

Carolinas Integrated Sciences & Assessments
2015 - 2016 Annual Report
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The CISA Program

The [Carolinas Integrated Sciences & Assessments](#) (CISA) program, a NOAA-funded [Regional Integrated Sciences & Assessments](#) (RISA) team, works to integrate climate science into decision-making processes and improve society's ability to respond to climatic events and stresses. CISA conducts applied climate research in collaboration with a wide range of stakeholders across the Carolinas, including federal, state, and local agencies, resource managers, non-governmental organizations, and the private sector.

Our primary focus areas – water, coasts, and health – are embedded within and integrated across our research projects. To address the challenges associated with climate variability and change and impacts to these sectors, CISA works to provide decision makers with information that meshes with existing management and planning processes, and deliver climate information and services that are sensitive to the broader social, political, economic, and environmental contexts in which these decision makers operate.

A significant component of the CISA Program is the team's communications and outreach activities. As a trusted source of climate information for the Carolinas, CISA is able to support state and local adaptation projects and capacity-building by providing opportunities for information exchange and translating scientific data into useable formats for decision makers and the public.

New Areas of Focus and Partnership

Charleston Resilience Network

The [Charleston Resilience Network](#) (CRN) was established in 2015 as a volunteer-based effort to bring together public and private sector stakeholders in the Charleston, SC, metropolitan area with an interest in building regional resilience to episodic natural disasters and chronic coastal hazards. The CRN works to foster a unified strategy and provide a forum to share science-based information, educate stakeholders, and enhance long-term planning decisions that result in resilience. CISA PI Elizabeth Fly is a founding member of the CRN. In 2016, the CRN received two external grants to support their work; Fly is the lead investigator on both. A [NOAA Regional Coastal Resilience Grant](#) was awarded to the CRN to assess the capacity of the Charleston region's infrastructure to cope with nuisance and severe flooding. CISA PIs Greg Carbone and Kirstin Dow are also investigators on this grant. A [National Infrastructure Protection Plan \(NIPP\) Security and Resilience Challenge](#) grant from the Department of Homeland Security, will support the development of multi-hazard coastal resiliency assessment and adaptation indices and tools for the region.

Outreach and Research in Response to the October 2015 Extreme Rainfall and Flood Event

A combination of meteorological conditions contributed to a historic rainfall and flooding event in the Carolinas in early October 2015. A trifecta of systems led to record-breaking precipitation totals and devastating impacts, including loss of life. Precipitation records were broken across much of eastern and central South Carolina, with four-day totals ranging from 6 to 21 inches. Infrastructure failures, including multiple dam breaches, were a major cause of the spatial extent and depth of the flooding in parts of Columbia, SC. Flood waters crested downstream in the days following the extreme rainfall leading to coastal flooding impacts and record streamflow. In order to provide a comprehensive assessment of the event from a climatological and meteorological perspective as well as

to initiate conversation about rebuilding with resilience to future, similar events in mind, CISA produced an [informational 4-pager](#) which was distributed throughout networks in the Carolinas. Carbone and Gao have continued research to assess the event as part of the [Analysis of Extreme Rainfall Events](#) project.

New NC Climate Integration and Outreach Specialist to Join the CISA Team

In 2015-2016 CISA established, and conducted the search for, a new Climate Integration and Outreach Specialist position to be based at the University of North Carolina at Chapel Hill (UNC-CH). A candidate has been selected and is scheduled to join CISA in July 2016. This position addresses a recommendation articulated by our external reviewers for a greater, on-the-ground CISA presence in NC. This new position will allow us to strengthen our team's collective knowledge of NC climate issues and significantly enhance our capacity to respond to stakeholder needs and requests. In addition to new projects and partnerships which will emerge as the new Climate Integration and Outreach Specialist interacts with NC stakeholders, this person will also coordinate efforts advance CISA's ongoing climate-health research, applications, and communications.

South Atlantic Regional Research on Coastal Community Resilience: "Advancing understanding of risk: Increasing accuracy of hazard damage assessment tools by improving base data and analyzing opportunities and barriers for use in adaptation planning"

In 2016 Dow and Fly will participate on a new project, with collaborating researchers, Sea Grant staff, and community partners from Florida, Georgia, North Carolina, and South Carolina. The four South Atlantic Sea Grant programs and NOAA Office of Coastal Management sponsor this award. The overall goal of the project is to conduct and evaluate a participatory process to help local governments build capacity to better visualize, understand, and plan for local coastal hazard risks. The team will use the [FEMA HAZUS model](#) coupled with improved digital elevation files to refine risk assessments. The team will use the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process to engage with the partner communities. They will also evaluate the effectiveness of VCAPS in supporting different stages of the resilience planning process.

Climate Services

North Carolina

The Public Health Toolbox allows researchers to investigate the linkages between climate and human health and to identify climate-public health vulnerabilities across different regions and populations in North Carolina. CISA PI Konrad has led the development of the toolbox, which integrates North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT) data, climate and weather data, and geographic and demographic information. Colleagues from the NC Division of Public Health, NC State Climate Office, UNC Chapel Hill School of Emergency Medicine, and UNC Gillings School of Global Public Health have participated in the development and application of this new tool. Specific to CISA, the toolbox has been used to investigate vulnerability to heat stress and waterborne disease.

Increasing Understanding of Heat-Related Illness in NC with the Heat Health Vulnerability Tool

Using the *Public Health Toolbox*, CISA researchers Konrad and Sugg investigated the connections between heat and heat-related illness in North Carolina. They developed empirical relationships, which they then exploited to build the *Heat Health Vulnerability Tool* (HHVT). More information can be found in the [Health](#) projects section of the report. The HHVT translates recent, current, and predicted weather/climate conditions across the Carolinas into useful information regarding the probability of public health emergencies. Specifically, the HHVT predicts the number of emergency department (ED) visits using National Weather Service daily maximum heat index forecasts and empirical relationships identified between ED visits and the daily maximum heat index. The tool allows the user to estimate levels of heat morbidity for different demographic groups across sub-regions of NC.

