Indian Town Hall Trailhead, NC. Photo by Zach Taiji

CAROLINAS INTEGRATED SCIENCES & ASSESSMENTS

PROJECT PROGRESS REPORT: 1 JUNE 2017 - 31 MAY 2018

NOAA AWARD NA16OAR4310163

CISA
A NOAA RISA TEAM

RISA
Regional Integrated Sciences and Assessments

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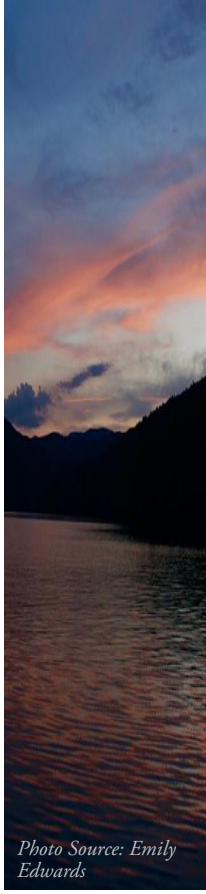
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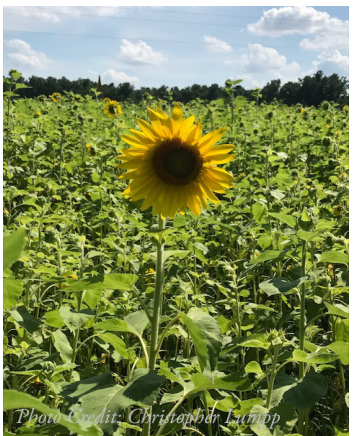
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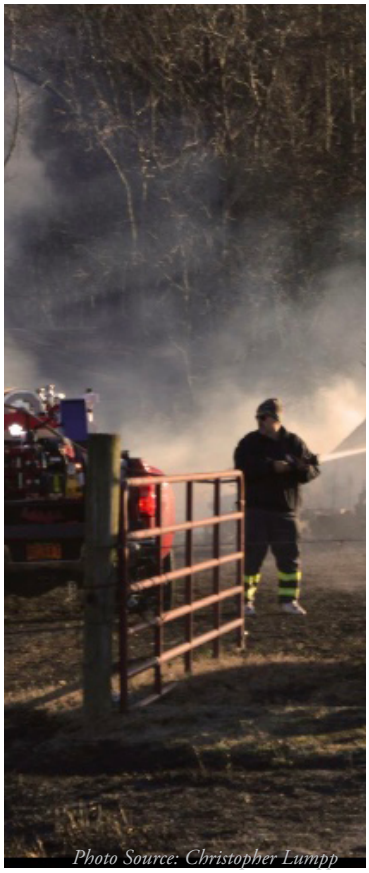
Photo Source: Christopher Lumpp

THE CISA TEAM

CISA Executive Team

Kirstin Dow (Lead PI), Univ. of South Carolina
Amanda Farris (Program Manager), Univ. of South Carolina
Kerry Guiseppe (Program Coordinator), Univ. of South Carolina
Greg Carbone (PI), Univ. of South Carolina
Chip Konrad (PI), The Univ. of North Carolina at Chapel Hill and NOAA Southeast Regional Climate Center
Kirsten Lackstrom (PI), Univ. of South Carolina
Dan Tufford (PI), Univ. of South Carolina
Ashley Ward (Outreach and Extension Specialist), The Univ. of North Carolina at Chapel Hill
Sarah Watson (Coastal Climate & Resilience Specialist), CISA and S.C. Sea Grant Consortium

Research Staff

Research Associates

Karen Beidel, Sylricka Foster, Peng Gao, Jordan McLeod, Lauren Rouen, Angus Spencer, Xiao Xiao

Research Assistants

Ekaterina Altman, Nick Bundrick, Jordan Clark, Eleanor Davis, Kristen Downs, Armon Hanks, Mattie Hibbs, Kiley Hurst, Matthew Jurjonas, Junyu Lu, Gwen Miller, Leah Moore, Aashka Patel, Lisa Reed, Marygrace Rowe, Savannah Ward, Rachel Woodul

Collaborating Investigators

Jeff Allen, SC Water Resources Center, Clemson University
Tanner Arrington, SC Department of Natural Resources
Michelle Covi, Virginia Sea Grant and Old Dominion University
Corey Davis, State Climate Office of North Carolina
William Davis, The Citadel
Rick DeVoe, S.C. Sea Grant Consortium
Jason Evans, Stetson University
Simon Ghanat, The Citadel
Sean Heuser, State Climate Office of North Carolina
Shana Jones, Carl Vinson Institute of Government, University of Georgia
Norm Levine, College of Charleston
Hope Mizzell, South Carolina State Climatology Office
Jim Morris, University of South Carolina
James Nolan, Carl Vinson Institute of Government, University of Georgia
Scott Pippen, Carl Vinson Institute of Government, University of Georgia
Louie Rivers, North Carolina State University
Thomas Ruppert, Florida Sea Grant
Erin Seekamp, North Carolina State University
Dan Tomczak, North Carolina Association of Floodplain Managers
Seth Tuler, Social and Environmental Research Institute
Christine Voss, University of North Carolina at Chapel Hill
Rebecca Ward, State Climate Office of North Carolina
Jess Whitehead, North Carolina Sea Grant

The CISA Program

Established in 2003, the Carolinas Integrated Sciences & Assessments (CISA) is 1 of 11 NOAA Regional Integrated Sciences & Assessments (RISA) teams. RISAs are interdisciplinary research teams that work to expand and build the nation's capacity to prepare for and adapt to climate impacts by addressing science questions facing decision makers. A key component of the RISA program is working at the regional level to address significant and timely climate issues of concern.

The CISA team works to increase resilience in the Carolinas through decision-relevant climate research in collaboration with a wide range of stakeholders. CISA has established long-term partnerships with federal, state, and local government agencies, resource managers, non-governmental organizations, and the private sector. Working at the intersection of climate with water, coasts, and health, CISA provides decision makers with tailored information that can be integrated into management and planning processes. 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. The educational Climate Connections Workshop Series and SC Drought and Water Shortage Tabletop exercise, hosted in partnership with the SC State Climatology Office, provided opportunities for the network to engage in-person about the most significant weather and climate impacts in the region.

EXPANDING OUR REACH

Providing Climate Information & Services Through New Partnerships

Meeting a Growing Demand for Tailored Climate and Health Information

CISA's climate and health related work began as an investigation into heat-related illness in North Carolina. We continue to expand the scope of this work to improve our capacity to engage and inform groups about climate-related health risks, giving particular attention to highly susceptible communities.

Photo Source: Emily Edwards

Engaging Tribal Communities

North Carolina is home to more than 150,000 Native Americans, one of the largest state populations, represented across eight tribes. These communities face disproportionately higher levels of impacts to health, livelihoods, cultural practices, and rights to natural resources because of extreme weather events and projected regional economic growth. Planning for these impacts requires engagement with climate science in ways that are new to community decision makers. To address this need, we are collaborating with Healthy Native North Carolinians to develop Climate-Health Community Profiles specific to Native American communities in North Carolina. The profiles will include scaled-down community-level information relevant for decision making; summaries of current and future health impacts from extreme events; and narratives from communities about issues of concern, strategies for adaptation, and lessons learned. The incorporation of narratives and the participatory process of creating the profiles will give Native communities agency in creating usable, functional, and culturally specific resources.

Developing Wet Bulb Globe Technologies

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). Because 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. 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 are currently comparing two different methods of estimating WBGT from meteorological observations to see which approach provides the best approximation. This information will be incorporated into a web-based application that provides an hourly forecast of WBGT for the next three days, updated on a daily basis. The application displays the information graphically to depict the degree of danger (i.e. heat stress). A beta test with NC high school athletics programs in summer 2018 will help to refine the tool before broader dissemination.

Assessing the Threat of Heat on Premature Labor

Research on the impact of high heat on pregnant women has focused largely on outcomes following extreme events, such as a particular heat wave, or on the impact of all temperature extremes (heat and cold weather). Literature consistently shows a statistically significant relationship between high heat and/or high heat index with either pre-term labor or shortened gestational age. However, these relationships have not been examined for populations in the Southeastern U.S. Unlike previous studies focused on single heat events, this study examines the impact of high heat during the full heat season (May-September) over 5 years in North Carolina. This study also seeks to assess potential differences in heat impacts on pre-term labor by evaluating regions within the state (e.g. piedmont versus coast) as well as urban and rural areas. Results will be used to enhance a heat-health early warning system, enabling public health officials and emergency preparedness officials to target pregnant women with prevention messaging.

Meeting Climate Information Needs for Emergency Planning and Preparedness

Recent work has allowed us to engage with emergency managers, tailoring climate information and resources for their needs.

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 business-specific emergency preparedness plans and provide staff trainings. The tool provides decision support 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. Although designed in response to difficulties in meeting these CMMS requirements, the tool is not restricted to that purpose. Revisions and improvements to the tool will be based on small group consultations and engagement with stakeholders at the May 2017 NC Public Health Preparedness and Response Symposium.

Educating and Informing South Carolina Emergency Managers on Drought

In September 2017, we worked with the SC State Climatology Office, the SC Water Resources Center, and the SC Emergency Management Division (EMD) to host the first-ever drought and water shortage exercise for the State of South Carolina. Traditionally, the SC EMD has exercised a variety of different emergency management scenarios, from hurricanes to cyberattacks, in order to test the state's response and recovery plans and operations. This new exercise, which recreated a gradually worsening drought scenario, brought together over 80 participants from a variety of agencies and organizations, including state- and local-level emergency managers, many of whom were exposed to the SC Drought Response Plan and procedures for the first time. More detail is provided in the Featured Projects section of this report.

Forging New Partnerships in NC Coastal Communities

CISA graduate student Ellie Davis is working with farmers in Hyde County, NC to research coastal soil salinization affecting agriculture in the region. CISA's long-term partnership with the NC Sea Grant program also helped to identify two small projects we were able to support as components of broader efforts to document and communicate the impacts of climate change and sea level rise on the North Carolina coast.

Documenting Water Levels in North Carolina Estuaries through the NC King Tides Project

As high water-level events become increasingly common and coastal areas experience more frequent recurrent flooding, there is a growing need for more spatially explicit water-level data throughout the North Carolina estuaries. The intermingling of natural forces including astronomical tides and wind can lead to water levels that deviate significantly from those predicted, making such predictions a difficult task, especially on a local scale. This subaward to researchers at UNC-Chapel Hill expanded the North Carolina King Tides Project to include installation of water-level gauging stations, monitored and reported by trained citizen scientists. The resulting water-level database is both spatially and temporally specific, creating a more holistic understanding of water-level patterns throughout the coastal zone. The data and photographs produced from the citizen science water-level monitoring effort are intended for use by the scientific, regulatory, and management communities, as well as the public, to gain a better understanding of what drives water levels in NC as well as to stimulate thinking about rising seas. This database begins to fill the void in water-level records that exists between USGS stream gauges and NOAA Tides and Currents coastal stations.

