information networks." Through the network analysis, we explored the expansion of CISA's network over time, how we are creating this expansion (i.e., through targeted outreach, communications, and collaborative projects), and the effectiveness and impact of CISA's efforts to enhance the exchange and use of climate information.

Overall, for the 2005-May 2018 period, we identified 133 activities that CISA led or co-led. This total included 53 long-term research projects, 51 project-specific events, and 29 outreach events such as workshops and conferences. During that time, a total of 2,035 "unique" individuals and 683 "unique" organizations participated in CISA activities.

We used an "affiliation network" approach to explore the question "How does CISA help to connect different individuals, organizations, and sectors with one another?" In this approach, nodes consist of both "activities" and "organizations. "Edges" represent the connections between the nodes (i.e., connections between activities and organizations). Using the Gephi network analysis software, we generated a variety of network analysis measures to examine the relative importance of different activities in supporting a climate information network in the Carolinas and the relative importance of different organizations in this network. The graphics on the next page help to illustrate those connections across the network.

Strengthening Ties through Projects and Events

The eigencentrality measure (Figure 2 below) indicates a node's importance in the network based on that node's connections. It reflects a node's connections to other nodes as well as how many ties those other nodes have. The larger text size indicates the most important organizations and activities in the network. In this figure, "most important" corresponds to the "most connected" nodes. Events such as the Carolinas Climate Resilience Conferences (CCRC), and organizations such as the Department of Interior, SC Department of Natural Resources, NOAA's National Ocean Service, and National Weather Service emerge as the "most connected" nodes.
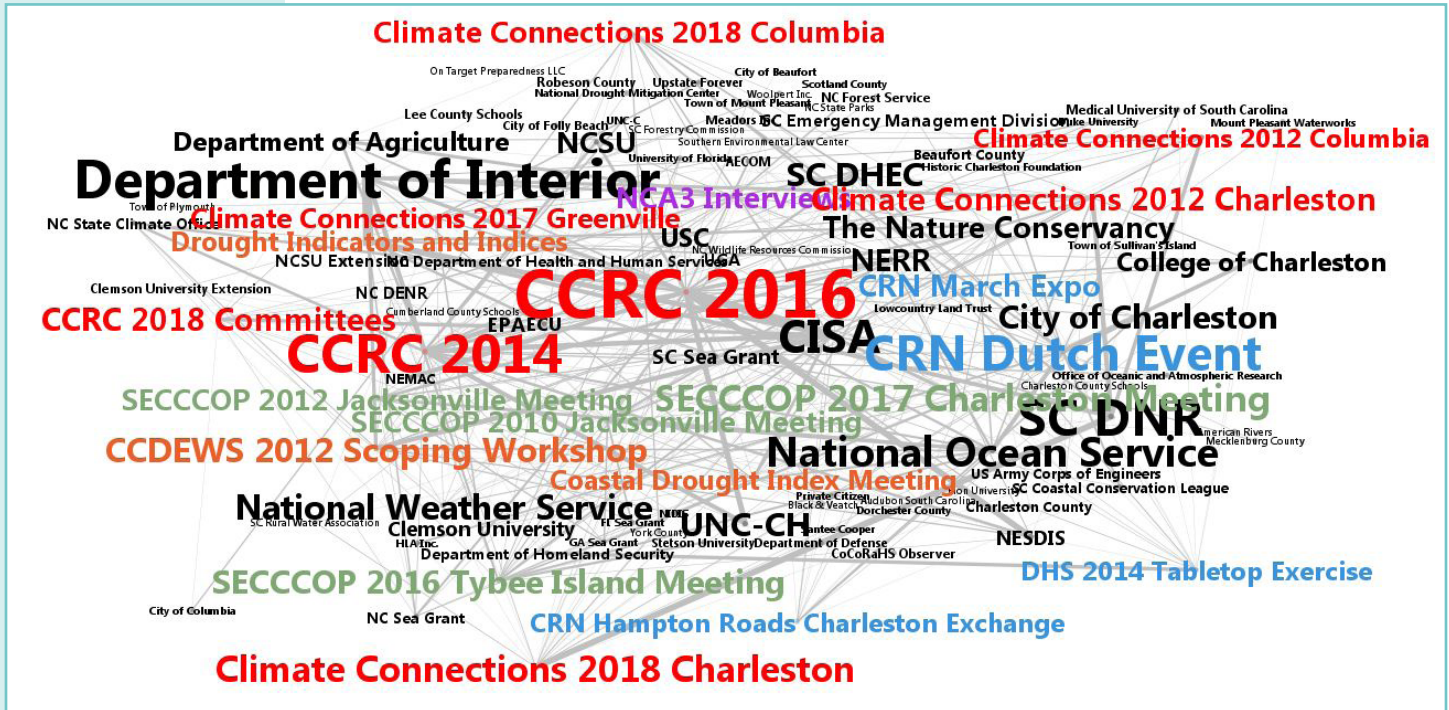
Cross Pollinating the Carolinas Climate Adaptation Network