Ongoing engagement with project partners and stakeholders has been an important component of the HHVT's development and ongoing improvement. Climate Ready NC, a CDC Building Resilience Against Climate Effects

(BRACE) program, is using the tool to monitor potential heat-health events and engage with health officials and other stakeholders about heat-health vulnerabilities. In 2015-2016, Climate Ready NC partners organized meetings focused on obtaining user feedback regarding the usefulness and accessibility of the tool. The first stakeholder meeting was conducted in September 2015, to coincide with the launch of the first version of the tool. HHVT Version 2.0 incorporated stakeholder input and was launched in May 2016, and a second meeting was held to elicit additional feedback. Both meetings were conducted in Fayetteville, NC, part of the “Sandhills” region that experiences some of the highest incidences of HRI in North Carolina. Participants represented county health and emergency management departments, the NC Department of Health and Human Services, healthcare systems, school systems, cooperative extension, and Fort Bragg. Konrad will continue to work with Climate Ready NC to engage stakeholders and improve the tool throughout 2016-2017.

Citizen Science Condition Monitoring Reports Inform NC Drought Management Advisory Council

Rebecca Ward, Extension Climatologist with the State Climate Office of NC and member of the NC Drought Management Advisory Council (NC DMAC) has been an engaged stakeholder since the launch of the [Drought Impacts Monitoring and Reporting through Citizen Science Engagement](#) project. Each week, Rebecca reviews condition monitoring reports submitted by NC CoCoRaHS observers and shares relevant information about changing conditions with other members of the DMAC. Ward conveyed the usefulness of these reports in an e-mail in 2015 when dry conditions were emerging in parts of NC. She wrote, “We've been watching conditions quickly deteriorate in the western half of NC over the last few weeks and these have been invaluable sources of on-the-ground information. This is a time of year where there still aren't many impacts to be felt in more "typical" sectors such as agriculture. The wealth and detail of information in these reports is amazing -- from talking about stagnant creeks that were flowing only a few weeks ago, to squishy yards, to the species of plants that are emerging. Connecting the information in these reports with objective indicators such as streamflow levels or SPI really gives us a fuller picture of what's happening in parts of the state.”

South Carolina

City of Charleston Uses CISA Expertise to Develop Sea Level Rise Strategy

The City of Charleston, SC, has seen a 409% increase in nuisance flooding days since the 1960s¹. The City is now making a concerted effort to incorporate planning for future inundation into all activities by developing a sea level rise (SLR) Strategy. As a first step, the City sought the expertise of PI Fly in deciding which SLR scenarios to use for future planning. Fly, along with representatives from the NOAA Office of Coastal Management and the National Weather Service, met with City officials to analyze current flooding trends and future SLR projections from the National Climate Assessment. In consultation with CISA and NOAA, the City determined that planning for a SLR of 1.5 ft. by 2040 and 2.5 ft. by 2060 works best for the City’s current needs. The City will reassess these projections every five years. These projections were then used to develop the SLR Strategy, a comprehensive inventory of initiatives that are a guiding framework to make the City more resilient to SLR and recurrent flooding. The Strategy was presented to and adopted by City Council in spring 2016.

Beaufort and Port Royal Sea Level Rise Task Force Use CISA Expertise to Educate the Public

Stakeholders in the City of Beaufort and Town of Port Royal formed a task force to address the area’s vulnerability to sea level rise (SLR) and develop adaptation strategies. The task force has thirteen members, including Beaufort’s mayor and Port Royal’s planning administrator. CISA provided technical assistance to the task force in identifying vulnerable areas using the NOAA and Climate Central sea level rise viewers and understanding types of flood mitigation options for public and private entities. After receiving approval and encouragement from the Beaufort City Council and Port Royal Town Council to continue work and engage neighborhood groups, the task force created materials appropriate for public education and outreach. CISA assisted in the development of these

¹ Sweet, W., J. Park, J. Marra, C. Zervas, and S. Gill. 2014. [Sea Level Rise and Nuisance Flood Frequency Changes around the United States](#). US Department of Commerce, Washington, D.C.

materials by providing content on sea level rise vulnerability and flood resilience strategies and maps produced from data visualization of sea level rise projections. Presentations have been given to seven neighborhood associations as well as to the Director of the Lady's Island Airport, where plans to construct additional runways directly coincide with areas projected to be impacted by SLR. CISA assisted the task force in writing a letter to the Federal Aviation Administration (FAA), requesting that the FAA require Lady's Island Airport to consider future SLR in airport improvements and design standards.

Program Impacts

Measuring the overall program-level impact of CISA

In summer 2014, CISA commissioned an external evaluation to assess overall program progress and to identify opportunities to continue to strengthen the program. This evaluation included interviews with PIs, other team members, advisory committee members, and stakeholders to evaluate work-to-date and to help CISA think creatively about future directions. The evaluation report was shared with the CISA advisory committee at an in-person meeting in fall 2014 to discuss findings and next steps for the research team.

This evaluation was conducted prior to Year 4 of CISA's 5-year award and provided an overall assessment of the program's impact. Since then, program efforts have been informed by feedback received from the evaluation team and advisory committee, focusing on new projects and initiatives to better connect climate with the topics of most relevance to local and regional decision makers. Much of this work has been implemented in 2015-2016. For example, CISA is establishing a new Climate Integration and Outreach Specialist position at UNC-CH to address the need for a greater on-the-ground, CISA presence in North Carolina. We are also taking advantage of focusing events, such as the October 2015 extreme rainfall event in South Carolina, to conduct targeted outreach and research.

During the course of CISA's current award (2011-2016), the team has adopted several approaches to monitor and assess our impact. These include more quantitative measures such as readership of the quarterly newsletter and listserv; numbers of presentations and written materials provided to stakeholder and scientific audiences; and number and types of communities and other partners with whom we work. Participant evaluations of hosted workshops and conferences help to inform future planning efforts to ensure that these in-person engagements effectively support networks. Several projects integrate evaluation questions and metrics in the implementation of research and engagement activities; examples include the Citizen Science-Condition Monitoring (see below) and VCAPS projects. In addition, Dow is participating in the AAAS Leshner Leadership Program on Public Engagement with Science, which includes further support for evaluation. The CISA team will apply insights gained from these various efforts to expand project- and program-level evaluation in the coming years, specifically under the decision support and knowledge integration research themes included in CISA's 2016-2021 Statement of Work.