Resilience Inclusion on the Coast: Exploring Sea Level Rise in Diverse Communities on the Albemarle-Pamlico Peninsula of North Carolina

This project was designed to engage low-lying, rural, minority communities that are highly vulnerable to coastal flooding and sea level rise impacts on the Albemarle Pamlico Peninsula of eastern North Carolina. Using the Rural Coastal Community Resilience framework, stakeholder engagements brought to light perceptions of adaptive capacity and barriers to flood management at multiple scales of government. The project contributes to the understanding of climate justice and climate resilience by expanding research to be inclusive of minority residents within rural coastal communities. The project also fostered new network opportunities as NC Sea Grant had not engaged the study's communities before and firsthand connections were made between local leaders and the Sea Grant coastal hazards specialists. Additionally, through contracting Angus Spencer, a local leader, to work as a field technician the project helped build local capacity by engaging someone from the communities in a more technical role for coastal hazard planning.

CUSTOMIZING CLIMATE INFORMATION IN THE CAROLINAS

Climate Projections for South Carolina's Coast

Building Regional Resilience Capacity in Charleston, SC

The Charleston region regularly experiences recurrent flooding as a function of tide cycles and rainfall events. Such flooding impacts transportation, causes loss of property and, in extreme cases, threatens lives. The Charleston Regional Resilience Grant project is a two-pronged approach to identifying current and future flood risks and effectively communicating those results to residents and decision-makers. Using state-of-the-art modeling techniques, research partners with the College of Charleston, The Citadel, and CISA, are developing a high resolution, parcel-level flood model that presents a more realistic view of what happens during a storm or an unusually high tide. CISA project members produced future precipitation scenarios based on dynamically downscaled precipitation data from the CORDEX-North America project, which were incorporated into this parcel-level flood model. This model will be presented to four neighborhoods in the Charleston region using a variety of approaches rooted in risk communication methods informed by multi-disciplinary social science. Once complete, decision-makers and residents throughout the region can 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.

Tailored Climate Adaptation Information and Tools for Georgetown, SC

A project team with members from CISA, the North Inlet-Winyah Bay NERR, and Coastal Carolina University is working with The Consensus Building Institute to transfer the New England Climate Adaptation Project (NECAP) to Georgetown County, SC. The project will use South Carolina-specific downscaled climate projections provided by CISA in local end-user and community engagement sessions to teach decision makers how to effectively use the projections for planning and resources management. Our 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 GCM models from the MACAv2-METDATA downscaling product 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). The projections will be used by project partners to host a train-the-trainer workshop on how to effectively utilize the new local simulations for decision making in Georgetown. Ultimately, the project aims to educate local decision makers and community members, increasing their awareness and concerns about potential local climate change risks and allowing them to explore obstacles and opportunities to address them as a community.

Drought Information for Decision Making

Citizen Science Reports Inform Drought Designations

CISA initiated the Citizen Science Condition Monitoring pilot project in 2013 to evaluate a new method for drought impacts monitoring and reporting. Integrating condition monitoring with existing tools developed by the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network, allowed us to expand the program to a national network of 20,000+ citizen scientists in 2016. Between October 2016 and May 2018, 3,425 CoCoRaHS volunteers across all 50 states, Puerto Rico, and the Bahamas submitted 25,644 condition monitoring reports. Evaluation of the Carolinas pilot indicated that the network of citizen scientists, knowledgeable about their local communities and environments, can play an important role in drought early warning. Decision makers interviewed during the evaluation reported using the reports to assess on-the-ground conditions and make drought designations. For example, the NC Drought Management Advisory Council incorporates report information into their weekly state drought map. Several NWS Forecast Offices use the reports to recommend the drought status in their county warning areas and for other projects and forecasts (e.g. fire weather warnings). US Drought Monitoring map authors contacted download the reports weekly as a GIS layer to review as part of their "convergence of evidence" in drought designation.

Launching a New Drought Information Portal for South Carolina

One of the key needs identified by stakeholders at the 2017 South Carolina Drought and Water Shortage Tabletop Exercise was for educational opportunities to enhance agencies' familiarity with the Drought Response Plan and their role in drought response and mitigation. To address this need, we partnered with Tanner Arrington (SC DNR Land, Water, and Conservation Division) to develop the new scdrought.com website. The website was launched in May 2018 and tailors information from the Carolinas Precipitation Probabilities and Patterns and other sources to provide SC-specific information about current official drought status, drought indicators and indices, drought resources, specifics for the Drought Response Committee, and a South Carolina drought planning page. The website has received rave reviews since its publication.

> *"I love the new drought website. Wish you would have had that during all those years at the newspaper when I had to search the web for things. Now you can just start drought response meetings by telling people to call up the website! Keep up the great work."*
> *~ Joey Holleman, SC Sea Grant Consortium*

Photo Credit: Emily Edwards

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
- 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** (see the CISA by the Numbers infographic) and **qualitative analysis** of individual projects and the program as a whole.

Individual projects, such as the Convergence website, development of the Hazardous Extremes Risk Assessment (HERA) tool, and the citizen science condition monitoring project, integrate evaluation questions and metrics throughout research and engagement activities. Direct stakeholder feedback helps us to 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. In addition, evaluation requests are circulated to all workshop and conference attendees to improve future events and assess which content is most relevant and useful.

An **evaluation of our communications and outreach materials** was conducted in January 2018 to assess how well these materials are meeting climate information needs for the network. An online survey was circulated to recipients of our quarterly newsletter (3,269 recipients) and the Carolinas Climate Listserv (332 subscribers) and posted to our social media accounts (Facebook and Twitter, 192 and 473 followers, respectively). Responses indicate that the niche role CISA plays in connecting networks within the Carolinas and providing localized climate information continues to fill a critical information need for the region.

A **program-wide evaluation** is scheduled for fall 2018, during Year 2 of the current grant (2016 – 2021). **Three external reviewers** will be provided program background materials to inform feedback interviews with CISA team members, collaborators, advisory committee members, and stakeholders. Reviewers will evaluate work-to-date and help us consider project priorities for the remainder of the grant. The external review will be held in conjunction with the 2018 Carolinas Climate Resilience Conference so that evaluators will have ample opportunities to interact directly with the CISA team, partners, and stakeholders.

We are also conducting a **network analysis project** as part of this broader program evaluation effort to assess progress towards our overarching goal of "fostering climate information networks" in the Carolinas. Through our portfolio of activities, we work to encourage communication between researchers and practitioners and extend peer-to-peer knowledge sharing in order to increase awareness and use of climate information for decision making. The network analysis will explore the expansion of CISA's network over time, the various factors that have facilitated this expansion, and the effectiveness and impact of CISA's efforts to enhance the exchange and use of climate information in the Carolinas.

We also look to our Advisory Committee to help us stay connected to other work in the region, keep a finger on the pulse of stakeholder needs, and advise on the balance of efforts and impact. We hold an in-person meeting annually, engage the Advisory Committee in the planning of the Carolinas Climate Resilience Conference, and provide regular communications and program updates through sharing minutes of the monthly full team call and quarterly newsletters. Advisory Committee members will be tapped for discussions with program evaluators as well, to share impressions of our work and how well we are meeting the needs of stakeholders in the Carolinas.

CISA BY THE NUMBERS

June 2017 - May 2018

51 presentations

42 conferences, training sessions, and workshops

11 journal articles, reports, and dissertations

22 newsletters

20,654 outreach & engagements

$647,218 leveraged funds

$4,531 travel support

student research assistants **18**

research associates **29**

collaborating organizations **100**

2017-2018 HIGHLIGHTED ACCOMPLISHMENT

South Carolina Drought & Water Shortage Tabletop

CISA led organizational efforts for the **first South Carolina Drought and Water Shortage Exercise** in September 2017 in response to the need identified by the SC State Climatologist and Drought Response Committee Chair. This coordinated drought exercise was designed to assess the effectiveness of SC drought plans and legislation, improve awareness of local, state, and federal players in SC drought response, identify key mission areas for each State Emergency Support Function, and collect ideas for future efforts that will proactively prepare the state for droughts. More than **80 participants representing federal and state agencies, the SC Governor's Office, public water suppliers, county and municipal governments, industry, consulting companies, and nonprofit organizations** gathered at the South Carolina Emergency Operations Center in West Columbia, SC to exercise drought response. Over the course of the event, attendees walked through a series of gradually worsening drought scenarios, in which they reviewed the plans and procedures that govern state-, basin-, and local-level responses to drought and water shortages.

Key identified needs and action items:

- Update drought response plans and procedures to ensure a coordinated and timely response to droughts
- Create educational opportunities to enhance agencies' familiarity with the Drought Response Program and their role in drought response and mitigation
- Effective communications before, during, and after drought events, across agencies and with the public
- Enhanced data and information products that can be used to build common understanding of drought risks, impacts, and vulnerabilities

As a first step in addressing drought information needs, we worked with Tanner Arrington (SC DNR GIS Manager) to design and develop the **new scdrought.com website, which will serve as the drought information hub for the state**.

More than half (58%) of workshop survey respondents reported that they identified action items for their own organization as a result of the exercise. These actions items centered on reviewing and updating drought response plans and ordinances.

The tabletop exercise provided an in-depth look into the actions necessary to deal with drought all the way to activation of emergency operations. To my knowledge, this was the first time participants had to think about actions and solutions to that extreme, which was quite eye-opening. After participating in the exercise, we have been working to revise our drought response plan and corresponding Town ordinances. Thanks for the professionalism of the report and the table top exercise."
~ Clay Duffie, General Manager, Mount Pleasant Waterworks.

Photo Source: Ekaterina Altman

Key Publications

Deeb, R., D. Tufford, G. Scott, J. G. Moore, and K. Dow. 2018. Impact of Climate Change on *Vibrio vulnificus* Abundance and Exposure Risk. Estuaries and Coasts. DOI: https://doi.org/10.1007/s12237-018-0424-5
- This study assessed how changes in water temperature under future climate scenarios may affect the occurrence of *Vibrio vulnificus*.

Farris, A., E. Davis, K. Guiseppe, K. Lackstrom, and R. Ward. 2018. CoCoRaHS Citizen Science Condition Monitoring: Phase 2 Final Report. Columbia, SC. 106 pp.
- This report summarizes findings from the evaluation of tools and resources developed to support the CoCoRaHS condition monitoring program and includes recommendations for future work to support the continued success of the national program. News release.