The betweenness centrality measure (Figure 3 below) reflects the number of times an activity connects organizations who are otherwise disconnected or may not be able to reach other organizations. Importance reflects an activity's function in facilitating information exchange between otherwise unconnected entities. Compared to the eigencentrality measure (above), the betweenness centrality measure has several pros and cons. Individual organizations' roles in the network are not emphasized as much, but we see that several new activities emerge, most notably CISA's health-related engagements (in dark green) which increased with the hiring of Ashley Ward in 2016. Higher values are also given to activities where we engaged organizations that might not be considered CISA's "core" constituents, but where we may have expanded our network. Examples include the NCA3 Interviews, Coastal Drought Interviews, and SECAS. On the other hand, the CRN Dutch Event, where Dutch experts shared their vision for "living with water", emerges as the "most important" activity. This reflects the large number and proportion of attendees representing the private sector, local businesses, and community groups in the Charleston area that have not participated in previous CISA activities. In addition, while CISA did support this activity through our ongoing engagement with the SC Sea Grant Consortium and the CRN, this Dutch Event was a one-time discussion event and not representative of CISA's central efforts.
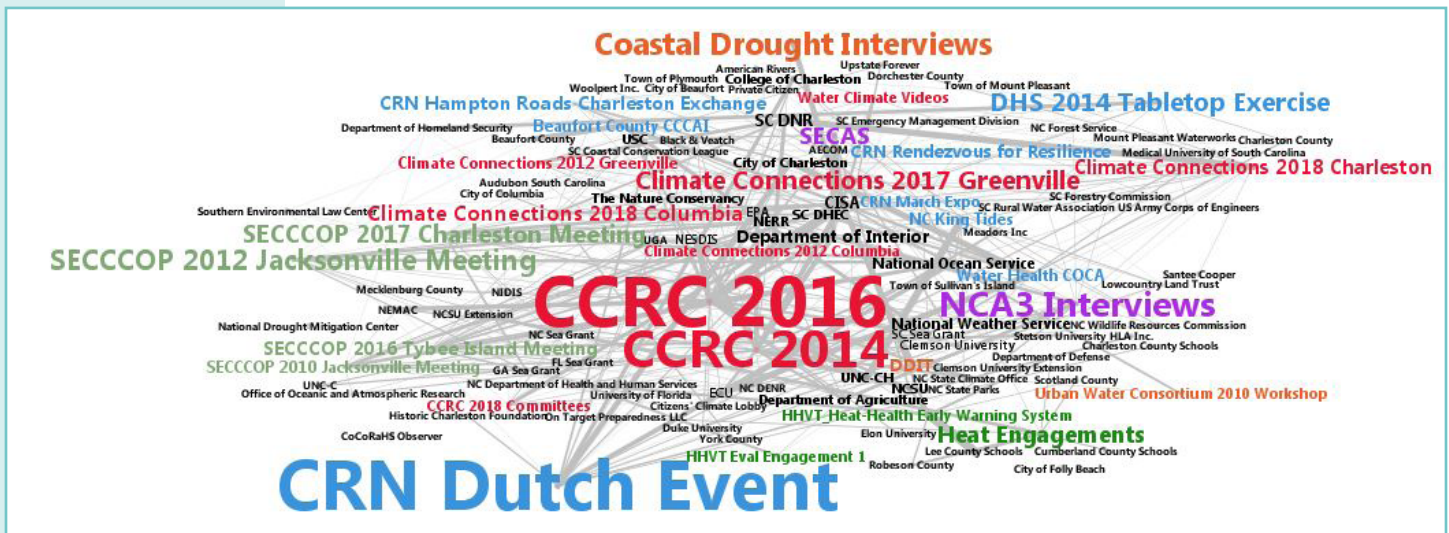
CISA
BY THE NUMBERS

18 student researchers

30 collaborating organizations

923 project partners and stakeholders

16 newsletters

8 journal articles and project reports

16 conferences, training sessions, workshops

$9,858 in travel support

$567,164 leveraged grant funds

Projects Overview

Launched in 2012, the Coastal Carolinas DEWS focuses on 1) improving understanding of the unique vulnerabilities and impacts of drought on coastal ecosystems and 2) developing tools, information, and other resources that will help managers and decision makers integrate drought and coastal resource management activities.

Several CISA projects contribute to the Coastal Carolinas DEWS, through building understanding of droughts' effects on the Carolinas' coastal ecosystems, developing new approaches and products to improve the use of drought information, and engaging with regional decision makers on drought issues.

The Coastal Salinity Index

Team Members: Lackstrom, Rouen

Overview: The Coastal Salinity Index (CSI) was developed to characterize coastal drought by monitoring the freshwater-saltwater interface. The tool is intended to improve understanding of the ecological and human impacts of changing salinities. CISA collaborates with DEWS partners at the USGS South Atlantic Water Science Center on several activities designed to advance the CSI's development.

2018-2019 Activities:

- Continued development of the **CSI Website**, providing real-time CSIs for 17 sites in North Carolina, South Carolina, and Georgia. This site is hosted by the USGS South Atlantic Water Science Center. CISA developed content and engaged colleagues and decision makers to obtain feedback on the website prototype. This feedback was used to enhance the site's functionality and usability.
- **CSI values for 97 sites** from North Carolina to Texas have been calculated and will be available through USGS ScienceBase later in 2019. CSI prioritized 34 sites for CSI calculation that are of interest to Coastal Carolinas DEWS and worked with USGS to determine the best approach to address missing data issues
- A **USGS Open-File Report** documenting the activities listed here is currently in the editing process and is expected to be available by mid-summer 2019. The report includes the "**CSI User Guide**" developed by CISA.

Deliverables:

- Completed the CSI R-package, which can be used to calculate the CSI using your own data or data downloaded from other sources, such as USGS or NERRS. Available at https://github.com/USGS-EDEN/CSI.
- See Appendix: 2018 - 2019 CISA Deliverables for additional citations.

Data Management: The salinity and ecological response datasets are available in several forms on the CISA project website (http://cisa.sc.edu/projects__salinity.html): Excel spreadsheets, ArcGIS layers, Google Earth (KML) layers. The CSI data release, Open-File Report, SAWSC CSI website, and other final deliverables are currently under review by USGS. They will follow USGS data management requirements and be available through USGS when completed in summer 2019.

Citizen Science Condition Monitoring Project

Team Members: Farris, Lackstrom, Guiseppe, Davis, Mullin, Ramthun

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. This project addresses a need for improved understanding of drought impacts and for impacts information to facilitate decision making. Learn more about how the reports are used to inform drought designations on page 7.

2018-2019 Activities:

- Updates to the CoCoRaHS Condition Monitoring Web Map, to include:
  - » Creation of the "consistent stations" filter to allow users to view reports from the most reliable CoCoRaHS observers
  - » Updated geolocation features to make finding a specific station easier
  - » Improved search options to allow map viewers to search specific reports in the current map view and easily filter specific types of information such as soil moisture levels, fire risk, or to view reports from a specific station
  - » Enhanced time slider functionality to allow users to view report from any desired day since the launch of the national web map in October 2016
- Team members began the process of collecting information to inform regional condition monitoring guidance for other climates and geographies across the U.S.

Deliverables:

- The above web map updates were disseminated to drought decision makers via this informational flyer: New Features Added to the Condition Monitoring Webmap.
- See Appendix: 2018 - 2019 CISA Deliverables for additional citations

Support for South Carolina's Drought Response Program

Team Members: Lackstrom, Altman, Farris, Guiseppe

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.

2018-2019 Activities:

- Assisted with the development of new information resources for the scdrought.com website
- Collaboration with SC EMD on an information sheet tailored to emergency managers
- A "drought manual" has been draft for SC Drought Response Committee members
- Preparations are underway for the 2nd SC Drought Tabletop Exercise, to be held July 24, 2019

Deliverables:

- The scdrought.com website has drawn over 7,500 in the past year and received the "Notable State Document" award from the SC State Library.
- See Appendix: 2018 - 2019 CISA Deliverables for additional citations.

Innovating Drought Communications with North Carolina Decision Makers

Team Members: R. Ward, C. Davis, Lackstrom

Overview: In the aftermath of recent droughts, decision makers across North Carolina articulated needs for information and communications that enhance existing drought resources. This project, led by the State Climate Office of North Carolina (SCONC) is developing sector-specific information for drought decisions, delivering accessible and actionable information, and improving the transparency of the drought monitoring process.