Overall program-level impact

The 2014 external review team commended the CISA program for its accomplishments, including the execution of a highly regarded research agenda, development of climate communications and outreach capabilities, building of collaborative partnerships, and providing respected leadership on climate issues and concerns in the Carolinas.

Applied Research. CISA's research program serves [South Carolina](#) coastal communities through the provision of technical assistance, such as development and guidance on the use of sea level rise projections. CISA is also using project-specific evaluation to inform the iterative research design that is fundamental to CISA's approach to providing decision support services.

For example, the [Drought Impacts Monitoring and Reporting through Citizen Science Engagement](#) project has included evaluation of the project's citizen science engagement efforts and current and potential use of the information produced through the project. CISA team members solicited feedback from observers through a series of online surveys. Survey results have been used to inform outreach with the observers such as monthly

newsletter, blog content, and quarterly conference calls. Following on decision maker interviews after the first year of reporting, revisions are in process for the condition monitoring report form and creation of a web map to spatially display the reports. Report form revisions include the development of a quantitative scale bar, which allows observers to select from various levels of wetness or dryness to give a quick snapshot of local conditions. The web map will enhance the accessibility and utility of reports provided by CoCoRaHS observers. CISA plans to work with observers and users of the new scale bar and web map to evaluate their effectiveness through 2017.

Communications and Outreach. The CISA team continues to refine strategies for effectively communicating and engaging with a variety of audiences about climate in the Carolinas.

- The [Carolinas Climate Resilience Conference](#), the first of which was hosted in April 2014 and the second planned for September 2016, is a cornerstone activity in developing CISA's network of climate adaptation practitioners in the region. There were 196 attendees in 2014 with over 100 presentations representing a variety of sectors and topics.
- CISA's quarterly newsletter, [Carolinas Climate Connection](#), is currently circulated to over 1200 people. Readership of the newsletter, as reported through Constant Contact analytics, exceeds the industry average of 20% by about 7%.
- The [Carolinas Climate Listserv](#) circulates posts once to twice per week as relevant news become available. There are currently 252 subscribers. An evaluation survey circulated to recipients of these resources in August 2014 received an overall positive response with suggestions for additional content which have been incorporated into subsequent issues.
- An [informational 4-pager](#) produced by CISA team members following the October 2015 extreme rainfall and flooding event was circulated broadly throughout networks in the region. It was linked to other agencies' webpages including the [US Geological Survey](#), shared in local news stories, and discussed in venues such as the SC Conservation Leaders' Summit and with the Central Midlands Council of Governments. CISA is pursuing follow-up research and discussion with many of these stakeholders.
- CISA team members gave 52 presentations at local, state, and national events.

Regional Leadership and Partnerships. In order to identify opportunities for collaboration and to seek synergies with other efforts, CISA team members interact with climate practitioners and stakeholders throughout the Southeast region and at the national level as well. This role has helped the CISA team to obtain grants to further advance climate adaptation research and planning in the Carolinas. These CISA team members provide leadership for important regional-level networking processes. Specific examples include:

- Steering committee co-chairs of the [Southeast and Caribbean Climate Community of Practice](#) (Farris, Fly). More information on this partnership is provided below.
- Point-of-contact for the Coastal Carolinas NIDIS Drought Early Warning System (DEWS) program (Dow, Farris, Lackstrom)
- Co-chair of the [NIDIS Engaging Preparedness Communities Working Group](#) (Lackstrom)
- Participation in quarterly coordination calls with other federal agencies in the Southeast providing climate services (Dow)
- Participation in the [South Carolina Coastal Information Network](#) and its quarterly meetings (Fly, Farris)
- Participation in the National Adaptation Forum [program committee](#) (Farris)
- Participation in collaboration calls with [NCAnet](#) (Farris)

Increasing Capacity to Prepare and Adapt to Climate Variability and Change in the Carolinas

CISA helps to build the capacity of local and regional decision makers to prepare for and adapt to climate variability and change. Examples of 2015-2016 activities include:

The Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process continues to expand throughout the Carolinas and to other states. In 2015-2016 CIs Schiavinato and Whitehead conducted VCAPS exercises in Hyde County and the Town of Nags Head, NC. PI Fly and CI Whitehead helped the Eastern Shore Land

Conservancy in Maryland conduct VCAPS trainings to prepare them to conduct a VCAPS workshop with key stakeholder in Kent County, MD.

CISA provides technical assistance to coastal communities. As part of the CISA-Sea Grant partnership, Liz Fly and other CISA team members work closely with coastal communities to help them plan for and address climate risks. Examples of 2015-2016 activities include:

- working with the City of Beaufort and Town of Port Royal Sea Level Rise Task Force to identify SLR impacts and vulnerabilities and develop informational materials for public education and outreach
- convening public and private sector stakeholders to support Charleston Resilience Network efforts to assess and address coastal hazards
- providing technical support to the City of Charleston in the development of their Sea Level Rise Strategy
- facilitating public discussions, producing educational materials, and developing sea level rise scenarios for the City of Folly Beach, SC, for incorporate of sea level rise into their municipal Comprehensive Plan

The Atlas of Hydroclimate Extremes is being developed in response to a need voiced by resource managers and decision makers for an improved baseline understanding of information about extreme events, as well as normal precipitation, in the Carolinas. CISA PI Carbone is leading efforts to conduct research and analyses for the Atlas and develop visualizations and narratives to help connect data to decision contexts. The Atlas will be made available online and will include information such as the frequency of drought and high rainfall events, conditions necessary to support drought recovery, and impacts associated with hydroclimate extremes.

In-person engagements are repeatedly identified by CISA stakeholders as the best way to support a network of climate adaptation practitioners in the Carolinas. To support this network, CISA organized several in-person engagements in 2015-2016, including the Southeast and Caribbean Climate Community of Practice (CCoP) workshop, a Coastal Vulnerability Workshop (with the North Inlet/Winyah Bay National Estuarine Research Reserve), two *Heat Health Vulnerability Tool* meetings, and the NIDIS Coastal Carolinas DEWS strategic planning meeting, among others. Over 200 people attended various workshops and trainings organized by CISA team members in 2015-2016 (see [Appendix: CISA Deliverables, 2015-2016](#)).