Gao, P., G.J. Carbone, and J. Lu. 2018. Flood Simulation in South Carolina Watersheds Using Different Precipitation Inputs. Meteorological Applications (in press).
- This article documents a method to improve precipitation inputs to hydrological models in order to simulate streamflow more accurately in a coastal South Carolina watershed by using a combination of gridded NOAA data and NWS rain gauge data.

Lackstrom, K. and E. Altman. 2018. South Carolina Drought and Water Shortage Tabletop Exercise Summary Report. Columbia, SC. 44 pp.
- This report summarizes outcomes and feedback of the first drought and water shortage tabletop exercise hosted in South Carolina. It also includes decision maker recommendations for future work to improve South Carolina's drought preparedness and response program.

Tuler, S. 2018. Assessment of adaptation, policy, and capacity building outcomes from 14 VCAPS processes. Columbia, SC. 33 pp.
- This report documents the assessment of 14 VCAPS exercises conducted between 2008 and 2017 in order to improve the process and document how facilitated dialogues can support climate adaptation.

Photo Source: Kirstin Dow

RESEARCH TO ADVANCE UNDERSTANDING OF CLIMATE & ITS IMPACTS IN THE CAROLINAS

CISA conducts applied research to answer stakeholders' questions about climate variability and extremes, projections of future climate, and climate-related impacts on the Carolinas' resources and communities.

Climate Change and Conservation in the Southeast: A Review of State Wildlife Action Plans

This project was designed to support the Southeast Conservation Adaptation Strategy (SECAS) and its work to develop a shared, regional conservation vision. The project examined State Wildlife Action Plans (SWAPs) across 15 southeastern states and Puerto Rico. SWAPs are required in order for states and territories to be eligible for State and Tribal Wildlife Grants (SWG) funding. The first editions of the plans (due in 2005) typically did not consider climate change. Since then, more state agencies not only recognize the need to prepare for a changing climate but now have access to a multitude of resources, tools, and guidance documents designed to help them assess climate impacts and develop adaptation options.

Project objectives were to 1) identify the various approaches used to address climate change in the recent (2015) SWAP updates, 2) highlight key commonalities and differences among the states, and 3) improve understanding of the challenges and opportunities that state agencies face as they address climate change risks. Methods included detailed review of the SWAPs and follow-up interviews with SWAP coordinators.

Key Findings:

- While all states recognized the climate change threat, they exhibited a diversity of planning approaches. Factors such as staff capacity and expertise and consistency with other planning processes influenced the methods and extent to which the SWAPs integrated climate change.
- Few states conducted climate change vulnerability assessments expressly to inform their SWAPs. Many interviewees suggested that interstate collaboration and resources to conduct regional-scale assessments would enhance the current, limited use of impact and vulnerability assessments.
- Climate adaptation strategies tend to be stated in general terms and few examples of implemented actions exist thus far. Acting with intentionality (i.e. linking specific strategies to climate impacts) and developing Southeast-specific resources for monitoring change and the effectiveness of conservation actions could enhance the uptake of novel management strategies.
- Overarching conservation goals as articulated in the SWAPs tend to be persistence-oriented, although some internal conversations are considering how climate change will affect the future feasibility of conservation strategies designed with static climate conditions in mind.

Citizen Science Contributions to Drought Monitoring

For over two years, Rebecca Ward (State Climate Office of North Carolina) has shared CoCoRaHS Condition Monitoring reports with the NC Drought Management Advisory Council as part of her regular drought assessment activities. In the past year, others from SCONC (C. Davis, D. Bertrand) have contributed to SCONC's drought assessment activities, including reviewing and sharing CoCoRaHS reports. Feedback from drought decision makers indicates that these reports provide useful information that is not provided by other sources, particularly regarding changing conditions caused by weather patterns or seasonal transitions.

However, even as CoCoRaHS reports have become integrated into more drought monitoring efforts, questions remain about their accuracy and reliability. To address these, we conducted multiple analyses to compare Carolinas observers' scale bar selections and narrative reports with other, objective drought measures. Our analyses, led by the State Climate Office of North Carolina, included comparing over 2,700 reports and scale bar selections to objective drought indices, as well as examining the reports and scale bar selections of individual observers. These analyses provide insight into what information is used to make scale bar selections and how this is similar to, or different from, information provided by objective drought indices. Quantitative comparisons between scale bars and objective drought indices suggest the citizen scientists' assessments do reflect prevailing meteorological conditions, particularly at shorter timescales (e.g. 1-month). Observer reports and scale bar selections for six selected case study observers were also compared with contemporary, objective drought information. These comparisons revealed a complex web of observations and interpretations used by observers in preparing their reports. The information provided is often nuanced, and takes into account traditionally captured data (e.g. precipitation) in conjunction with other, harder-to-measure information (i.e. phenological or wildlife responses to changing moisture conditions). When combined, this information provides drought decision makers with a more detailed picture of evolving moisture conditions.

Testing and Applying the Coastal Salinity Index (CSI)

The Coastal Salinity Index (CSI) was developed to characterize coastal drought, monitor changing salinity conditions, and improve understanding of the effects of changing salinities on fresh and saltwater ecosystems, fish habitat, and freshwater availability for municipal and industrial use. The initial effort to develop the CSI relied on data from two USGS water quality stations, located in large drainage basins – the Yadkin-Pee Dee and Savannah. Coastal watersheds vary from small tidal creeks, to Coastal Plain rivers, to large rivers that originate in the Piedmont or Blue Ridge provinces of North Carolina, South Carolina, and Georgia. These different rivers and systems respond differently to precipitation, riverine flow, and tidal conditions, depending on the geologic setting. They also have different river and water management regimes. In order for the CSI to be more broadly useful as a drought monitoring tool, it is necessary to expand comparisons and analyses beyond the two original sites.

In spring 2017, the USGS South Atlantic Water Science Center received funding from the National Integrated Drought Information System (NIDIS) to further develop and disseminate the CSI. CSIs for new sites in South Carolina were calculated as part of the process to develop and test a CSI R-package. To assess how, when, and where the CSI can contribute to drought monitoring and resource management, we are investigating the following questions: How does the CSI, at different CSI time intervals (1- to 24-months) and at different locations, compare with other drought indices? What is the "best" time scale for using the CSI? As each estuary system has different characteristics, how can the CSI be used to compare drought response within or across specific river basins?

We conducted a Pearson correlation analysis to compare the newly available CSIs with drought indicators (Z-index, PDSI, PMDI, PHDI, SPIs) in SC Climate Divisions 4 and 7. The correlations show which CSI interval (calculated for each water quality station site) best fits each drought indicator. While the CSI shows similar drought and wet trends when compared to other drought indicators, the CSIs calculated at the 3-, 6-, and 9-month intervals may be the most useful for drought monitoring. For most sites, and compared to the Z-index and PDSI, the PHDI and PMDI had the highest correlations with the 2- to 6-month CSIs (R values range from .64 to .81 for the PHDI and .60 to .81 for the PMDI). Correlations between the CSIs and SPIs of 1- to 24-month intervals show that the CSI lags behind the SPI, suggesting that the salinity response to drought is slower than other indicators. Results will be used to develop guidance for potential users of the CSI, including State Climate Offices, drought committees, and coastal resource managers. Next steps include using gridded SPIs to conduct a similar analysis on the watershed scale and comparing the CSI with ecological data to link drought to specific environmental impacts and thresholds.

Photo Source: Dare County, Flickr Creative Commons

Influencing Policies & Planning for Climate Adaptation

Planning for Sea Level Rise in Charleston, SC

The new "High Water Impacts" section of the Charleston County Comprehensive Plan includes recommendations for coordination with CISA and others who have been at the forefront of raising awareness about the risks of sea level rise in the region. Specifically, the plan recommends coordination with these groups to consider policies that *"ensure Charleston County is resilient to flooding and high water impacts in the future."* Andrea Harris-Long, Charleston County Zoning and Planning Department stated, *"We have included creating this new element focused on high water impacts and resiliency in our 'priority recommendations' list in the Priority Investment Element. This list contains projects we want to undertake before the next review of the Comprehensive Plan."* Through our work with the Charleston Resilience Network and other partners in the region, we will continue to provide technical support and translate the needed climate science to help the County make informed long-term planning decisions.

Ongoing Work in the City of Folly Beach leads to New Policy Focus for Waterfront Resilience

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 to request technical assistance in the analysis of the future impacts of sea level rise to the community. This initial consultation led to a request for a more thorough assessment of their risks and support in identifying potential adaptation solutions. Our work with key decision makers helped to identify adaptation strategies that were laid out in the City's Sea Level Rise Adaptation Report. In June 2017, City Council voted unanimously to adopt the plan and recommendations, including developing a marsh management plan. Then in May 2018, the city council again voted unanimously for a six-month moratorium on beach and marsh front development while the community identifies needs and policy recommendations for future-thinking waterfront development. We are continuing to work with the City around this new focus of developing policy recommendations to improve waterfront while building resilience.

Work in Beaufort County, SC Continues to Support Coastal Resilience Planning

Beaufort County is located in the heart of the South Carolina Lowcountry, which sits just above sea level. County planners recognized their vulnerability to rising sea levels several years ago and initiated a collaboration with CISA and other partners to develop strategies that could be integrated into the County's Comprehensive Plan to address these risks. This original Sea Level Rise Adaptation Report continues to inform other regional vulnerability assessments. Most recently, the Lowcountry Council of Governments drew on information provided by CISA as they completed a joint land use study (JLUS) to identify at-risk infrastructure. The JLUS includes adaptation and mitigation strategies to minimize risks and maintain services to the community and military bases in the region.

OUTREACH & ENGAGEMENT TO FOSTER CLIMATE INFORMATION NETWORKS IN THE CAROLINAS

CISA is a trusted source of climate information and provides a variety of opportunities for information sharing and dialogue around climate issues.

Photo Source: Ashley Ward

Communications & Outreach Materials

- The Carolinas Climate Connection, our quarterly newsletter, is circulated to over 3,200 individuals. Content includes a featured researchers from the CISA team, case studies of local climate adaptation efforts, and summaries of our stakeholder engagements, among other topics.
- The Carolinas Climate Listserv is circulated to 332 subscribers once or twice per week as relevant news becomes available.
- To reach a broader public audience, we maintain social media accounts on Facebook (192 followers) and Twitter (473 followers).
- CISA leads communications efforts for the Southeast and Caribbean Climate Community of Practice which includes social media accounts, a website, a news and events e-mail distribution list for 251 recipients, and member webinars.
- We maintain multiple lines of communication with over 2,000 Carolinas CoCoRaHS volunteers for the citizen science condition monitoring project. We circulate a monthly newsletter and hold observer conference calls during which we provide project news, drought status updates, and opportunities for volunteers to talk and learn from one another and the decision makers who use their condition monitoring reports.
- The Appendix: CISA Deliverables, 2017-2018 provides a full list of our communications, outreach, and engagement efforts.