2018-2019 Activities:

- We conducted online surveys and webinar focus groups with three key sectors (agriculture, forestry, and water resources) to identify and refine priorities for developing research products, then turned them into tailored prototypes.
- We have begun engaging stakeholders to evaluate the quality and efficacy of these prototypes.

Deliverables:

- SCONC hosts the project website.
- The Phase 1 Summary Report and Phase 1 2-pager summarize the Phase 1 activities and results.
- The Spring 2019 Update summarizes project progress, including decision maker engagements, to date.
- In May 2019 the NC DEQ/DWR began posting prototype NC drought map infographics developed through Project Nighthawk on the ncdrought.org website.

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

Basin-level Analysis of Extreme Precipitation Events

Team Members: Carbone, Gao, Lu

Overview: CISA researchers are investigating observational records and model output to better understand extreme precipitation in the Carolinas. The research aims to overcome challenges associated with insufficient sample sizes, the ability of point data to represent basin water volumes, and estimating infrequent events.

2018-2019 Activities: Using two watersheds in South Carolina, we examined how differently-sized hydrologic units respond to three different representations of heavy rainfall, using the US Army Corps of Engineers' Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS).

Deliverables:

- Gao, P., G.J. Carbone, and J. Lu. 2018. Flood simulation in South Carolina watersheds using different precipitation inputs. Advances in Meteorology, vol. 2018, Article ID 4085463. https://doi.org/10.1155/2018/4085463.

Data Management: We generated precipitation data for the watersheds from the three sources described above. These data, and all other model inputs and outputs are stored on a networked hard drive maintained by Greg Carbone. Questions should be directed to Greg Carbone (carbone@mailbox.sc.edu).

Historical and Future Assessment of Agricultural Drought

Team Members: Carbone, Lu

Overview: This project aims to put agricultural drought in historical context. Using historical crop yield data, we compared how correlation between agricultural output and drought conditions varied across modeling methodologies. We also examined the key sources of uncertainty in forecasting agricultural drought.

2018-2019 Activities:

- We developed a monthly agriculturally based drought index called the Integrated Scaled Drought Index (ISDI) that combines satellite-derived measures of moisture and land surface temperature with in-situ precipitation and model-derived soil moisture.
- We compared the robustness of different models to identify the foremost sources of uncertainty in forecasting agricultural drought.

Deliverables:

- Lu, J., G.J. Carbone, and J. Grego. 2019. Uncertainty and hotspots in 21st century projections of agricultural drought from CMIP5 models. *Scientific Reports* 9(1), 4922. https://doi.org/10.1038/s41598-019-41196-z.
- Lu, J., G.J. Carbone, and P. Gao. 2019. Mapping the agricultural drought based on the long-term AVHRR NDVI and North American Regional Reanalysis (NARR) in the United States, 1981-2013. *Applied Geography* 104: 10–20. https://doi.org/10.1016/j.apgeog.2019.01.005.

Data Management: Map are currently stored on a networked hard drive maintained by Junyu Lu, and also have been made publicly available on the Carolinas Precipitation Patterns & Probabilities Atlas. Questions should be directed to Greg Carbone (carbone@mailbox.sc.edu).

Organic Soil Moisture Monitoring in Coastal North Carolina

Team Members: R. Ward, C. Davis, Heuser

Overview: In partnership with the Nature Conservancy, US Fish & Wildlife Service, and NC State Parks, we are establishing a system of soil moisture monitoring stations to inform fire risk decision making in eastern North Carolina, a region where wide variation in organic soil properties has made fire risk measurement difficult.

2018-2019 Activities:

- Meetings held with partner organizations to gather and incorporate feedback into the management of monitoring stations, collection of soil samples, and visualization of gathered data.
- Three monitoring stations have been installed, with a fourth scheduled for completion in summer 2019.

Deliverables:

- Current and archived data from the organic soil moisture monitoring stations are viewable on the Fire Weather Intelligence Portal map and on meteograms for each station showing change over time. The parameters include air temperature, relative humidity, and precipitation, along with volumetric soil moisture content for all five levels at each station, averaged across the three sensor columns.

Data Management: Organic Soil Moisture (OSM) Monitoring Station Data, Created by the State Climate Office of North Carolina, Published beginning March 6, 2018, Housed in the SCONC's internal MySQL database, Access provided on the Fire Weather Intelligence Portal at https://climate.ncsu.edu/fwip/. Questions should be directed to Corey Davis at cndavis@ncsu.edu.

Assessing Climate Sensitivity and Long-Term Water Supply Reliability with a NC Water System

Team Members: Carbone, Patel

Overview: This collaborative project seeks to address a local water utility's questions about the appropriate use of climate change projections to inform long-term water supply planning. We employ a vulnerability-based approach to understand the nature of climate changes that are consequential to planning decisions in order to extract credible and relevant information.

2018 – 2019 Activities: The reliability of water supply is significantly affected only under extreme long-lasting dry periods. Changes in extremes, however, are challenging to ascertain meaningfully from available climate model ensembles because of role of natural variability. We are, therefore, exploring the potential usefulness of initial condition ensembles like CESM-LENS for this analysis.

Data Management: Stochastic meteorological inputs are used to drive a rainfall-runoff model and two reservoir operation models to understand the nature of drought conditions that lead to low storage or low firm yield levels. Simulation inputs and outputs are stored by Aashka Patel (aashkajp@gmail.com) on a secure network drive.

Impacts of Heat on Pregnant Women

Team Members: A. Ward, Konrad, Clark, Runkle, Sugg

Overview: This study seeks to understand the impact of high heat on gestation period over a 5-year period during the heat season of May-September. This study also seeks to understand differences between the impact of heat on preterm labor in urban and rural areas as well as regional differences in North Carolina.

2018 - 2019 Activities:

- Analysis was conducted to describe the relationship between high heat days, preterm delivery, and length of gestation in NC during the 2011-2015 heat seasons. Results have been summarized in presentations and an article currently in press.

Deliverables:

- Ward, A., Clark, J., McLeod, J. Woodul, R., Moser, H., Konrad, C. "Excessive heat and preterm birth in North Carolina, 2011-2015." (Accepted: International Journal of Biometeorology)

Data Management: All data is saved on password-protected computers. Electronic transmission of data occurs via encrypted software (VeraCrypt) and is shared only with project partners. Direct questions to Chip Konrad (cek@email.unc.edu).