Featured Engagement: The Southeast and Caribbean Climate Community of Practice

Initiated by NOAA's Southeast and Caribbean Regional Team (SECART) and regional Sea Grant programs, the Southeast and Caribbean Climate Community of Practice (CCoP) was created in 2010 in response to the growing need for climate extension professionals to bridge the gap between science and decision makers. Comprised of individuals from government, academic, non-profit, and private sectors, the CCoP provides a forum for sharing lessons learned and best practices related to climate communication and adaptation. The CCoP also provides education and networking opportunities to increase their members' knowledge and awareness of climate science and, ultimately, to increase adaptive capacity in the region. Co-chairs Fly and Farris support the CCoP through a monthly e-mail round-up of webinars, events, and other resources of interest to the CCoP members; information sharing through a new [CCoP webpage](#); and [webinars](#).

A successful proposal to the National Sea Grant Program 2014 Special Projects grant funded an [in-person CCoP workshop](#) April 13-15, 2016 in Tybee Island, GA. 64 people from Florida, Georgia, North Carolina, South Carolina, Virginia, and Puerto Rico attended representing a variety of sectors, agencies, and organizations. The workshop included presentations on climate communications, vulnerability assessments, using the National Flood Insurance Program's Community Rating System (CRS) to support climate adaptation, a tools café, a tour of adaptation strategies which have been implemented on Tybee Island with support from members of the CCoP, and a keynote by City of Beaufort, SC Mayor Billy Keyserling.

Proudest Accomplishment: CISA Expertise Supports Charleston's Climate Resilience Network

Several years of effort and the interdisciplinary expertise of the CISA team have coalesced to address a significant climate vulnerability in the Carolinas, specifically in the Charleston region where long-term planning efforts are increasingly acknowledging the need for strategies to become more climate resilient. Recent publications and media coverage of increased nuisance flooding and devastating impacts caused by the October 2015 extreme rainfall and flooding event in the Charleston region catalyzed local action to address the implications of sea level rise. The successful partnership between CISA and the NC and SC Sea Grant programs (established as the Carolinas Coastal Climate Outreach Initiative [CCCOI] in 2007), is serving as an important resource for this community.

The [Charleston Resilience Network](#) (CRN) was launched in spring 2015 as an outcome of a Climate Change Tabletop Exercise hosted by the US Department of Homeland Security's (DHS) Office of Infrastructure Protection (IP). PI Fly helped to found the CRN with partners from the Berkeley-Charleston-Dorchester Council of Governments, Charleston County Emergency Management, City of Charleston, SC Sea Grant Consortium, SCANA Corporation, and SC Department of Health and Environmental Control's Office of Ocean and Coastal Resources Management. The goal of the CRN is to foster a unified strategy and provide a forum to share science-based information, educate stakeholders, and enhance long-term planning decisions that build resilience². The CRN is spear-heading many of the local initiatives in which CISA team members are participating and support through a variety of efforts.

PI Fly supported planning efforts to organize a symposium in partnership with the National Academy of Sciences (NAS) Resilient America Roundtable on February 23, 2016, to examine the Charleston region's resilience through the lens of the October 2015 flood event. The symposium brought together a diverse range of stakeholders to share information and lessons learned across key sectors, as well as discuss practices, partnerships, and opportunities to enhance resilience to similar future events. Carbone, Dow, and Fly are all PIs on a NOAA Regional Coastal Resilience grant designed to understand the capacity of the Charleston region's infrastructure to cope with nuisance and severe flooding. PI Fly is also a lead on a new National Infrastructure Protection Plan (NIPP) Security and Resilience Challenge grant from the US DHS to develop multi-hazard coastal resiliency assessment and adaptation indices and tools for the Charleston region. Carbone's current work on the Atlas of Hydroclimate Extremes and analysis of extreme rainfall events will inform the climate science used to assess vulnerabilities. Dow's efforts will leverage the years of experience CISA and partners have developed in facilitating analytical-deliberative dialogue using the VCAPS process. The effort is further supported by Farris and Fly as co-chairs of the Southeast and Caribbean Climate Community of Practice. The in-person workshop they organized in April 2016 spread awareness of the CRN throughout the region through presentations and networking with other members of the CRN at the workshop. The CRN will also be showcased through sessions at the upcoming 2016 Carolinas Climate Resilience Conference.

Research Highlights

Spatial and Temporal Patterns of Gastrointestinal Illness and Their Relationship with Precipitation across the State of North Carolina

Hartley (2015) used the [NC DETECT Public Health Toolbox](#) to assess relationships between precipitation patterns and waterborne disease in NC between 2008 and 2012. Correlations between incidences of emergency department (ED) admissions for gastrointestinal illness (GI) and precipitation patterns were analyzed in conjunction with demographic information to improve understanding of populations most vulnerable to these diseases. Results indicate that there are significant correlations between rates of ED admissions and poverty elements. Additionally, there is significant clustering of disease after "heavy" rain, categorized as 2" or more.

² www.charlestonresilience.net

Several geographically explicit areas of high GI occurrence were identified at the county level, with seven counties showing 300% or greater increases in admissions after heavy rainfall.

Assessing the Usefulness of Citizen Science Information for Drought-Related Decision Making

One component of the Citizen Science Condition Monitoring Project was to assess how drought impact information provided by citizen scientists could be used in drought monitoring and communications. The project team conducted interviews with individuals and organizations that monitor drought and/or use drought impacts information. Interviewees indicated that the citizen science observations are considered credible sources of “on the ground” and localized information. They add value to an existing, trusted tool (i.e., CoCoRaHS) and can supplement objective indicators that are typically used in drought monitoring. However, interviewees also indicated a need for real-time synthesis and communication of the information to improve its usability and accessibility for potential users. CISA is incorporating these research results into the design of the next phase of the project.