Photo Source: Matthew Jurjonas

Photo Source: Christine Vos

In-Person Workshops and Conferences

- CISA partnered with the Charleston Resilience Network (CRN) to host a Coastal Resilience Knowledge Exchange with officials from Hampton Roads, VA and Charleston, SC to share lessons learned when dealing with sea level rise and other coastal hazards.
- The CRN hosted five Coffee Hours to provide professionals in the area with an opportunity to share what they are doing within the realm of resilience, building up the network. The CRN Expo was an extension of these more informal events, providing exhibitor opportunities for participating organizations to showcase their projects and ideas for cross-sector collaboration.
- "Living with Water: Dutch Approaches and Charleston's Future" was hosted by the CRN to bring His Excellency Henne Schuwer, Ambassador of the Kingdom of the Netherlands, and other Netherlands officials to Charleston to share the Dutch approach to water management.
- The South Carolina Climate Connections Workshop Series provided information to relevant stakeholders about responses to recent extreme events and how lessons learned have been incorporated into planning for future events.
- The SC Drought Tabletop and Water Shortage Exercise led participants through worsening drought conditions to assess the effectiveness of SC drought plans and legislation and collect ideas for future efforts that will proactively prepare the state for drought.
- The Appendix: CISA Deliverables, 2017 – 2018 provides a full list of conference, meetings, trainings, and workshops we hosted.

CISA Coastal Climate and Resilience Specialist Video

This video, produced in collaboration with the RISA program office, shares the story of how our work in coastal South Carolina is helping the Cities of Charleston and Folly Beach pro-actively consider how to increase their resilience to intensifying stresses from coastal flooding. Interviewees discuss how the technical and organizational assistance we have provided has helped them consider risks, identify viable solutions, and educate community members.

Fire in the Coastal Carolinas: An Interactive Story Map

The story map was created in partnership with the State Climate Office of North Carolina (SCONC) as part of the Coastal Carolinas Drought Early Warning System (DEWS) outreach initiative. The story map includes information about the unique nature of fire risk in the Coastal Carolinas, where peat soils can enhance fire risk and impacts. There is also information about the coastal soils monitoring project which we are supporting in partnership with the SCONC.

OUR WORK IN PRACTICE

CISA's interdisciplinary, multi-state team works with partners and decision makers across the Carolinas, integrating social and natural sciences to characterize the risks, vulnerabilities, and potential impacts of climate variability and change. From the insights we gain, we develop decision-relevant tools and analyses that meet our stakeholders' specific needs and help build regional capacity to address climate concerns. By emphasizing processes that facilitate learning, we help to foster information exchange among decision makers, researchers, and climate service providers. This portfolio of research and engagement is designed to achieve CISA's overarching mission of increasing adaptive capacity in the Carolinas.

Weathering the Storm: Impacts of Extremes on SC's Built and Natural Environment

In the fall of 2017 and spring of 2018, we hosted the South Carolina Climate Connections Workshop Series in collaboration with the South Carolina State Climatology Office and the SC Water Resources Center. The workshops, entitled "Weathering the Storm: Impacts of Extremes on South Carolina's Natural and Built Environment" were motivated by the success of the 2012 series of climate workshops and stakeholder informational needs. A series of extreme events including the October 2015 heavy rainfall and flooding event, the 2016 wildfires in the Western Carolinas, Hurricane Matthew in 2016, and Hurricane Irma in 2017 have raised serious concerns about how well-prepared South Carolina is for the impacts of extreme events.

Workshops were held in Greenville, Columbia and Charleston, SC. Representatives from the state's flood mitigation program, dam and reservoir safety program, department of transportation, forestry commission, and department of natural resources discussed the impacts of these recent extremes, how their agencies responded, and how lessons learned are shaping the future of their work. Workshop registrations filled rapidly, attracting a total of 212 attendees from federal, state, and local governments, scientists, NGOs, land and water resource managers, utility representatives, the private sector, and local staff of a US Representative.

As a free service to attendees of these workshops we provided continuing education credits for engineers, surveyors, and certified floodplain managers. Six floodplain credits and 27 engineer and survey credits were provided to attendees at the workshops, saving recipients an estimated $5,000 in training expenses.

Motivating Action for Drought Planning and Preparedness

The South Carolina Drought and Water Shortage Tabletop Exercise exceeded expectations in helping stakeholders and decision makers better understand the strengths and breaking points in the SC Drought Response Act, state drought regulations, the Drought Annex of the SC Emergency Response Plan, and local drought plans and procedures. According to participants, for many this was the first time they were exposed to the SC Drought Response Plan and procedures. Since the exercise, held in September 2017, water utility participants reported reviewing and updating their own local drought plans and ordinances, some of which have not been updated in more than 10 to 15 years.

A representative from the Governor's Office also attended the exercise, paving the way for actions at the state level. Most notably, the Governor's Office has made (or recommended) several new appointments to the South Carolina Drought Response Committee (DRC). This is a significant breakthrough as the committee has had ~50% vacancies for several years. As of early June 2018, 13 new committee members have been recommended for appointments, marked as "appointment pending" on the scdrought.com website. This is over 25% of the total (48) DRC positions available.

Bridging the Divide: Connecting Coastal Communities adapting to Sea Level Rise

The Charleston Resilience Network (CRN) is a collaboration of public, private, and non-profit organizations seeking to enhance the resilience of the greater Charleston region and communities. The CRN mission is to foster a unified regional strategy and provide a forum to share science-based information, educate stakeholders, and enhance long-term planning decisions that result in resilience. Serving over 700,000 people in the greater Charleston region, the CRN is working to protect a myriad of cultural and infrastructure assets throughout the region.

Through support of the Resilience Program Coordinator for the CRN, jointly funded by CISA and the S.C. Sea Grant Consortium, we are continuing to build out the CRN network and provide education and outreach opportunities for members and stakeholders to better understand coastal climate hazards and the threat of sea level rise. The CRN network consists of 115 member organizations across the region, approximately 40 of which joined within the last year. New members are invited to introduce themselves, their organizations, and their own resilience efforts at the bi-monthly coffee hours. Other events such as the CRN Expo, held in March 2018 provide an opportunity for members to connect and showcase their work. At the "Living with Water: Dutch Approaches and Charleston's Future" event, held on March 27, 2018, over 300 members of the Charleston community gathered to hear His Excellency Henne Schuwer, Ambassador of the Kingdom of the Netherlands to the United States and other senior officials. These representatives discussed Dutch approaches to water management and how Dutch planning principles and processes have been integrated in other regions of the United States.

CISA provided $4,531 in travel support and coordination support to host a 2-day Coastal Resilience Knowledge Exchange with officials from Hampton Roads, VA, to share lessons learned when dealing with coastal hazards. The Hampton Roads region, comprised of 1.7 million people, is also actively working to mitigate chronic flooding. The knowledge exchange provided attendees (made up largely of local professionals such as engineers, planners, legislators, academics) with information on the Charleston region, followed by presentations from eight local/regional staff and other practitioners from the Hampton Roads region. Then, breakout sessions made deeper dives into specific issues. One prominent idea resonating from these discussions was the concept of seeing water as an asset, rather than a nuisance, and to applying this approach to the development of engineering resilience projects. This is a successful Hampton Roads strategy, learned from the Dutch. Bringing together city staff established a peer to peer connection that is continuing. The Director of the CRN has visited Norfolk and staff from two of the cities, Hampton and Norfolk, are planning to visit Charleston again in the near future to continue the knowledge exchange.

Photo Credit: Kirstin Dow

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

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.

Coastal Carolinas DEWS Program Coordination

Team Members: Lackstrom, Farris, Dow

Overview: CISA serves as the main point-of-contact for NIDIS Coastal Carolinas (CC) DEWS activities. This includes disseminating information about program activities to drought decision makers and stakeholders in the Carolinas and maintaining communications and coordination with NIDIS and the DEWS project partners.

2017 – 2018 Activities:

- We worked with partners to develop and disseminate information about the CC DEWS program.

Deliverables:

- Updates to CC DEWS content on the drought.gov website. Presentations and organized sessions at stakeholder meetings, including the American Meteorological Society's 23rd Conference on Applied Climatology.
- See Appendix: CISA Deliverables, 2017-2018 for additional citations.

Communicating Coastal Drought Early Warning Information

Team Members: Lackstrom, Altman, Farris, Guiseppe, Rouen, R. Ward

Overview: The goal of this project is to coordinate communication and outreach efforts and promote an integrated approach to drought early warning communications, messaging, and outreach in the Coastal Carolinas. CISA assists NIDIS with communications and outreach to Coastal Carolinas DEWS stakeholders and develops coastal drought content and resources for the Carolinas and the drought.gov website.

2017 – 2018 Activities:

- Stakeholder engagements including presenting to the SC Coastal Information Network to share information about the DEWS and NIDIS-supported drought resources.

Deliverables:

- The Coastal Fire Story Map has been completed. The Coastal Drought Story Map is in progress.

Citizen Science-Condition Monitoring Project

Team Members: Farris, Lackstrom, E. Davis, Guiseppe, R. Ward

Overview: This project engages citizen scientists and the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network to promote drought impacts monitoring and reporting using "condition monitoring" reports to document the effects of weather and climate on their communities.

2017 – 2018 Activities:

- Conducted Phase 2 evaluation to include observer feedback surveys and decision maker interviews.
- Completed report content analysis, comparing the condition monitoring scale bar to objective drought indices to determine how well observer reports correlate with objective data. Analyses included comparing over 2,700 reports and scale bar selections to objective drought indices, as well as examining the reports and scale bar selections of individual observers.
- Worked with CoCoRaHS staff to develop online resources including a national web map and summary report charts to improve use and accessibility of the reports.
- Helped to create a condition monitoring training animation for new observers.

Deliverables:

- Evaluation results, report content analysis, and recommendations for the future of the national program are available in the Phase 2 Final Report
- National Condition Monitoring Web Map, Report Summary Charts, and Training Animation launched in September 2017
- NC Climate Blog posts
- See Appendix: CISA Deliverables, 2017-2018 for additional citations.
-

Data Management: CoCoRaHS Condition Monitoring Reports are volunteer reports describing how recent precipitation, or a lack thereof, has affected their local community and environment. All reports are publicly available on the CoCoRaHS website: www.cocorahs.org. Document and interview coding protocols as well as interview recordings, transcripts, and notes are maintained on a secure server at the University of South Carolina. Online feedback survey results are stored in a password protected Survey Monkey account. Questions about project data can be directed to Amanda Farris, afarris@sc.edu or 803.777.6875.