BUILDING REGIONAL RESILIENCE TO WATER-RELATED HAZARDS IN THE CHARLESTON, SC REGION: A CHARLESTON RESILIENCE NETWORK INITIATIVE

Team Members: Watson, Dow, Carbone, Bundrick, Knapp, Levine, DeVoe, Ghanat, W. Davis

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

2018 – 2019 Activities:

- Public engagements were hosted in collaboration with the Town of Mt. Pleasant and City of North Charleston in July and November 2018, respectively. The engagements incorporated over 30 staff members from each municipality and were attended by nearly 100 residents.
- Engagements are currently being planned for July and September 2019 in the City of Folly Beach, the Eastside neighborhood on the Charleston peninsula, and in West Ashley.

Deliverables:

- Climate model output from Had_RegCM and GFDL_WRF was used to produce precipitation projections which were incorporated into the parcel-level flood model. Maps were then created to use during the two public engagements to display model output that participants helped to ground-truth based on previous flooding events.

Data Management: We have collected precipitation data 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 Peng Gao. Questions should be directed to Greg Carbone (carbone@mailbox.sc.edu).

FROM NECAP TO GCAP: TRANSFERRING CLIMATE ADAPTATION KNOWLEDGE AND TOOLS FROM NEW ENGLAND TO GEORGETOWN, SC

Team Members: Carbone, Dow, Lu

Overview: We are working with the developers from the New England Climate Adaptation Project (NECAP) to localize consensus based decision-making simulations to address the coastal flooding issues in Georgetown, SC.

2018 - 2019 Activities: South Carolina-specific downscaled climate projections provided by CISA team members were incorporated into three stakeholder engagement activities. More information about these engagements and next steps is available on .

Data Management: Processed downscaled MACA data for 129 pixels (4km×4km) spatially in Georgetown County, SC are stored on a hard drive maintained by Greg Carbone (carbone@mailbox.sc.edu).

CONTRIBUTIONS TO THE SOUTHEAST CONSERVATION ADAPTATION STRATEGY

Team Members: Dow, Farris, Guiseppe, Kupfer, Lackstrom

Overview: These projects aim to support the Southeast Conservation Adaptation Strategy (SECAS) and its work to develop a shared, regional conservation vision.

2018-2019 Activities:

- The State Wildlife Action Plans (SWAP) analysis, conducted across 15 southeastern states and Puerto Rico, was completed. This analysis sought to identify the various approaches used to address climate change, highlight key commonalities and differences among the states, and improve understanding of the challenges and opportunities that state agencies face as they address climate change risks.
- A second phase of the project focuses on adaptive management strategies for longleaf pine ecosystems, to investigate managers' perceptions about the implications of climate change and urban growth for prescribed burning practices in the region. More information about that project can be found on .

Deliverables:

- Lackstrom, K., P. Glick, K. Dow, B. A. Stein, M. N. Peterson, E. Chin, and K. Clark. 2018. Climate Change and Conservation in the Southeast: A Review of State Wildlife Action Plans. 44 pp. http://go.ncsu.edu/se_swap_review_report
- Lackstrom K., P. Glick, K. Dow, B. A. Stein, M. N. Peterson, E. Chin, and K. Clark. 2018. Climate Change and Conservation in the Southeast: A Review of State Wildlife Action Plans – Report Summary. 4 pp. https://globalchange.ncsu.edu/secsc/wp-content/uploads/SE-SWAP-Analysis-Report-Summary.pdf
- See Appendix: 2018 - 2019 CISA Deliverables for additional citations.

Data Management: For the SWAP analysis, document and interview coding protocols, interview recordings, transcripts, and notes are maintained by Kirsten Lackstrom (lackstro@mailbox.sc.edu) on a password protected server. To ensure privacy and confidentiality, identifying information has been removed from the interview documents.

Assessing Business Impacts of Hurricanes and Flooding in the Charleston, SC Region

Team Members: Dow, E. Davis, Schanne, Sherlock

Overview: Small businesses play a critical role in the local and national economy, creating job growth and stability. Recent hurricanes have caused business closures and revenue losses. This project aims to survey impacted businesses in Charleston, SC, to better understand the cost of hurricanes and localized flooding and identify strategies to make local economies more resilient.

2018-2019 Activities: Conducted 29 in-depth interviews with Charleston-area business owners regarding supply chain disruptions and preferred solutions; 121 additional interviews are planned.

Data Management: Eleanor Davis (davis.eleanorj@gmail.com) maintains the dataset of survey responses on a password protected server, with limited access to project team members only.

South Atlantic Regional Research on Coastal Community Resilience

Team Members: Dow, Watson

Overview: The four South Atlantic Sea Grant programs (GA, FL, NC, and SC) received funding from the NOAA Office of Coastal Management to begin a new South Atlantic Regional Research on Coastal Community Resilience program. The overall goal of the project is to help local governments build capacity to better visualize, understand, and plan for coastal hazard risks. CISA is partnering with the City of Beaufort, SC for our portion of this project.

2018 – 2019 Activities:

- Results of the legal analysis, completed by partners at GA Sea Grant and which looked at issues related to adaptation of historic properties to reduce flood risk, was presented to the City of Beaufort. This sparked new interest from the City to investigate the implications of sea level rise on stormwater management.
- In partnership with the Low Country Hazards Institute and the SC Sea Grant Consortium, CISA researchers are working on a vulnerability assessment for the City of Beaufort. The assessment is intended to inform their comprehensive planning process and provide background to apply for grant funding to support future engineering studies and economic development.

Shaping the Future of Folly Beach, SC through Sea Level Rise Adaptation

Team Members: Watson

Overview: CISA and the SC Sea Grant Consortium have been working with local government leaders to better understand how sea level rise could be addressed through code and ordinance upgrades in Folly Beach, SC. The City has also requested support in developing a marshfront management plan to assess and mitigate tidal flooding.

2018 - 2019 Activities: Held presentations with the planning commissioners and the Folly Beach City Council to examine the potential outcomes of different ordinances on the marshfront.

Deliverables: Increases to the City's setback ordinances were formally introduced in January 2019 and finalized in April 2019. More information about this collaboration and future work can be found on page 4.

Providing Innovative Decision Support Services

Carolinas Precipitation patterns & Probabilities Atlas

Team Members: Carbone, Beidel, Gao, Lu

Overview: The Carolinas Precipitation Patterns & Probabilities Atlas (Atlas) provides downloadable maps and figures characterizing various measures of precipitation and drought. It offers information not readily available elsewhere, such as frequency and duration of both dry and wet events, photographs, videos, and narratives of the impacts of precipitation extremes in the Carolinas.