Long-Term Agriculture Drought Monitoring using AVHRR NDVI and North American Regional Reanalysis from 1981 to 2013 in the United States

CISA researchers Lu, Carbone, and Gao have developed and tested a new agriculturally-based drought index that combines climate information and satellite-based observations of vegetation conditions to produce a continuous record from 1981 to present. The Integrated Scaled Drought Index (ISDI) integrates the Normalized Difference Vegetation Index (NDVI) from AVHRR GIMMS NDVI data, with land surface temperature (LST), precipitation, and soil moisture data from NECP North American Regional Reanalysis (NARR) project. ISDI maps were compared with US Drought Monitor and VegDRI maps for empirical validation. The ISDI showed strong correlations with July corn yield anomalies and August soybean yield anomalies. This tool can be used to monitor and assess drought conditions over a longer time scale than existing products allow.

Sensitivity of temporal variability and trends in design storm rainfall estimates to selection of the observed precipitation record

Following prior CISA efforts related to the [*Low Impact Development in Coastal South Carolina: Planning and Design Guide*](#), Rodgers, CISA research assistant, and Carbone examined annual maximum series derived from daily precipitation records to assess how the length of records affects estimates for 2-, 10-, 25, and 100-yr return-period events. The research found that truncating the early record to estimate 10-yr, 25-yr, and 100-yr events may misrepresent frequency and magnitude, and lead to insufficient drainage design (Rodgers 2015). This research will inform related work modeling urban flooding potential in the 21st century for the [*Charleston Resilience Network*](#) grant.

Climate in Context Contributions

Several CISA team members contributed to *Climate in Context*, sharing results and lessons learned from CISA’s use-inspired and decision-oriented research and outreach programs. Dow served as a co-editor. Specific chapters highlighted social science contributions to engagement research (Dow, Lackstrom), lessons learned from the Dynamic Drought Index Tool (DDIT) development and transfer process (Carbone, Dow), and the successes of the CISA-Sea Grant Extension partnership (Whitehead). See the [*Appendix: CISA Deliverables, 2015-2016*](#) for the full listing of contributions.

Climate Communications & Outreach in the Carolinas

Amanda Farris, CISA’s Climate Outreach Specialist, leads the teams’ communications and outreach activities. The goal of these activities is to support state and local adaptation projects and capacity-building by providing opportunities for information exchange and translating scientific data into useable formats for decision makers and the public. The [*Appendix: CISA Deliverables, 2015-2016*](#) provides a full list of CISA’s communications, outreach, and engagement efforts. More information can be found in the Stakeholders in the City of Beaufort and Town of Port Royal formed a task force to address the area’s vulnerability to sea level rise (SLR) and develop

adaptation strategies. The task force has thirteen members, including Beaufort's mayor and Port Royal's planning administrator. CISA provided technical assistance to the task force in identifying vulnerable areas using the NOAA and Climate Central sea level rise viewers and understanding types of flood mitigation options for public and private entities. After receiving approval and encouragement from the Beaufort City Council and Port Royal Town Council to continue work and engage neighborhood groups, the task force created materials appropriate for public education and outreach. CISA assisted in the development of these materials by providing content on sea level rise vulnerability and flood resilience strategies and maps produced from data visualization of sea level rise projections. Presentations have been given to seven neighborhood associations as well as to the Director of the Lady's Island Airport, where plans to construct additional runways directly coincide with areas projected to be impacted by SLR. CISA assisted the task force in writing a letter to the Federal Aviation Administration (FAA), requesting that the FAA require Lady's Island Airport to consider future SLR in airport improvements and design standards.

Program Impacts section.

Climate Communications. Ongoing activities include a quarterly newsletter, the Carolinas Climate Listserv, and maintenance of an online presence through the CISA website and social media. Farris also produces project information documents for dissemination to multiple audiences.

Carolinas Coastal Climate Outreach Initiative (CCCOI). PI Liz Fly leads CISA's Coastal Climate program in partnership with the SC Sea Grant Consortium. Established in 2007, the program serves coastal stakeholders as a trusted source of climate information and products. PI Fly also works closely with Jessica Whitehead, the NC Sea Grant Coastal Hazards Extension Specialist. Information about Fly's numerous outreach and communications efforts are detailed in the Appendix and in the [Coasts](#) projects descriptions.

Carolinas Climate Resilience Conference (CCRC). To respond to a stakeholder identified need for in-person networking and learning opportunities about climate science in the Carolinas, CISA hosted the first CCRC in April 2014. With nearly 200 participants, over 100 individual presentations, and a keynote address from Kathy Jacobs, then Director of the National Climate Assessment, the 2014 CCRC received an overwhelmingly positive response from participants. 97% of conference attendees indicated in the formal evaluation that they would return for a 2nd event. Additionally, in their final report the CISA external review team noted that the conference "received the most accolades of any CISA activity during the evaluators' interviews [with CISA partners]". CISA will host the 2nd CCRC September 12-14, 2016. Over 100 presentations are confirmed. Former US Republican Congressman Bob Inglis is scheduled to give the keynote address.

In-person presentations and engagements. The CISA team regularly participates in local, regional, and national conferences, workshops, and meetings to share information about CISA projects. Audiences include project stakeholders, government agencies, academics, and other outreach communities. Farris also organizes focused climate sessions at stakeholder workshops and conferences across the Carolinas.

New Audiences. Additional communications and outreach activities conducted in 2015-2016 include:

Supporting Continuing Education for Teachers in Ocean and Atmospheric Science

The American Meteorological Society (AMS) offers courses to fulfill continuing education credits for K-12 teachers. PI Liz Fly supported a Local Implementation Team (LIT) offering the AMS DataStreme course in Climate to teachers in Charleston and Beaufort Counties (SC) and Effingham County (GA). Six teachers participated in the course, earning continuing education credits and developing lesson plans shared nationwide. These teachers are now extending their new knowledge to students and other teachers in their districts.

New CISA Videos Showcase Impacts of the October 2015 Flood Event

Two new videos produced by CISA PI Greg Carbone and Research Assistant Chandler Green document the vivid visual impacts to neighborhoods and infrastructure in the Columbia area caused by the heavy rainfall and flooding event in October 2015. One [video captures the magnitude of this historic event](#) by directly comparing footage

taken during the flooding with footage taken two weeks later once waters receded. In the second video, the Mayor of [Arcadia Lakes](#), a residential community in Columbia, explains how two dams, constructed prior to significant development, failed during the extreme event and caused irreparable damage to private property.