Advancing the Development and Use of the Coastal Salinity Index

Team Members: Lackstrom, Tufford, Rouen, Lu, Hurst

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 effects of changing salinities on fresh and saltwater ecosystems, fish habitat, and freshwater availability for municipal and industrial use. CISA collaborates with partners at the USGS South Atlantic Water Science Center to advance the development and use of the CSI.

2017 – 2018 Activities:

- Assisting USGS with testing the CSI-R package and providing feedback on its development and outputs
- Developing the first draft of a CSI User Guide
- Continuing work to assess the linkages between ecological indicators and salinity conditions as expressed by the CSI
- Engaging with decision makers and other researchers to pilot the CSI's use and applications.

Deliverables: Research Review: Ecological Responses to Drought in the Coastal Carolinas and Georgia; First draft of the CSI User Guide (publicly available 2018-2019); Updated salinity and ecological response inventories

Data Management: The salinity and ecological response datasets are available in several forms on the CISA project website: Excel spreadsheets, ArcGIS layers, Google Earth (KML) layers. For questions, contact Kirsten Lackstrom, lackstro@mailbox.sc.edu or 803.777.3563.

Research to Advance Understanding Of Climate and Its Impacts in the Carolinas

Carolinas Precipitation Patterns & Probabilities Atlas

Team Members: Carbone, Lu, Beidel, Lackstrom, McCleod, Reed, Hibbs, Xiao

Overview: The Carolinas Precipitation Patterns & Probabilities Atlas (Atlas) provides over 1,000 downloadable maps and figures characterizing various measures of precipitation and drought. It offers information not readily available from other sources, such as frequency and duration of both dry and wet events, and photographs, videos, graphics, and narratives of the impacts of drought and heavy precipitation events in the Carolinas.

2017 – 2018 Activities:

- We continue to build out and enhance the maps, graphics, and other products available through the Atlas.
- We have obtained user feedback at several events and conferences in the Carolinas, which was used to improve Atlas products and functionality.

Deliverables: The Atlas was made available on the CISA website in fall 2016 and continues to be updated.

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 at carbone@mailbox.sc.edu or 803.777.0682.

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.

2017-2018 Activities:

- Provided South Carolina-specific downscaled climate projections using 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).

Deliverables: Tables and graphs with temperature, precipitation, and sea level rise projections were delivered to partners for display within the context of stakeholder engagements in Georgetown County.

Data Management: We have processed downscaled MACA data for 129 pixels (4km×4km) spatially in Georgetown County, SC. The data are stored on a hard drive maintained by Junyu Lu. Questions should be directed to Greg Carbone at carbone@mailbox.sc.edu or 803.777.0682.

Basin-Level Analysis of Extreme Rainfall Events

Team Members: Carbone, Gao

Overview: Following on stakeholder information needs about extreme rainfall after the October 2015 flooding event in South Carolina, CISA researchers are investigating observational records and model output to understand the nature of extreme precipitation in the Carolinas. The research aims to overcome challenges associated with insufficient sample sizes due to limited meteorological stations and observations, the ability of point data to represent the volume of water affecting an entire basin, and estimating infrequent precipitation events.

2017-2018 Activities:

- We examined two watersheds in South Carolina and how they respond to three different representations of heavy rainfall, using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) developed by the US Army Corps of Engineers.

Deliverables:

- Gao, P., G.J. Carbone, and J. Lu. 2018. Flood Simulation in South Carolina Watersheds Using Different Precipitation Inputs. *Meteorological Applications* (in press).

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 Peng Gao. Questions should be directed to Greg Carbone at carbone@mailbox.sc.edu or 803.777.0682.

Historic Drought Impacts to Agriculture in the Carolinas

Team Members: Carbone, Lu, Gao

Overview: We used long-term state- and county-level corn yield data from 1895 to 2014 to quantify and compare historical drought impacts on agriculture in the Carolinas using multiple models.

2017 – 2018 Activities:

- We applied and compared six trend simulation models to simulate the nonlinear trend and two decomposition models to remove the nonlinear trend from the yield time series.
- The comparison of each method evaluated the advantages and disadvantages with respect to applicability across time and space, efficiency, and robustness.

Deliverables:

- Lu, J. 2018. Measuring Agricultural Drought and Uncertainty in Future Drought Projections. PhD dissertation, University of South Carolina, SC.
- We developed SC and NC county-level yield anomaly maps and maps to display the SC and NC Integrated Scaled Drought Index (ISDI), which are publicly available on the Carolinas Precipitation Patterns & Probabilities Atlas

Data Management: We developed SC and NC county-level corn and soybean yield anomaly maps and maps to display the SC and NC Integrated Scaled Drought Index (ISDI). These are currently stored on a networked hard drive maintained by Junyu Lu, but will be made publicly available online. Questions should be directed to Greg Carbone at carbone@mailbox.sc.edu or 803.777.0682.

Impacts of Heat on Pregnant Women

Team Members: A. Ward, Konrad, Clark

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 pre-term labor in urban and rural areas as well as regional differences in North Carolina.

2017 – 2018 Activities:

- Analysis is underway to describe the relationship between high heat days, pre-term delivery, and length of gestation in NC during the 2011-2015 heat seasons. All results are preliminary.

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. Questions should be directed to Ashley Ward at arward@email.unc.edu or 919.962.7470.

Wet Bulb Globe Temperature Evaluation and Mobile Applications to Predict Individual Heat Strain

Team Members: Konrad, A. Ward, Clark

Overview: Wet Bulb Globe Temperature (WBGT) accounts for variables including the solar radiation and lack of ventilation and provides a better estimate of human heat stress than either heat index or humidex. 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.

2017 – 2018 Activities:

- We are comparing two different methods of estimating WBGT from meteorological observations to see which approach provides the best approximation.
- We have constructed the first working version of a web-based application that provides an hourly forecast of WBGT for the next 3 days, which are updated daily. We plan to assess the usability of the application through engagements with athletic programs at several high schools in late summer 2018.

Data Management: Mortality data were obtained from North Carolina Vital Records. Meteorological data were obtained through the NC State Climate Office CRONOS database. This dataset is freely downloadable with appropriate citation. Questions should be directed to Chip Konrad at cek@email.unc.edu or 919.962.3873.

Marsh Migration and Change within the Port Royal Sound Watershed

Team Members: Morris, Miller

Overview: This research was conducted to produce marsh migration data layers and information for the development of a Port Royal Sound watershed priority index. The index is a GIS-based tool that can be used to identify and prioritize parcels for local conservation efforts in the Port Royal Sound watershed.

2017 – 2018 Activities:

- We used the Marsh Equilibrium Model (MEM) to develop and provide marsh migration data layers and information to contribute to TNC's Port Royal Sound watershed priority index.

Deliverables:

- Miller, G.M. and J.T. Morris. 2017. A race for survival; will salt marshes in Jasper and Beaufort County, South Carolina drown or keep pace with rising sea level?. Ecological Society of America Annual Meeting, 6-11 August 2017, Portland, OR. https://f1000research.com/posters/6-1813
- Miller, G. M. and J.T. Morris. 2017. Marsh migration and change within the Port Royal Sound Watershed. Port Royal Sound Watershed Mapping Meeting, Port Royal Sound Maritime Center, September 28, 2017, Okatie, SC.
- A map package was developed containing marsh change layers for Port Royal Sound every ten years for 100 years into the future. An MP4 video of marsh change over time within Port Royal Sound was produced using these maps.

Data Management: The map package is stored on a secure server at the University of South Carolina. All data are available by emailing Gwen Miller at gjmiller@email.sc.edu.

Documenting Water Levels in North Carolina Estuaries through the North Carolina King Tides Project

Team Members: Voss, Tomczak, Rowe

Overview: As high water-level events become increasingly common and coastal areas experience more frequent nuisance flooding, there is a growing need for more spatially explicit water-level data throughout the North Carolina estuaries. Through our support, the NC King Tides Project expanded to include water level monitoring conducted by trained citizen scientists using gauging stations.

2017 – 2018 Activities:

- Project members installed water level monitoring gauges to create a water-level database using citizen-provided readings that are both spatially and temporally specific.
- We also conducted a variety of outreach and education efforts, to inform the public about the risks associated with coastal flooding and the opportunity to contribute to the project.

Deliverables:

- Conference presentations, community engagements, a video tutorial, project information sheets, data collection guides, newsletters, newspaper articles, and social media posts
- See Appendix: CISA Deliverables, 2017-2018 for additional citations.

Data Management: Water-level data collected at gauge stations is freely available in NOAA's Water Level Data Explorer. Additional project resources are available at http://nckingtides.web.unc.edu/. Questions should be directed to Christine Voss at c.m.voss.unc@gmail.com.

Organic Soil Moisture Monitoring in Coastal North Carolina

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

Overview: The organic soils found in the coastal Carolinas have historically played host to numerous large, long-lived wildfires, and traditional measures of drought and fire risk don't fully capture the conditions in these soils. In order to provide accurate, real-time information at selected locations with organic soils in eastern North Carolina, the State Climate Office of North Carolina is deploying three soil moisture monitoring stations funded by CISA and an additional station funded by the US Fish and Wildlife Service.

2017 – 2018 Activities:

- The first soil moisture station was installed during spring 2018 with the remaining installations planned for later in the year.

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 will be provided on the Fire Weather Intelligence Portal at https://climate.ncsu.edu/fwip/. Questions should be directed to Corey Davis at cndavis@ncsu.edu.

Collaborations to Support the Implementation of Climate Adaptation Strategies

NC Native American Collaboration: Climate Health Community Profiles

Team Members: A. Ward

Overview: We will develop Climate-Health Community Profiles, specific to Native American communities in North Carolina, to support decision-makers and inform adaptation strategies to build resilience against climate extremes. The profiles will include scaled-down community-level climate information relevant for decision-making; summaries of current and future health impacts from extreme events; and narratives from communities about issues of concern, strategies for adaptation, and lessons learned.

2017 – 2018 Activities:

- Engagements were held with tribal leaders and community members to discuss needs and direction of the project

Deliverables:

- Ward, A., Byrd, R., Watson, L., Emanuel, R. Building resilience to climate extremes to protect our health and lands. Workshop at 43rd Annual NC Indian Unity Conference, March 2, 2018, Greensboro, NC.

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

Team Members: Patel, Carbone

Overview: In collaboration with the Orange Water and Sewer Authority (OWASA), a water utility in Carrboro, NC, we are assessing the vulnerability of the utility's raw water supply to changing climatic conditions. The goal of the project is to help the utility incorporate climate change into their long-range planning.