2018-2019 Activities: Documented the data sources, methods, and code used to produce each graphic and map in the Atlas. This documentation will serve as a blueprint for the SC DNR as they maintain the Atlas into the future.

Deliverables: The Atlas is currently being used by the NC and SC State Climate Offices to give historical context to recent seasons and precipitation events.

Data Management: The Atlas is a public resource, accessible at www.cisa.sc.edu/atlas. All maps and graphics are freely downloadable with appropriate citation. Sources of public datasets used to develop various Atlas products are listed under each graphic. Questions should be directed to Greg Carbone (carbone@mailbox.sc.edu).

Convergence: Climate-Health Vulnerabilities Website

Team Members: A. Ward, McConnell, Woodul

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.

2018-2019 Activities: A climate extremes story map, integrating personal stories of public health impacts, is in development. Lesson plans for teachers to use alongside the story map will help promote use in public education. Other website updates include revisions to the HHVT and HERA tools and the addition of the WBGT tool.

Deliverables:

- Convergence website: https://convergence.unc.edu/
- See Appendix: 2018 - 2019 CISA Deliverables for additional citations

Hazardous Extremes Risk Assessment (HERA) Tool Development

Team Members: A. Ward, Charette, Clark, Eck, Spitzer, Woodul

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. The project is currently focused on making the HERA tool more comprehensive, covering a wider variety of impacts.

2018-2019 Activities:

- Data layers on traffic accidents, flooding, and winter weather have been added to the online HERA tool.
- Data needed to create the County-At-A-Glance maps for South Carolina are being processed, to be posted online in fall 2019.

Deliverables:

- HERA online climate and health decision support tool: https://convergence.unc.edu/tools/hera/
- See Appendix: 2018 - 2019 CISA Deliverables for additional citations.

Data Management:

- All data used for the HERA tool is publicly available. Data Includes Storm database, Death Certifications, 100 and 500 Year Flood Plain, Parcel, Top Heavy Precipitation Events, Heavy Precipitation, Property Damages, heat, and Agricultural Damage

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Heat health Vulnerability Tool

Team Members: Konrad, A. Ward, Clark, Hiatt

Overview: This project investigates the statistical relationships between different climate and weather conditions and the rates of hospitalizations for heat-related illness. This has been used to develop a model, the Heat Health Vulnerability Tool (HHVT), which combines weather data with community resilience measures to forecast changes in heat-related hospitalization.

2018-2019 Activities:

- The HHVT has been updated to incorporate day-of-week and additional years of data available from NC DETECT. The tool has also been updated to improve the user experience, including change of format in observed vs. forecasted data presentation and a change in format of dates
- Upgrades are being made to the HHVT model. Next steps will include model validation and the development of an early warning system for heat danger.

Deliverables:

- HHVT online heat-health decision support tool: https://convergence.unc.edu/tools/heat/

Data Management:

- The HHVT model is comprised of data from NC DETECT, North Carolina's epidemiological syndromic surveillance system, and maximum temperature data and heat index forecast data from the National Weather Service. Data from NC DETECT is protected and not available for public use. This data, in addition to NWS data, are stored at the State Climate Office of North Carolina. Questions should be directed to Chip Konrad (cek@email.unc.edu).

Use of Wet Bulb Globe Temperature To Estimate Heat Stress

Team Members: Konrad, Clark

Overview: Heat advisories in the southeast typically rely on heat indices that don't 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 monitors. This includes the development of a web application that converts NWS gridded weather data into WBGT data on an hourly basis.

2018-2019 Activities:

- UNC has arranged to test the WBGT application with the NC High School Athletics Association to monitor heat stress during sports practices at 10 NC high schools.
- Upgrades are being made to make the tool outputs more user friendly. Upgrades include better calculations and the ability to display a range of values such as sun vs. shade.
- This project will expand from the initial pilot to include all NC and most of Virginia in the coming year.

Deliverables:

- Wet Bulb Globe Temperature Online Forecasting Tool: https://convergence.unc.edu/tools/nc-wbgt/

Data Management:

- Mortality data for the state of North Carolina were obtained from North Carolina Vital Records, a division of the North Carolina Department of Health Human Services. Meteorological data was obtained through the NC State Climate Office CRONOS database. These dataset are freely downloadable with appropriate citation. Questions should be directed to Chip Konrad (cek@email.unc.edu).

Appendix: CISA Deliverables 2018-2019

Stakeholder Conferences, Meetings, Trainings, and Workshops

Abeels, H., A. Farris, J. Gambill, K. Guiseppe, T. McCue, T. Miller, G. Olmi, A. Pope, L. Ramirez, S. Watson, H. White and J. Whitehead. Southeast & Caribbean Climate Community of Practice Workshop, April 1-3, Wrightsville Beach, NC. 68 Participants.

Carneval, C., K. Dow and D. Marcy. Southeast Findings of the New National Climate Assessment. November 29, 2019. Webinar. 205 Participants.

Farris, A. and M. Hanisko. Resources for Resilience: Sea Level Rise 2-Pager. October 10, 2018. Webinar. 31 Participants.

Farris, A. and M. Hanisko. Resources for Resilience: Florida's Adaptation Planning Guidebook and the Gulf of Mexico Mitigation Guidebook. January 22, 2019. Webinar. 31 Participants.

Farris, A. and K. Guiseppe. 2018 Carolinas Climate Resilience Conference. October 29 – 31, 2018, Columbia, SC. 248 Participants.

Lackstrom, K. Coastal Salinity Index, April 12, 2019. Webinar. 10 Participants.

Ward, R., C. Davis and K. Lackstrom. Phase 1 Webinar for the Agriculture and Forestry Sectors, November 28, 2018. Webinar. 10 Participants.

Ward, R., C. Davis and K. Lackstrom. Phase 1 Webinar for the Water Resources Sector, December 10, 2018. Webinar. 13 Participants.

Ward, R., C. Davis and K. Lackstrom. Weather & Climate Workshop. February 22, 2019, Chatham County Extension Center, Pittsboro, NC. 4 Participants.

Ward, R. and C. Davis. NC DMAC Annual Meeting, April 4, 2019, Raleigh, NC. 14 Participants.

Ward, R., C. Davis and K. Lackstrom. NC Fire Environment Committee Meeting, May 20, 2019, Waynesville, NC. 15 Participants.

Ward, R. and C. Davis. Weather & Climate Workshop, May 30, 2019, Union County Extension Center, Monroe, NC. 5 Participants.

Watson, S. North Charleston Flood Expo. July 9, 2018, North Charleston, SC. 105 Participants.

Watson, S. VCAPS Exercise Facilitation with NC Sea Grant, August 24, 2018, Swansboro, NC.