CISA Video Outreach Guides Local High School Climate Change Project

CISA collaborated with Westwood High School, the University of South Carolina, and the Old-Growth Bottomland Forest Research and Education Center at Congaree National Park to mentor 38 ninth grade honors geography students in researching and communicating climate change at the local level. Using information collected through research and interviews with scientists, students produced short videos on a variety of topics pertaining to climate change in South Carolina including agriculture, wildlife, beach erosion, and the October 2015 floods.

Key Publications

Brennan, A., G. Carbone, K. Dow, L. Fly, C. Konrad, K. Lackstrom, and D. Tufford. [The South Carolina Floods of October 2015](#). Carolinas Integrated Sciences & Assessments, Columbia, SC.

Buizer, J., K. Dow, M. E. Black, K. L. Jacobs, A. Waple, R. H. Moss, S. Moser, A. Luers, D. I. Gustafson, T. C. Richmond, S. L. Hays, C. B. Field. 2016. Building a sustained climate assessment process. *Climate Change* 135: 23-27. DOI 10.1007/s10584-015-1501-4

Lackstrom, K. and A. Brennan. 2016. [The NIDIS Coastal Carolinas DEWS Program Progress Report](#). Submitted to NIDIS and the NOAA Climate Program Office, March 2016.

Parris, A., G. Garfin, K. Dow, R. Meyer and S. Close, eds. 2016. *Climate in Context: Science and Society Partnering for Adaptation*. Wiley and Sons: New York.

Sugg, M. M., C. E. Konrad II, and C. M. Fuhrmann. 2015. Relationships between maximum temperature and heat-related illness across North Carolina, USA. *International Journal of Biometeorology*, 1-13. DOI 10.1007/s00484-015-1060-4

CISA's Work in Practice

City of Folly Beach, SC, Plans for Sea Level Rise in 2015 Comprehensive Plan

The City of Folly Beach is a small barrier island community that faces a variety of coastal hazards, including the threat of rising seas from both the ocean and marsh sides of the island. The City requested technical assistance to take a more proactive approach in planning for current and future sea level rise hazards. Fly helped facilitate public discussions about the threats of these hazards to the City. Scenarios from NOAA's Sea Level Rise Viewer were used to help visualize potential future inundation. Fly also provided information on the nature of the impacts which would result from inundation. This outreach effort by CISA enhanced understanding among City leaders about the options available to plan for sea level rise, which led the City to take a significant step in increasing resilience by including consideration of this threat in its municipal Comprehensive Plan. This initial consultation with CISA has led to continued engagement through public forums, grant opportunities, and plans for implementing the Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process on the island to help develop a specific sea level rise strategy.

Beaufort County, SC, Continues Discussion on Sea Level Rise with Adaptation Report

Beaufort County is located in the heart of the South Carolina Lowcountry, the coastal region that sits just above sea level. In planning for the future, the County recognized its potential vulnerability to long-term sea level rise, and partnered with CISA, the SC Sea Grant Consortium, NC Sea Grant, and the Social and Environmental Research Institute (SERI) to engage the community in a participatory process to discuss and prioritize potential adaptation strategies. The "Sea Level Rise Adaptation Report: Beaufort County, South Carolina" is the product of this multi-

year engagement with the County and includes 23 adaptation strategies vetted by a stakeholder group and public workshop participants. The report was presented to both the Rural and Critical Lands Preservation Program and the Natural Resources Committee of Beaufort County. Based on the information in the report, the Natural Resources Committee intends to incorporate strategies into the Natural Resources chapter of the Beaufort County Comprehensive Plan. In addition, the committee recommended that all County departments consider the adaptation strategies as they develop policies, procedures, plans, and projects.

Citizen Science Condition Monitoring Goes National

CISA launched a pilot project in September 2013 to expand drought impacts monitoring and reporting in the Carolinas as a result of stakeholder feedback indicating a need for more on-the-ground reporting. Supported by NIDIS, this project is conducted in partnership with the [Community Collaborative Rain, Hail, and Snow](#) (CoCoRaHS) network. CISA adapted existing tools developed by CoCoRaHS for drought impacts reporting to support condition monitoring reports, which provide more information regarding the onset, intensification, and recovery of drought conditions. Based on the positive feedback received about the project and discussions with CoCoRaHS headquarters and the [National Drought Mitigation Center](#), which incorporates these CoCoRaHS reports into the [National Drought Impacts Reporter](#), drought impacts reporting has now shifted to condition monitoring reporting at the national level. The CoCoRaHS drought impacts report form will change to a condition monitoring report form this summer. Additional recruitment will be conducted in the Carolinas to support continued assessment and evaluation of the effort. National-level webinars and training materials will also be disseminated to support observers as they transition to this new reporting format.

Overview of Ongoing Projects

NIDIS Drought Early Warning System Program in the Coastal Carolinas

CISA collaborates with the National Integrated Drought Information System (NIDIS) to build understanding of drought's effects on the Carolinas' coastal ecosystems, conduct related research, and engage decision makers as part of the Coastal Carolinas Drought Early Warning System (CC DEWS) pilot program. Launched in 2012, the CC DEWS has focused 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. This section describes NIDIS-related activities and projects conducted by the CISA PIs and staff.

CC DEWS Communications and Coordination

Team Members: Lackstrom, Farris, Dow

Overview: CISA serves as the main point-of-contact for NIDIS 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 the different projects conducted as part of the CC DEWS program. Projects have been conducted by CISA PIs and staff (see below), as well as by Ryan Boyles (State Climate Office of NC, assessment of coastal fire risks), Michael Childress (Clemson University, blue crab landing forecasting tool), and Paul Conrads (USGS South Atlantic Water Science Center, development of the Coastal Salinity Index).

Progress & Results:

- Farris and Lackstrom wrote and submitted [The Coastal Carolinas DEWS Program Progress Report](#) to the NIDIS and NOAA Climate Program Offices in March 2016. The report highlights DEWS accomplishments and progress, including projects conducted by CISA, Clemson University, the State Climate Office of North Carolina, and USGS partners.
- Farris and Lackstrom worked with NIDIS and other CC DEWS project leads to develop and disseminate information about the program. Products include articles in the Fall 2015 issue of the NIDIS publication [Dry](#)

Times, a series of [2-pagers](#) about the CC DEWS program and individual projects, updates to CC DEWS content on the [drought.gov website](#), presentations, and organized sessions at stakeholder meetings.