2017 – 2018 Activities:

- Our vulnerability analysis shows that the combined effect of the length of a drought and its severity can tell us when reservoir storage drops below the 20% capacity – a storage level deemed critical by the utility to maintain in dry conditions while meeting projected demands. In most cases, only intense droughts lasting approximately 24 months or longer seem to reduce the reservoir levels to critically low levels.

Deliverables: Patel, A. Incorporating Climate Change in Long-Range Water Supply Planning: A case study with OWASA. Presented at the Climate Resiliency Summit organized by Piedmont Triad Regional Council, Kernersville, NC. May 14-15, 2018.

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. The inputs and outputs of these simulations are stored by Aashka Patel (aaskajp@gmail.com) on a secure network drive.

Building Regional Resilience to Water-Related Hazards in the Charleston, SC Region: A Charleston Resilience Network Initiative

Team Members: Watson, Dow, Carbone, Bundrick, Levine, DeVoe, Gahant, 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.

2017 – 2018 Activities:

- Meetings with the CRN board to provide guidance on the selection of communities and approaches to local engagement
- Partners developed highly local, parcel-level flood models that present a realistic view of what happens during a storm or an unusually high tide. In 2018-2019, this model will be presented to four neighborhoods in the Charleston region using a variety of risk communication approaches.

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.
- Engagements with leadership in four neighborhoods in the Charleston region are laying the groundwork for sharing results of the modeling effort with residents in upcoming workshops in 2018-2019.

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 at carbone@mailbox.sc.edu or 803.777.0682.

South Atlantic Regional Research on Coastal Community Resilience

Team Members: Dow, Watson, Whitehead, Jones, Pippen, Ruppert, Evans, Nolan

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

2017 – 2018 Activities:

- This project has faced numerous delays as hurricanes and storms have taken precedence in community efforts and partners encountered technical difficulties with modeling.

Resilience Inclusion on the Coast: Exploring Sea Level Rise in Diverse Communities on the Albemarle Pamlico Peninsula of North Carolina

Team Members: Seekamp, Jurjonas, Spencer, Rivers

Overview: This project is designed to engage low-lying rural minority communities that are highly vulnerable to coastal flooding and sea level rise impacts on the Albemarle Pamlico Peninsula of eastern North Carolina. The research was intended to contribute to the climate justice and climate resilience body of knowledge by expanding research to be inclusive of minority residents within rural coastal communities.

2017 – 2018 Activities:

- Using the Rural Coastal Community Resilience framework, stakeholder engagements (3 focus groups and 2 workshops) were conducted to capture perceptions of adaptive capacity and barriers to flood management within multiple scales of government.

Deliverables: The research contributed to dissertation chapter for Jurjonas; Conference presentations were also given about the work; See Appendix: CISA Deliverables, 2017-2018 for additional citations.

Providing Innovative Decision Support Services

Drought Preparedness and Planning: Support for South Carolina's Drought Response Program

Team Members: Lackstrom, Farris, Altman

Overview: CISA and the South Carolina State Climatology Office (SC SCO) initiated this project in January 2017 with the overarching goal of assisting the SC SCO in advancing the State's Drought Response Program and improving drought preparedness and response.

2017-2018 Activities:

- CISA led the planning and organization of South Carolina's first-ever Drought and Water Shortage Tabletop Exercise.
- We also worked with SC DNR to develop informational resources to support South Carolina's drought planning and communications processes. These resources have been integrated into the new scdrought.com website, launched in May 2018.

Deliverables:

- Altman E., Lackstrom, K., and Mizzell, H. 2017. Drought and Water Shortages: South Carolina's Response Mechanisms, Vulnerabilities, and Needs. South Carolina Journal of Water Resources 4(1): 57–62.
- South Carolina Drought and Water Shortage Tabletop Exercise Report

Convergence: Climate-Health Vulnerabilities Website

Team Members: Ward, Konrad, Clark

Overview: Building on the development of the Heat Health Vulnerability Tool (HHVT), we are working with stakeholders to provide even more decision-relevant information about the connections between climate extremes and health through the Convergence web portal. Convergence provides links to research findings, information on climate extremes in the Carolinas, and the populations most vulnerable to their impacts.

2017 – 2018 Activities:

- Analyzed results of Convergence and HHVT user evaluation, which showed positive usability and functionality of the tool, accuracy in interpretation of results, and prompted minor refinements.
- Validation of the HHVT model and refinement of the tool to include additional variables such as day of week are currently underway.

Deliverables:

- Ward, A., Shaughnessy, S., Maudlin, L.: Collaborative Development and Evaluation of Web-Based Tools to Address Heat Related Illness in North Carolina. Presented at NC American Public Health Association (APHA), September 27, 2017, Asheville, NC
- Ward, A., Shaughnessy, S., Maudlin, L.: Engaging Stakeholders in the Development and Evaluation of Web-Based Tools to Address Heat Related Illness in North Carolina. Presented at the American Meteorological Society Conference (AMS), January 8, 2018 Austin, TX
- Konrad, C.E., and A. Ward: Heat-Health Vulnerability in North Carolina and the Development of a Web-Based Tool to Predict Emergency Room Visits. Presented at the Climate Prediction Applications Science Workshop, May 24, 2018, Fargo, ND
- HHVT Website analytics - 544 page views during 2017 heat season; Convergence website analytics - 3,590 (2,597 unique) page views during 2017 heat season

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 protect 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 Ashley Ward at arward@email.unc.edu or 919.962.7470.

Hazardous Extremes Risk Assessment (HERA) Tool Development

Team Members: Ward, Konrad, Woodul

Overview: HERA is a decision-support tool designed to assist community agencies in planning and preparedness for extreme events. The tool was designed in response to new CMMS requirements for emergency preparedness, but is not restricted to only those purposes.

2017-2018 Activities:

- A beta version of the HERA tool provides decision-support through data visualizations, county-level data and information on extreme events including probabilities and recurrence intervals, comparisons across counties and to state averages, and information on event-specific impacts.
- Stakeholder feedback will inform refinements to the tool in 2018-2019

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.

Fostering a Network of Adaptation Practitioners

Supporting a Regional Resilience Network in Charleston, SC

Team Members: Foster, Watson, Covi

Overview: Established in 2015, the Charleston Resilience Network (CRN) is composed of public and private sector stakeholder organizations within the Charleston, SC metropolitan area that have a collective interest in the resilience of communities and critical infrastructure to climate extremes and long term climate change. CISA jointly supports a Resilience Program Coordinator in partnership with the SC Sea Grant Consortium to help organize CRN activities.

2017 – 2018 Activities:

- Engaged a network of 115 member organizations during bimonthly coffee hours and the CRN Expo
- Hosted the Coastal Resilience Knowledge Exchange with officials from Hampton Roads, VA to share lessons learned when dealing with coastal hazards
- Hosted the Living with Water: Dutch Approached and Charleston's Future in March 2018, a 2-day event with delegates from the Netherlands Embassy

Deliverables:

- Presentations, stakeholder outreach events
- Holleman, Joey. "Virginia coastal communities share coastal flooding experience with Charleston at Knowledge Exchange event." The Charleston Resilience Network. Web. 12 Jul. 2017.
- See Appendix: CISA Deliverables, 2017-2018 for additional citations.

South Carolina Climate Connections Workshop Series

Team Members: Farris, Guiseppe, Altman, Mizzell, Allen

Overview: In the fall of 2017 and spring of 2018, we hosted a series of three climate-related workshops in collaboration with the SC State Climatology Office and the SC Water Resources Center to provide information relevant to stakeholders in three South Carolina regions about responses to recent extreme events.

2017-2018 Activities:

- The 1-day workshops, titled "Weathering the Storm: Impacts of Extremes on South Carolina's Natural and Built Environment", were held in Greenville, Columbia, and Charleston, SC. The series attracted a total of 212 attendees.

Deliverables: Continuing education credits provided to six floodplain managers and twenty-seven licensed engineers (approx. savings of $5,000 for participants). Communications and outreach materials developed to promote the workshop series, reaching over 1,000 people.

Contributions to the Fourth National Climate Assessments

Kirstin Dow is serving as a lead author for the Southeast Chapter. She has participated in weekly chapter calls, as well as All Author calls and meetings. The chapter recently completed its 5th and final round of responding to comments.

Appendix: CISA Deliverables, 2017 - 2018

Stakeholder Conferences, Meetings, Trainings, and Workshops

Altman, E. Exhibit table at Waccamaw Conference. February 10, 2018. Conway, SC. 135 attendees.

Carbone, G. Weather and Climate Lessons for Catawba Trail Elementary School. December 13, 2017. Columbia, SC. 30 attendees.

Dow, K. SC Citizen's Climate Lobby meeting. January 21, 2018. Columbia, SC. 10 attendees.

Farris, A. and K. Lackstrom. NC Drought Management Council annual meeting. April 12, 2018. Raleigh, NC. 25 attendees.

Farris, A, and K. Guiseppe. Charleston Climate Connections Workshop. March 22, 2018. Charleston, SC. 84 attendees.

Farris, A. CoCoRaHS Condition Monitoring Observer Call. October 18, 2017. 20 attendees.

Farris, A. and K. Guiseppe. Columbia Climate Connections Workshop. February 22, 2018. West Columbia, SC. 77 attendees.

Farris, A. and K. Guiseppe. Greenville Climate Connections Workshop. December 12, 2017. Greenville, SC. 51 attendees.

Foster, S. CRN April Coffee Hour. April 20, 2018. Charleston, SC. 20 attendees.

Foster, S. CRN Expo. March 1, 2018. Charleston, SC. 59 attendees.

Foster, S. CRN January Coffee Hour. January 19, 2018. Charleston, SC. 20 attendees.

Foster, S. CRN July Coffee Hour. July 25, 2017. Charleston, SC. 20 attendees.

Foster, S. CRN November Coffee Hour. November 15, 2017. Charleston, SC. 24 attendees.

Foster, S. CRN September Coffee Hour. September 26, 2017. Charleston, SC. 21 attendees.

Foster, S. and M. Covi. Hampton Roads and Charleston Coastal Resilience Knowledge Exchange. June 15-16, 2017. Charleston, SC. 51 attendees.

Foster, S. Living with Water: Dutch Approaches and Charleston's Future. March 27—28, 2018. Charleston, SC. 360 attendees.

Lackstrom, K. CSI Working Group Webinar. April 25, 2018. 23 attendees.

Lackstrom, K. CSI Working Group Webinar. September 26, 2017. 14 attendees.

Lackstrom, K., E. Altman, A. Farris, and H. Mizzell. South Carolina Drought and Water Shortage Tabletop Exercise. September 27, 2017. West Columbia, SC. 80 attendees.

Seekamp, E. and M. Jurjonas. Adapting to More Water and Saltier Water in Eastern North Carolina, Stakeholder Workshop. November 2, 2017. Columbia, NC. 28 attendees.