Watson, S. Be Flood Ready Scanlonville. November 9, 2018, Mt. Pleasant, SC. 58 Participants.

Watson, S. "Risk Communication Basics." NOAA Office for Coastal Management Training, January 16, 2019, Mt. Pleasant, SC. 32 Participants.

Journal Articles

Gao, P., G.J. Carbone, and J. Lu. "Flood simulation in South Carolina watersheds using different precipitation inputs." Advances in Meteorology. 2018. Article ID 4085463. DOI: 10.1155/2018/4085463

Lu, J., G.J. Carbone, and J. Grego. "Uncertainty and hotspots in 21st century projections of agricultural drought from CMIP5 models." Scientific Reports, 9(1), 4922. 2019. https://doi.org/10.1038/s41598-019-41196-z.

Lu, J., G.J. Carbone, and P. Gao. "Mapping the agricultural drought based on the long-term AVHRR NDVI and North American Regional Reanalysis (NARR) in the United States 1981-2013." Applied Geography vol.104, pp.10–20. 2019. DOI: 10.1016/j.apgeog.2019.01.005

» **The Integrated Scaled Drought Index (ISDI) combines satellite-based observations of vegetation with climate data and information, including temperature, precipitation, and soil moisture. Because the satellite data dates back to 1981, the index allows for an assessment of historical drought for the longest time frame during the satellite era. The ISDI can also be used for future agricultural drought monitoring. ISDI maps are available as part of the** Carolinas Precipitation Patterns and Probabilities Atlas**.**

Ward, A., J. Clark, J. McLeod, R. Woodul, H. Moser, and C. Konrad. "Excessive Heat and Preterm Birth in North Carolina, 2011-2015." 2019. (Accepted: International Journal of Biometeorology)

Media Interviews

Corwin, T. "Report: Climate change threatens crops, coastland, and health." Kirstin Dow quoted. The Augusta Chronicle. Published online November 29, 2018.

Crone, A. "Meeting addresses climate change, need for sustainable development in Georgetown County." Sara Watson quoted. South Strand News. Published online March 11, 2019.

Dailey, R. "What Do U.N., U.S. Climate Change Reports Mean for Florida and the Southeast?" Kirstin Dow quoted. WFSU Public Media. Published online November, 30, 2019.

Grist Staff. "We broke down what climate change will do, region by region." Kirstin Dow quoted. Grist. Published online November 29, 2018. Republished by Slate, November 30, 2019.

Hardy, C. "Climate Change and South Carolina." Kirstin Dow interviewed. On Point. WACH Fox, Columbia, SC, December 2, 2018.

Henson, R. "Climate Change in the Womb." Ashley Ward interviewed. Weather.com. Published online May 15, 2019.

Street, L. "SC Communities Begin Adapting to Climate Change." Statehouse Report. Published online December 7, 2018.

White, Z. "Sea Level Rise." Kirstin Dow interviewed. Charlotte Observer, Charlotte, NC, July 26, 2018.

Wolfe, W. "Warming climate likely harmful to human health." Kirstin Dow quoted. The Brunswick News, Published online November 29, 2018.

Wynn, L. "Climate Change, Cities Make Storms Wetter." Chip Konrad quoted. Coastal Review Online. Published online December 5, 2018.

NEWSLETTERS

Farris, A., K. Guiseppe, and S. Mullin. Carolinas Climate Connection, 1st Quarter, March 2019. Web.

Farris, A. and K. Guiseppe. Carolinas Climate Connection, 4th Quarter, December 2018. Web.

Farris, A. and K. Guiseppe. Carolinas Climate Connection, 3rd Quarter, October 2018. Web.

Farris, A. and K. Guiseppe. Carolinas Climate Connection, 2nd Quarter, July 2018. Web.

Guiseppe, K., E. Davis, A. Farris, S. Mullin. CISA and CoCoRaHS Condition Monitoring Newsletter. 12 Monthly Issues, June 2018 – May 2019. Web.

PROJECT AND RESEARCH INFORMATION DOCUMENTS

Farris, A. and S. Mullin. New Features Added to the Condition Monitoring Web Map. Informational Flyer. February 2019.

Ward, R., C. Davis, E. Foster, and K. Lackstrom. Project Nighthawk: Spring 2019 Update. May 2019. 2 pp.

Ward, R., C. Davis, E. Foster, and K. Lackstrom. Innovating Approaches to Drought Communications with North Carolina Decision Makers: Project Nighthawk Phase 1 Writeup. 2018. 16 pp.

Ward, R., C. Davis, E. Foster, and K. Lackstrom. Project Nighthawk Takes Flight: Phase 1 Summary. 2018. 2 pp.

ORGANIZED CONFERENCE SESSIONS

Carbone, G. and C. Konrad. "Ask the Climatologist: Reflecting on Historic, Recent, and Future Heavy Rain Events." Organized session at the Carolinas Climate Resilience Conference, October 29 – 31, 2018, Columbia, SC.

Dow, K. and S. Watson. "Science and engagement co-production around compounding climate risks and impacts in the Charleston, SC region." Organized session at the National Adaptation Forum, April 23 – 25, 2019, Madison, WI.

Dow, K. and S. Watson. "Engaging with Charleston Communities about Flood Risks and Impacts." Organized session at the Carolinas Climate Resilience Conference, October 29 – 31, 2018, Columbia, SC.

Lackstrom, K. "Drought and Coastal Ecosystems: Monitoring and Modeling Using the Coastal Salinity Index." Organized session at the National Conference on Ecosystem Restoration, August 26-30, 2018, New Orleans, LA.

Lackstrom, K. "When the Well Runs Dry: Coping with Drought in the Carolinas." Organized session at the Carolinas Climate Resilience Conference, October 29-31, 2018, Columbia, SC.

Ward, A. "Resilience in the Face of Climate Change: Native American Communities coping when Earth Becomes Non-Native." Organized session at the Carolinas Climate Resilience Conference, October 29-31, 2018, Columbia, SC.

Ward, A. "Exploring and Assessing Health Vulnerabilities to Climate Extremes." Organized session at the Carolinas Climate Resilience Conference, October 29-31, 2018, Columbia, SC.

Ward, A. "Too Hot to Handle: Heat and Human Health." Organized session at the Carolinas Climate Resilience Conference, October 29-31, 2018, Columbia, SC.

Ward, R., C. Davis and K. Lackstrom. "Too Much, Too Little or Just Right? Drought Information Resources for Water Managers." Organized session at the NC Water Resources Research Institute Annual Conference, March 21 – 22, 2019, Raleigh, NC.