- The CISA team is working with NIDIS staff to develop and implement a strategy for writing a CC DEWS Strategic Plan. In 2015-2016 this work included identifying and organizing a steering committee for the effort, organizing and preparing materials for a strategic planning meeting held in June 2016, and identifying and communicating with meeting invitees and new potential partners for the CC DEWS program. This work will continue into summer and fall 2016 as CISA writes the meeting report and assists with the development, writing, and dissemination of the CC DEWS Strategic Plan.

Drought Impacts Monitoring and Reporting through Citizen Science Engagement

Team Members: Farris, Davis, Dow, Eckhardt, Lackstrom, Selvaraj, Sullivan, Westerkam

Overview: The aim of this project is to further understanding of the usefulness of citizen science engagement as a means to enhance drought impacts monitoring and reporting and improve understanding of drought impacts. Building on existing tools developed by the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network, CISA recruited volunteers to submit daily precipitation measurements and weekly status reports about the condition of ecosystems and communities in their area. The focus on regular reporting (“condition monitoring”), in contrast to intermittent drought impact reports, is intended to create a baseline for comparison of change through time and to improve understanding of the onset, intensification, and recovery of drought.

Progress & Results:

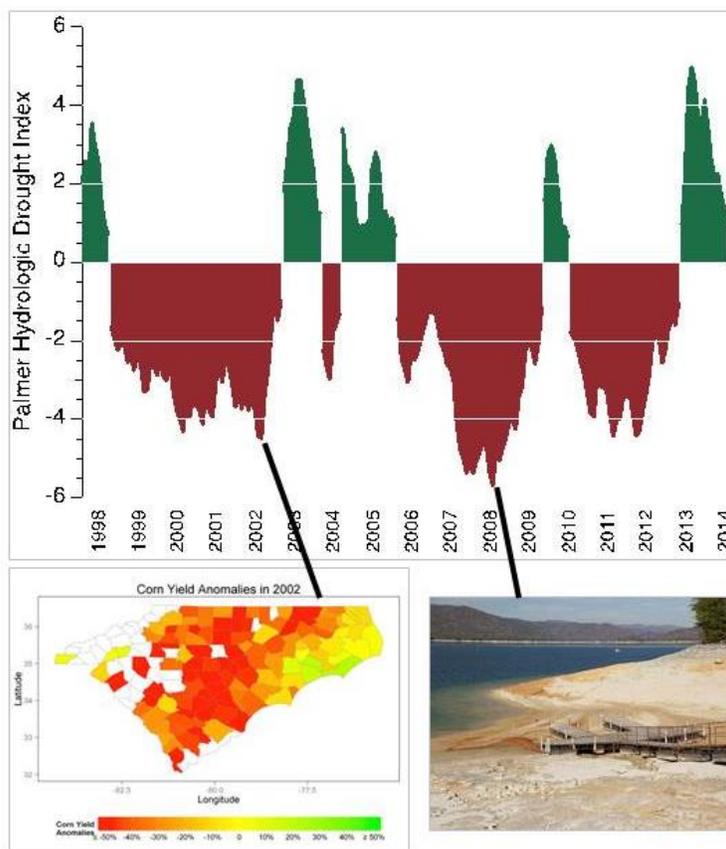
- CISA initiated “Phase 1” of this project in 2013, successfully recruiting over 40 volunteers. From September 2013 to December 2015, project volunteers provided over 1,500 condition monitoring reports through the CoCoRaHS website. (These reports are also uploaded to the National Drought Impact Reporter.) The CISA team coded and analyzed these reports using NVivo, a qualitative analysis software package. CISA used this information to develop maps, graphs, and charts to summarize and visualize the report content for interviews with decision makers responsible for drought monitoring and decision making. Interviews indicated that the reports are relevant to and being currently used for drought monitoring.
- Building on best practices developed through other citizen science efforts, CISA has sustained a continuous stream of information sharing and engagement with project volunteers. Efforts include the [“Cuckoo for CoCoRaHS in the Carolinas”](#) blog, a monthly newsletter, a [project webpage](#) with education and training materials, and quarterly conference calls to share information and answer questions. In order to assess the usefulness of these interactions, a series of online surveys have been circulated to volunteers during the 1-year commitment period.
- In 2015-2016, the CISA team began “Phase 2” of the “Citizen Science Condition Monitoring Project.” Based on feedback from drought decision makers and citizen scientists, CISA is working with CoCoRaHS, the National Drought Mitigation Center Drought Impact Reporter, and the NC and SC state climate offices to modify the process through which volunteers provide drought and condition monitoring information and to develop a streamlined process to communicate this information to users. The first component of this project was to develop a quantitative metric to allow observers to identify drought conditions or record a change in conditions through time. A “condition monitoring scale bar” is being added to the existing CoCoRaHS online reporting form to supplement the open-ended, qualitative information currently provided by observers. To improve the communication and visualization of citizen scientists’ observations, CISA research assistant David Eckhardt has developed a [web map](#) that extracts their assessments of drought conditions and displays them on a map of the Carolinas. The scale bar and web map will be fully operational in summer 2016.
- Eckhardt developed the condition monitoring scale bar as part of his master’s thesis; a final “Phase 1” report and manuscripts are in progress.

Atlas of Hydroclimate Extremes for the Carolinas

Team Members: Carbone, Lu, Gao, Konrad, McLeod

Overview: Through interviews, meetings, and other engagements, decision makers have indicated the need for an improved baseline understanding and information about drought and normal precipitation in the Carolinas.

To address this need, CISA is developing a digital atlas of hydroclimate extremes in the Carolinas as part of the NIDIS CC DEWS program. The atlas will complement existing information sources on extreme precipitation (e.g. NOAA's Atlas 14) and drought (e.g., products from the National Drought Mitigation Center). It will include maps and figures characterizing various measures of precipitation, drought, and the water balance. Some of the drought indices are those used operationally by resource managers, others are new, or offer spatial or temporal resolution not readily available from other sources. The atlas will allow users to explore probability distributions and recurrence intervals for a large number of stations across the Carolinas by season. It will integrate station and regional products, and photographs, videos, and narratives of drought and heavy precipitation events.