Seekamp, E. and M. Jurjonas. Rural Coastal Community Resilience Focus Group. August 17, 2017. Creswell, NC. 15 attendees.

Seekamp, E. and M. Jurjonas. Rural Coastal Community Resilience Focus Group. September 14, 2017. Columbia, NC. 5 attendees.

Seekamp, E. and M. Jurjonas. Rural Coastal Community Resilience Focus Group. September 19, 2017. Alligator, NC. 38 attendees.

Seekamp, E. and M. Jurjonas. Salinization in Eastern North Carolina Agency Workshop. October 2, 2017. Manteo, NC. 37 attendees.

Voss, C. and D. Tomczack. Citizen Science Water – Level Monitoring Training. Ongoing; began in September, 2017. NC Coast. 75 attendees to date.

Voss, C. and D. Tomczack. Community Involvement in Monitoring King Tide Events Webinar. May 10, 2018. 60 attendees. 100 views since posted on YouTube.

Voss, C. and D. Tomczack. Earth Day Educational Event. April 20, 2018. Jacksonville, NC. 635 attendees.

Voss, C. and D. Tomczack. Marina Day. May 12, 2018. Carolina Beach, NC. 61 attendees.

Voss, C. and D. Tomczack. North Carolina Association of Floodplain Managers Annual Conference. April 17, 2018. Wilmington, NC. 100 attendees.

Voss, C. and D. Tomczack. Operations Committee Meeting. March 6, 2018. Carolina Beach, NC. 15 attendees.

Voss, C. and D. Tomczack. SciREN Coast Networking Event. February 15, 2018. Pine Knoll Shores, NC. 34 attendees.

Voss, C. and D. Tomczack. Southeastern NC CRS Users Group Meeting. January 25, 2017. Supply, NC. 18 attendees.

Voss, C. and D. Tomczack. STEAM Night. April 18, 2018. Morehead City, NC. 80 attendees.

Voss, C. and D. Tomczack. UNC – IMS 70th Anniversary Open House. October 21, 2017. Morehead City, NC. 500 attendees.

Voss, C. and D. Tomczack. Wrightsville Beach Elementary School NCKT Presentation. March 1, 2018. Wrightsville Beach, NC. 64 attendees.

Ward, A. and C. Konrad. HERA Engagement. July 6, 2017, Franklin County, NC.

Ward, A. and C. Konrad. HERA Engagement. November 16, 2017. Asheville, NC. 8 attendees.

Ward, A., C. Konrad, and J. Clark. HHVT-Convergence Occupational Health Engagement. August 10, 2017. Pinehurst, NC.

Ward, A., R. Byrd, L. Watson, R. Emanuel. Building Resilience to Climate Extremes to Protect Out Health and Lands. Workshop at 43rd Annual NC Indian Unity Conference. March 2, 2018. Greensboro, NC. 25 attendees.

Ward, R. NC Drought Management Advisory Council. Weekly. Teleconference. 13 organizations participate weekly.

Watson, S. Risk Communication Basics, A Risk Communications Training by NOAA's Office for Coastal Management and the Charleston Resilience Network. December 6, 2017. North Charleston, SC. 21 attendees.

Journal Articles

Altman E., Lackstrom, K., and Mizzell, H. 2017. "Drought and Water Shortages: South Carolina's Response Mechanisms, Vulnerabilities, and Needs". *South Carolina Journal of Water Resources*: Vol. 4: Iss. 1, Article 6. Available at: https://tigerprints.clemson.edu/jscwr/vol4/iss1/6

Clark, K. E., E. Chin, M. N. Peterson, K. Lackstrom, K. Dow, M. Foster, and F. Cubbage. 2018. "Evaluating Climate Change Planning for Longleaf Pine Ecosystems in the Southeast United States". *Journal of the Southeastern Association of Fish and Wildlife Agencies* Vol. 5: pp. 160-168.

Deeb, R., D. Tufford, G. Scott, J. G. Moore, and K. Dow. 2018. Impact of Climate Change on *Vibrio vulnificus* Abundance and Exposure Risk. Estuaries and Coasts. DOI: https://doi.org/10.1007/s12237-018-0424-5

Gao, P., G.J. Carbone, and J. Lu. 2018. Flood Simulation in South Carolina Watersheds Using Different Precipitation Inputs. *Meteorological Applications* (in press).

Lackstrom, K., A. Farris, D. Eckhardt, N. Doesken, H. Reges, J. Turner, K.H. Smith, and R. Ward. 2017.CoCoRaHS Observers Contribute to "Condition Monitoring" in the Carolinas: A New Initiative Addresses Needs for Drought Impacts Information. *Bulletin of the American Meteorological Society*, 98, 2527-2531. DOI: 10.1175/BAMS-D-16-0306.1

Lu, J., G. J. Carbone and P. Gao. 2017. Detrending crop yield data for spatial visualization of drought impacts in the United States, 1895–2014. Agricultural and Forest Meteorology, 237–238, 196-208. DOI: 10.1016/j.agrformet.2017.02.001

Newsletters

Farris, A. and K. Guiseppe. 2018. Carolinas Climate Connection, 1st Quarter, March 2018.

Farris, A. and K. Guiseppe. 2017. Carolinas Climate Connection, 4th Quarter, December 2017.

Farris, A. and K. Guiseppe. 2017. Carolinas Climate Connection, 3rd Quarter, September 2017.

Farris, A. and K. Guiseppe. 2017. Carolinas Climate Connection, 2nd Quarter, June 2017.

Guiseppe, K., E. Davis, A. Farris, K. Lackstrom. CISA and CoCoRaHS Condition Monitoring Newsletter. 12 Monthly Issues, June 2017 – May 2018. Web.

Voss, C. NC King Tides Project Quarterly Newsletters. Web.

Project and Research Information Documents

Jurjonas, M. and E. Seekamp. Research Fact Sheet from Columbia, NC Workshop. November 2, 2017.

Ward, A. Convergence Infographics: Where Weather Hit Us Hard; Tackling Weather and Climate; Staying Cool and Watching the Heat Index; Flood Risk: What Does This Mean for Me? Chapel Hill, NC. 2017.

Media

Carbone, G. Climate Matters: How Climate Change Affects South Carolina. WLTX Interview. March 1, 2018. Web.

Carbone, G. Why People Around the World Fear Climate Change more than Americans Do. The Conversation. October 3, 2017. Web.

Davis, C. Five Burning Questions about the Second Half of 2017. NC State Climate Office Climate Blog. July 18, 2017. Web.

Davis, C. May Showers Seal a Wet Spring, but What Will Summer Bring? NC State Climate Office Climate Blog. June 2, 2017. Web.

Davis, C. Winter Wanes Early in a Near-Record Warm February. NC State Climate Office Climate Blog. March 2, 2018. Web.

Davis, C. and R. Ward. After Irma, Dry Weather Dominates in September. NC State Climate Office Climate Blog. October 2, 2017. Web. Davis, C. The State Bakes During a Warm, Dry, July. NC State Climate Office Climate Blog. August 3, 2017. Web.

Foster, S. Charleston gets a visit from the real flood control experts, but can the Dutch really help here? Editorial. Post and Courier. March 29, 2018. Web.

Foster, S. Welcome Dutch Fixes for Charleston's Flooding Woes. Editorial. Post and Courier. April 2, 2018. Web.

Holleman, J. Virginia Coastal Communities Share Coastal Flooding Experience with Charleston at Knowledge Exchange Event. The Charleston Resilience Network. Web. July 12, 2017.

Voss, C. Carolina Beach Participating in UNC King Tides Project. The Island Gazette. April 24, 2018. Web.

Tomczack, D. "Community Engagement in Monitoring King Tide Events" Webinar. NC Association of Floodplain Managers Newsletter, Spring/Summer 2018 edition.

Voss, C. Coastal Communities Prepare for King Tide Cycle. WNCT Channel 9 interview. January 29, 2018.

Voss, C. King Tides Project Comes to Oriental. Town Dock. May 15, 2018.

Voss, C. NC King Tides Project Collects Data about the Tide Level During Eclipse. WNCT Channel 9 interview. August 21, 2017.

Voss, C. Sunny Day Flooding, How King Tides Affect Coastal Communities and How You Can Help. Port City Daily. April 26, 2018.

Organized Conference Sessions

Dilling, L., K. Lackstrom, and T. Wall. 2018. Building Resilience to Weather and Climate Extremes Across Scales. 13th Symposium on Societal Applications: Policy, Research and Practice at the American Meteorological Society Annual Meeting, January 7-11, 2018. Austin, TX.

Dow, K. and K. Lackstrom. 2017. Peering into the Future of Southeastern Wildlife Conservation: Understanding Key Drivers of Landscape Changes. Southeastern Association of Fish and Wildlife Agencies 71st Annual Conference. October 29 – November 1, 2017. Louisville, KY.

Foster, S. 2017. Old City, High Water. Coastal Conservation League Winthrop Civic Forum. October 12, 2017. Charleston, SC.

Foster, S. 2017. The Case for Resilience: Planning, Design, and Building Charleston's Future. Urban Land Institute and American Institute of Architects. August 15, 2017. Charleston, SC.

Presentations

Carbone, G. Climate Change and Threats to Coastal Regions. Guest lecture at the University of South Carolina's Coastal Law Laboratory, July 3, 2017, Charleston, SC.

Carbone, G. A Climate Change Discussion Following *An Inconvenient Sequel*. The Nickelodeon Theatre, August 23, 2017, Columbia, SC.

Carbone, G. What Climate Change Might Mean for Social Workers. Meeting of the South Carolina Chapter of the National Association of Social Works, March 22, 2018, Columbia, SC.

Clark, K., E. Chin, M. N. Peterson, K. Dow, and K. Lackstrom. Evaluating Climate Change Planning for Longleaf Pine Ecosystems in the Southeast United States. Southeastern Association of Fish and Wildlife Agencies 71st Annual Conference, October 31, 2017, Louisville, KY.

Conrads, P., L. Rouen, and K. Lackstrom. Using the Coastal Salinity Index for Monitoring Drought Along the Gulf of Mexico and the Southeastern Atlantic Coast. 23rd Conference on Applied Climatology, June 28, 2017, Asheville, NC.

Dinon Aldridge, H. Cuckoo for CoCoRaHS (especially during March Madness). Central North Carolina Chapter of the American Meteorological Society Monthly Meeting, March 15, 2018, Raleigh, NC.

Dow, K. Engaging Coastal Communities. South Carolina Beach Advocates meeting, November 7, 2017, James Island, SC.

Dow, K. Panel Discussion. Free Times Summer Breakfast Series: Climate Change Forum. June 27, 2017, Columbia, SC.

Dow, K. Sea Level Rise in South Carolina. Sierrafest, September 30, 2017, Georgetown, SC.