Watson, S. and J. Whitehead. "Turning Plans into Action: Lessons from Coastal Communities." Organized session at the Carolinas Climate Resilience Conference, October 29 – 31, 2019, Columbia, SC.

Watson, S. "Working Together to Create Effective Resilience and Adaptation Networks." Organized session at the Carolinas Climate Resilience

Conference, October 29 – 31, 2019, Columbia, SC.

Presentations

Altman, E. and K. Lackstrom. "Preparing South Carolina for Drought: Lessons Learned from the State's First Drought and Water Shortage Tabletop Exercise." Carolinas Climate Resilience Conference, October 29-31, 2018, Columbia, SC.

Combest-Friedman, C., A. Farris, N. Gardiner and S. Watson. Panel Discussion. "Communicating the Value of Co-production and Social Networks for Climate Adaptation." National Adaptation Forum, April 24, 2019, Madison, WI.

Dow, K. "Fourth National Climate Assessment: Key Findings for the Southeast." Southeast & Caribbean Climate Community of Practice Workshop, April 1-3, 2019, Wrightsville Beach, NC.

Dow, K. Panel Discussion. "The Fourth National Climate Assessment and IPCC Special Report on the Impacts of Global Warming: A Panel Discussion of the Science-Public Policy Dimensions of Climate Change Assessments." American Association of Geographers Annual Meeting, April 5, 2019, Washington, DC.

Farris, A. "Condition Monitoring in the Carolinas: Lessons Learned to Support a National Network of Citizen Science Observers, Drought Monitoring, and Decision Making." South Carolina Water Resources Conference, October 17, 2018, Columbia, SC.

Farris, A. and R. Ward. "How Does Your Garden Grow? Monitoring Weather and its Impacts in the Natural World." North Carolina State Extension master Gardeners Volunteer Association Annual Meeting, June 8, 2018, Greenville, NC.

Farris, A., E. Davis, K. Guiseppe, K. Lackstrom, R., N. Doesken, N. Newman, H. Reges, J. Turner and K. Smith. "Keys to Success: How a Citizen Science Pilot Study Became a National Drought Monitoring Program." Citizen Science Association Conference, March 13-17, 2019, Raleigh, NC.

Jacobson, R., C. Enquist, A. Farris, J. Jorns, J. Kim, J. Liechty, L. Lynch and M. Simpson. Panel Discussion. "Advancing Climate Networks and Regional Adaptation Forums: Lessons Learned from 2018 Events and Future Plans." National Adaptation Forum, April 24, 2019, Madison, WI.

Lackstrom, K. "Drought." SEOE Environmental Issues Seminar (ENVR 590), University of South Carolina, October 23, 2018, Columbia, SC.

Lackstrom, K. and E. Altman. "Preparing South Carolina for Drought: Lessons Learned from the State's First Drought and Water Shortage Tabletop Exercise." South Carolina Water Resources Conference, October 17-18, 2018, Columbia, SC.

Lackstrom, K. and L. Rouen. "Coastal Drought and the Need for a Coastal Salinity Index." National Conference on Ecosystem Restoration, August 26-30, 2018, New Orleans, LA.

Lackstrom, K. Panel Discussion. "Leveraging Crowdsourcing and Citizen Science to Produce Volunteer Geographic Information for Hazard Science, Disaster Research, and Emergency Management (Sophia Liu, Organizer). American Association of Geographers Annual Meeting, April 3-7, 2019, Washington DC.

Lackstrom, K., A. Farris and R. Ward. "Backyard Hydroclimatology: How Citizen Scientists Contribute to State- and National-Scale Drought Monitoring Efforts." American Association of Geographers Annual Meeting, April 3-7, 2019, Washington, DC.

Mizzell, H., K. Lackstrom, E. Altman and T. Arrington. "Enhancing Drought Education, Awareness, and Information-Sharing through a Web-based Drought Portal." South Carolina Water Resources Conference, October 17-18, 2018, Columbia, SC.

Petkewich, M., K. Lackstrom, L. Rouen, B. McCloskey and S. Yurek. "Monitoring Drought in Coastal South Carolina Using the Coastal Salinity Index." South Carolina Water Resources Conference, October 17-18, 2018, Columbia, SC.

Petkewich, M., P. Conrads, K. Lackstrom, L. Rouen and B. McCloskey. "Using the Coastal Salinity Index for Monitoring Drought along the Gulf of Mexico and the Southeastern Atlantic Coast." National Conference on Ecosystem Restoration, August 26-30, 2018, New Orleans, LA.

Ward, A. "Developing the Hazardous Extremes Risk Assessment (HERA) Tool." NC WRRI Annual Conference, March 22, 2019, Raleigh, NC.

Ward, R., K. Lackstrom, C. Davis, E. Foster and A. Gupta. "Innovating Approaches to Drought Communication with Water Resources Managers." NC WRRI Annual Conference, March 22, 2019, Jane S. McKimmon Center, North Carolina State University, Raleigh, NC.

Watson, S. "Building Community Resilience to Water-Related Hazards in the Charleston, South Carolina Region: A Charleston Resilience Network Initiative." South Atlantic Sea Grant Conference, July 31, 2018, Cedar Key, FL.

Watson, S. "Why We Flood." Charleston County Hazards Expo, August 11, 2018, North Charleston, SC.

Watson, S. "Future Flooding in Folly Beach." Folly Beach Planning Commission, August 20, 2018, Folly Beach, SC.

Watson, S. "Swamped Coast: Climate Change and the Lowcountry." SC Sea Grant Realtor Training Planning Committee, September 26, 2018, Charleston, SC.

Watson, S. "Engaging Neighborhoods to Better Plan for Flooding Disasters." Extension Disaster Education Network, October 18, 2018, College Station, TX.

Watson, S. "Engaging with Charleston Communities about Flood Risks and Impacts." Carolinas Climate Resilience Conference, October 30,

2018, Columbia, SC.

Watson, S. "Future Flooding in Folly Beach." Folly Beach Planning Commission, November 26, 2018, Folly Beach, SC.

Watson, S. "Swamped Coast: Sea Level Rise and the Lowcountry." Beaufort County Stormwater Partners, November 27, 2018, Okatie, SC.

Watson, S. "Swamped Coast: Sea Level Rise and Harbor Island." December 2, 2018, Harbor Island, SC.

Watson, S. "Swamped Coast: Climate Change and the Lowcountry." SC Sea Grant Realtor Training Planning Committee, December 6, 2018, Georgetown, SC.

Watson, S. "Applying Risk Communication Practices in Coastal Community Engagement." National Summit on Coastal and Estuarine Restoration and Management, December 11, 2018, Long Beach, CA.

Watson, S. "Swamped Coasts: Coastal Climate Resilience in Bluffton." Bluffton Watershed Committee, January 24, 2019, Bluffton, SC.

Watson, S. "Building Community Resilience to Water-Related Hazards in the Charleston, SC Region: A Charleston Resilience Network Initiative." SC Beach Preservation Association Conference, February 13, 2019, Isle of Palms, SC.

Watson, S. "Swamped Coast: Climate Change in Coastal SC." Bunnelle Foundation Common Issues Common Threads, February 28, 2019, Pawleys Island, SC.

Watson, S. "What Does Adaptation Look Like?" Southeast Caribbean Climate Community of Practice Workshop, April 3, 2019, Wrightsville Beach, NC.

Watson, S. "Science and Engagement Co-Production Around Compounding Climate Risks and Impacts in the Charleston, SC Region." National Adaptation Forum, April 24, 2019, Madison, WI.

Watson, S. "Swamped Coast: Climate Change in Coastal SC." Adaptation Training Presentation, May 29, 2019, Conway, SC.

Ward, A. and R. Emanuel. "Strategies to Understand and Address the Impact of Climate Change in Rural Eastern North Carolina." Rural Health Symposium, January 11, 2019, East Carolina University, Greenville, NC.

Ward, A. "Identifying and Engaging Vulnerable Groups." 1st Global Heat Health Forum, December 17-20, 2018, Hong Kong.

Ward, A. "The Impacts of Excess Heat on Preterm Labor in North Carolina, 2011-2015." North Carolina American Public Health Association, December 2018, Charlotte, NC.

Ward, A. "Community-directed Research to Assess the Impacts of Excessive Heat on Preterm Labor." October 2018, University of South Carolina, Columbia, SC.

Ward, A. "Hot as Blue Blazes: The Impacts of Excessive Heat on Preterm Labor in North Carolina, 2011-2015." Carolinas Climate Resilience Conference, October 29-31, 2018, Columbia, SC.

Ward, A. "HERA: Hazardous Extremes Risk Assessment." NC Emergency Management Symposium, October 23, 2018, Sunset Beach, NC.

POSTERS

Carbone, G., J. Lu, K. Beidel, K. Lackstrom, P. Gao, M. Griffin and H. Mizzell. "The Carolinas Precipitation Patterns and Probabilities Atlas." South Carolina Water Resources Conference, October 17-18, 2018, Columbia, SC.

Farris, A., K. Lackstrom, E. Davis, K. Guiseppe, S. Mullin, R. Ward, N. Doesken, N. Newman, H. Reges, J. Turner and K. Smith. "Assessing the Usefulness of Citizen Science Information in Drought-Related Decision Making: The Condition Monitoring Project." Citizen Science Association Conference, March 13-17, 2019, Raleigh, NC.

Lackstrom, K., E. Chin, K. Clark, K. Dow, P. Glick, N. Peterson and B. Stein. "Climate-Smart Conservation: An Assessment of State Wildlife Action Plans from the Southeast United States." National Conference on Ecosystem Restoration, August 26-30, 2018, New Orleans, LA.

Petkewich, M., B. McCloskey, K. Lackstrom, L. Rouen, R. Young, and P. Conrads. "Coastal Salinity Index Dissemination for Monitoring Drought along the Gulf of Mexico and the Southeastern Atlantic Coast, 1983 to 2018." Greater Everglades Ecosystems Restoration Conference, April 22-25, 2019, Coral Springs, FL.

Terando, Adam, L. Carter, K. Dow, K. Hiers, K. Kunkel, A. Lascurain, D. Marcy, M. Osland, P. Schramm, and A. Lustig. 2019. "Assessing Climate Risks and Adaptation Opportunities in the Southeast U.S. As Part of the Fourth National Climate Assessment." 2019 AGU Annual Meeting, December 10-14, 2018, Washington, D.C.

REPORTS

Abeels, H., A. Farris, J. Gambill, K. Guiseppe, T. McCue, T. Miller, G. Olmi, A. Pope, L. Ramirez, S. Watson, H. White and J. Whitehead. 2019 Southeast and Caribbean Climate Community of Practice Workshop Final Report. Wilmington, NC. 17 pp.

Guiseppe, K., E. Davis, A. Farris, L. Moore, A. Patel and L. Rouen. 2018 Carolinas Climate Resilience Conference Final Report. pp.23.

Lackstrom, K., P. Glick, K. Dow, B. Stein, M. Peterson, E. Chin and K. Clark. "Climate Change and Conservation in the Southeast: A Review

of State Wildlife Action Plans." 2018. pp.44. http://go.ncsu.edu/se_swap_review_report.

In support of the Southeast Conservation Adaptation Strategy (SECAS), this project assessed how states have addressed current and project climate change in their wildlife action plans. Report recommendations, based on project findings, focus on ways to advance the consideration and integration of climate into the state wildlife action planning process, as well as other conservation efforts. They are intended for the state fish and wildlife agencies, SECAS partners (FWS, conservation NGOs, foundations, private groups), and policy makers making decisions that will shape the Southeast region's future landscapes.

Lackstrom, K., P. Glick, K. Dow, B. Stein, M. Peterson, E. Chin and K. Clark. "Climate change and Conservation in the Southeast: A Review of State Wildlife Action Plans – Report Summary" 2018. pp.4. https://globalchange.ncsu.edu/secsc/wp-content/uploads/SE-SWAP-Analysis-Report-Summary.pdf.

Report Chapters

Carter, L., A. Terando, K. Dow, K. Hiers, K.E. Kunkel, A. Lascurain, D. Marcy, M. Osland, and P. Schramm. 2018. Southeast. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M Lewis, T.K. Maycock, and B.C. Stewart (eds)]. U.S. Global Change Research Program, Washington, D.C., USA, pp 743-808. DOI: 10.7930/NCA42018.CH19.

The Southeast chapter of the Fourth National Climate Assessment contains important key messages about observed and projected climate and impacts in the region, particularly those related to public health and economic losses. Chapter authors also highlight the pressing needs for coastal adaptation to sea level rise and heavy rainfall events given projections for daily high tide flooding by the end of the century.

Advisory Committees

Dow, K. NOAA Climate Working Group of the NOAA Science Advisory Board.

Dow, K., A. Farris, and C. Konrad. Organizing Committee Members. NOAA National Weather Service Climate Prediction Applications Workshop, June 11- 13, 2019, Charleston, SC.

Farris, A. Program Committee Member. National Adaptation Forum, April 23 – 25, 2019, Madison, WI.

Lackstrom, K. Committee Member. Center for Oceans and Human Health and Climate Change Interactions (OHHC2I), University of South Carolina, Columbia, SC.