Dow, K., P. Glick, E. Chin, K. Lackstrom, B. Stein, N. Peterson, K. Clark. Integration of Climate Change in Southeastern State Wildlife Action Plans: Assessing Challenges and Opportunities for Future-Oriented Conservation. Southeastern Association of Fish and Wildlife Agencies 71st Annual Conference, October 31, 2017, Louisville, KY.

Farris, A. and K. Lackstrom. Carolinas Integrated Sciences & Assessments: Supporting Climate Adaptation in the Carolinas. American Association of State Climatologists (AASC) Annual Meeting, June 28, 2017, Asheville, NC.

Farris, A. and K. Lackstrom. Using Citizen Science to Support Drought – Related Decision Making. American Meteorological Society 98th Annual Meeting, January 7 – 11, 2018, Austin, TX.

Farris, A. CoCoRaHS Condition Monitoring: Lessons Learned to Support a National Network of Citizen Scientists, Drought Monitoring, and Decision Making. 2018 WERA 1012 Meeting, May 16 – 18, 2018, Estes Park, CO.

Foster, S. Collaborative Partnerships to Advance Resilience Planning. National Planning Conference, April 23, 2018, New Orleans, LA.

Foster, S. Resilience in the Southeast. National Sea Grant Consortium Meeting, Savannah, GA, October 16-17, 2017.

Jurjonas, M. and E. Seekamp. Finding Agency for Climate Justice; An Adaptive Capacity Assessment Tool Developed in Coastal North Carolina (USA). International Association for Impact Assessment Conference, May 16, 2018, Durban, South Africa.

Jurjonas, M. and E. Seekamp. Is There a Social Cost to Protecting Wetlands? Diverse Perspectives on Ecosystem Services. Southeast Recreation Research Conference, March 26, 2018, Athens, GA.

Jurjonas, M. and E. Seekamp. Perspectives on Rural Coastal Resilience in North Carolina: Comparisons Between Diverse Communities. NOAA Social Coast Forum, February 8, 2018, Charleston, SC.

Konrad, C. and A. Ward. Heat-Health Vulnerability in North Carolina and the Development of a Web – Based Tool to Predict Emergency Room Visits. Climate Prediction Applications Science Workshop, May 24, 2018, Fargo, ND.

Lackstrom, K. CISA Climate Communications: Products and Resources. SC Coastal Information Network Quarterly Meeting, August 7, 2017, North Charleston, SC.

Lackstrom, K. Climate Change and its Impact on Emergency Services & Water Resources. South Carolina Association of Special Purpose Districts 2018 Leadership Program, May 17, 2018, Blythewood, SC.

Lackstrom, K., A. Farris, and R. Ward. A New System for Drought Impacts Monitoring and Reporting Using Citizen Science. American Meteorological Society 23rd Conference on Applied Climatology, June 26 – 28, 2017, Asheville, NC.

Lackstrom, K., H. Mizzell, and E. Altman. Drought Response and Planning in South Carolina: Opportunities and Challenges for Building Resilience Across Scales and Sectors. American Meteorological Society 98th Annual Meeting, January 7 – 11, 2018, Austin, TX.

Lackstrom, K., P. Conrads, B. McCloskey, and L. Rouen. Coastal Salinity Index: Monitoring Drought on the Gulf and Atlantic Coasts. American Meteorological Society 98th Annual Meeting, January 7 – 11, 2018, Austin, TX.

Miller, G. and J. Morris. Marsh Migration and Change within Port Royal Sound Watershed. Port Royal Sound Watershed Mapping Meeting, September 28, 2017, Okatie, SC.

Miller, G. Marsh Migration and Change within the Port Royal Sound Watershed. The Nature Conservancy Scoping Meeting, September 28, 2017, Okatie, SC.

Patel, A. Incorporating Climate Change in Long- Range Water Supply Planning: A Case Study with OWASA. Piedmont Triad Regional Council's Climate Resiliency Summit, May 14 – 15, 2018, Kernersville, NC.

Petkewich, M., B. McCloskey, L. Rouen, and K. Lackstrom. Monitoring Drought Along the Gulf of Mexico and the Southeastern Atlantic Ocean Using the Coastal Salinity Index. 2018 South Carolina Environmental Conference, March 11-14, 2018, Myrtle Beach, SC.

Rowe, M., C. Voss and D. Tomczack. The North Carolina King Tides Project: A Citizen Science Water-Level Monitoring Initiative. North Carolina Association of Floodplain Managers Annual Conference, April 17, 2018, Wilmington, NC.

Ward, A. HERA: Hazardous Extremes Risk Assessment Tool – a Web-Based Tool to Support Planning and Preparedness Decision-Making. NC Public Health Preparedness and Response Symposium, May 17, 2018, Greensboro, NC.

Ward, A. Panel Discussion. Climate Change Communication. Climate Change and Resilience Symposium, UNC Chapel Hill, April 20, 2018, Chapel Hill, NC.

Ward, A. Climate-Health Community Profiles: A Collaboration between CISA and the North Carolina American Indian Health Board. North Carolina American Indian Health Board Meeting, August 11, 2017, Chapel Hill, NC.

Ward, A. Collaborative Development and Evaluation of Web-Based Tools to Address Heat-Related Illness in North Carolina. American Meteorological Society Annual Conference, January 7 – 11, 2018, Austin, TX.

Ward, A. Indigenous Health and Environment: Opportunities for Partnership. Healthy Native North Carolinians Meeting, September 22, 2017, Chapel Hill, NC.

Ward, A. Collaborative Development and Evaluation of Web-Based Tools to Address Heat-Related Illness in North Carolina. NC Alliance of Public Health Agencies Meeting, September 27 – 29, 2017, Asheville, NC.

Ward, A. HERA: Hazardous Extremes Risk Assessment, A Decision-Support Tool. NC Division of Public Health Public Health Preparedness and Response Webinar, October 27, 2017, Raleigh, NC.

Ward, A., S. Shaughnessy, and L. Mauldin. Collaborative Development and Evaluation of Web – Based Tools to Address Heat Related Illness in North Carolina. NC American Public Health Association (APHA), September 27, 2017, Asheville, NC.

Ward, A., S. Shaughnessy, and L. Mauldin. Engaging Stakeholders in the Development and Evaluation of Web-Based Tools to Address Heat Related Illness in North Carolina. American Meteorological Society Conference, January 8, 2017, Austin, TX.

Ward, R. Climate and Weather Over the Past Year. NC Drought Management Advisory Council Annual In-Person Meeting, April 12, 2018, Raleigh, NC.

Ward, R. Monitoring Drought in NC: The NC Drought Management Advisory Council. Central North Carolina Chapter of the American Meteorological Society Monthly Meting, November 16, 2017, Raleigh, NC.

Watson, S. Coastal Climate and Resilience in the Charleston Region. CRN Coffee Hour, November 15, 2017, Charleston, SC.

Watson, S. Coastal Science Serving South Carolina. SC Association of Hazard Mitigation Conference, March 14, 2018, Hilton Head, SC.

Watson, S. Co-presentation with NOAA OCM at Social Coast Forum, February 9, 2018, Charleston, SC.

Watson, S. Co-presentation with NOAA OCM at Social Coast Forum, February 10, 2018, Charleston, SC.

Watson, S. Mt. Pleasant Be Flood Ready. Town of Mt. Pleasant Community Meeting. May 9, 2018, Mt. Pleasant, SC.

Watson, S. National Sea Grant/SC Sea Grant Consortium Aquaculture Communication Visioning. National Sea Grant Visioning Workshop, April 17 – 18, 2018, Atlanta, GA.

Watson, S. Risk Communication for Extension Professionals. EDEN, January 12, 2018, Webinar.

Watson, S. Swamped Coast: Climate Change in the Lowcountry. Coastal Discovery Museum Lecture, April 4, 2018, Hilton Head, SC.

Watson, S. Swamped Coast: Planning for Extreme Weather and Sea Level Rise. SC Climate Connections Workshop, March 22, 2018, Charleston, SC.

Posters

Jurjonas, M. and E. Seekamp. Rural Coastal Community Resilience: A Framework for Assessing Diverse Perceptions of Adaptive Capacity. NC State University College of Natural Resources Research Symposium, February 2, 2018, Raleigh, NC.

Lu, J. and G. Carbone. 2018. Uncertainty and hotspots in the 21st century projections of agricultural drought from CMIP5 models. American Association of Geographers Annual Meeting, April 10-14, 2018, New Orleans, LA.

Miller, G. and J. Morris. 2017. A Race for Survival; Will Salt Marshes in Jasper and Beaufort County, South Carolina Drown or Keep Pace with Rising Sea Level?. Ecological Society of America Annual Meeting, 6-11 August 2017, Portland, OR.

Voss, C. and Tomczack, D. AERS 70th Anniversary Conference, April 5 – 7, 2018, Rehoboth Beach, DE.

Reports

Altman, E. and K. Lackstrom. 2018. South Carolina Drought and Water Shortage Tabletop Exercise Summary Report. Columbia, SC. 44 pp.

Farris, A., E. Davis, K. Guiseppe, K. Lackstrom, R. Ward. 2018. CoCoRaHS Citizen Science Condition Monitoring: Phase 2 Final Report. Columbia, SC. 106 pp.

Lackstrom, K. 2018. Coastal Carolinas DEWS Strategic Plan. Columbia, SC. 24 pp.

Lackstrom, K., L. Rouen. 2017. Ecological Responses to Drought in the Coastal Carolinas and Georgia: Research Review.

Tuler, S. 2018. Assessment of Adaptation, Policy, and Capacity Building Outcomes from 14 VCAPS Processes. Columbia, SC. 33 pp.

Theses and Dissertations

Davis, E. 2018. Comparison of Sentinel-2 and Landsat 8 Oli in the Mapping of Soil Salinity in Hyde County, North Carolina. Masters' Thesis, Department of Geography, University of South Carolina.

Jurjonas, M. 2018. A Framework for Rural Coastal Community Resilience: Assessing Diverse Perceptions of Adaptive Capacity for Climate Change. PhD Dissertation, Chapter 4, North Carolina State University.

Lu, J. 2018. Measuring Agricultural Drought and Uncertainty in Future Drought Projections. PhD Dissertation, Department of Geography, University of South Carolina.

Videos

DDC International. 2018. NOAA's Carolina RISA team: Climate-smart communities make better investments. YouTube video.

Voss, C. and D. Tomczack. North Carolina King Tides Project - Submitting a Photo and Report. YouTube video.

Web-based Tools

Hazardous Extremes Risk Assessment (HERA) Tool. 2018. Developed by Ashley Ward, CISA, University of North Carolina, Chapel Hill. https://convergence.unc.edu/tools/hera/