Progress & Results:

- CISA researchers have conducted statistical analyses on precipitation data for 135 individual weather stations and climatic divisions across the Carolinas. Over 1000 maps and graphics have been created characterizing these statistics. As decision makers are interested in extremes associated with below- and above-normal precipitation, maps and graphics are being designed to convey information about the frequency and duration of both dry and wet events.
- An overview of this work is provided in a project 2-pager. A prototype website has been created to display atlas graphics, including pages using interactive tools to access and display data.
- In a related effort to improve assessment and communication of drought impacts, CISA researchers are investigating new approaches to assess drought effects on agricultural yields. One challenge is accounting for technological improvements when considering the relationship between climate and agricultural production on long time scales. This project quantifies and compares the role of technology across space and time by measuring the nonlinear and non-stationary nature of state- and county-level corn yield data from 1895 to 2014. Carolinas-specific information regarding agricultural drought impacts will be incorporated into the atlas.

Indicators and Indices of Drought in Southeastern Coastal Ecosystems

Team Members: Tufford, Chalcraft, Nolan

Overview: While many drought indices and indicators exist (focusing on, for example, agriculture or reservoir management), coastal ecological resources receive little attention. This project seeks to improve understanding of coastal resources that are adapted to or dependent upon particular spatial and temporal patterns of precipitation, salinity, or streamflow to determine stress caused by drought.

Progress & Results:

- In the first phase of the project, a needs assessment was conducted through 30 structured interviews with coastal resource managers along the Carolinas' coast. The interviews identified use of, and needs for, drought indices and indicators to effectively understand and monitor drought in coastal ecosystems. Research findings were published in the *Journal of Coastal Research* (Nolan et al., 2016).
- The second component of this project involves collaboration with USGS to apply and refine the Coastal Salinity Index (CSI), a key activity of the Coastal Carolinas DEWS program. Informed by needs and priorities identified through the stakeholder interviews, CISA researchers are obtaining ecological datasets to identify correlations and assess the linkages between ecological indicators and varying salinity levels as expressed by the CSI. Datasets being investigated include tree ring chronologies, litter fall, pore water salinity, water quality parameters, and flood depth and frequency in tidal marshes and forests in the Savannah and Waccamaw River drainages. Thus far, the correlations between the CSI and response variables are weak. CISA researchers will continue to work with USGS- and resource management partners in the coming year to identify and assess additional datasets that could be useful and relevant for drought monitoring.

Future Streamflow Forecasts for a Coastal Plain River

Team Members: Carbone, Childress, Lu, Tufford

Overview: Blue crabs are one of the most important commercial fisheries in the Southeast, but landings have declined during recent droughts. Low levels of freshwater discharge into the estuary changes the salinity profile which influences crab growth, movement and survival. This project aims to identify and examine a range of possible changes in Edisto River discharge between now and 2030. Streamflow projections are used as input into an individual-based blue crab model that is being used to examine the complex relationship between crab abundance and freshwater flows. This model, developed by Michael Childress, has been used in a NIDIS Coastal Carolinas DEWS project to provide crabbers and resource managers with information regarding projected, future blue crab landings under different climate and river discharge scenarios.

Progress & Results:

- CISA researchers used NOAA's Open-source Nonpoint Source Pollution and Erosion Comparison Tool (OpenNSPECT) to simulate seasonal streamflow and examine a range of possible changes in Edisto River discharge through 2030. Initial work in 2014-2015 developed climate scenarios for input into the tool.
- In 2015-2016, results from work to refine the model suggest modest increases in streamflow from now to 2030, especially during the critical spring season. These estimates include only the effect of natural processes on streamflow, e.g. precipitation, evapotranspiration. As both surface and groundwater withdrawals are expanding in the watershed, ongoing efforts will incorporate and consider the impact of those losses on streamflow.

Water

Analysis of Extreme Rainfall Events

Team Members: Carbone, Gao, Lu, Rodgers

Overview: CISA researchers are investigating observational records and model output to understand the nature of extreme precipitation in the Carolinas. This work has evolved from stakeholder questions about extreme rainfall events. One direction emphasizes the intensity and return period of extreme rainfall events in the historic record

and the usefulness of climate models to improve future infrastructure design, planning, and management. A second direction evolves from the intense precipitation event affecting South Carolina in October 2015.

Progress & Results:

- One study investigating how length of record affects return period estimates is featured in the [Research Highlights](#) section (Rodgers 2015).
- Building on stakeholder questions stemming from the October 2015 rain event, CISA researchers are examining methods to accurately estimate long-return period rainfall depths in watersheds. 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 events with long return periods. This research incorporates a bootstrap approach to estimate rainfall depth probabilities for an area (e.g., a watershed) by “borrowing” spatially across the southeastern United States. Rainfall plausibly occurs outside the area being examined. However, because of similar geographic and synoptic conditions within the southeastern U.S., the bootstrapping approach enables the exploration of rainfall across an area and the collection of large sample sizes, making the estimation of Generalized Extreme Value (GEV) distribution parameters and inference of long return period rainfall events reliable and robust. The resulting discharge-frequency functions characterizing hydrologic responses in the study watersheds are expected to provide insights that can be used to help inform storm water management and infrastructure design.
- Products include a published article (Gao et al. 2015), a 4-page synopsis of the October 2015 precipitation event, a master’s thesis (Rodgers 2015), and several manuscripts in preparation. Work has also been presented at professional conferences.

Modeling of the Winyah Bay Watersheds

Team Members: Tufford, Carbone, Gao, Patel, Rouen

Overview: CISA integrates climate data with hydrological models to assess the potential impacts of climate variability and change on water resources in the Southeast. CISA researchers are using EPA’s BASINS Hydrologic Simulation Program-Fortran (HSPF) and the Soil and Water Analysis Tool (SWAT) model to simulate the Yadkin Pee-Dee, Waccamaw, and Black Rivers at the 8-digit HUC level. These basin-wide models have been used to aid in assessing salinity intrusion in the future for public water supply managers along the Waccamaw River and the occurrence and potential range expansion of *Vibrio* in the Winyah Bay estuary.

Progress & Results:

- Tufford was asked by USGS colleagues to participate on a regional water supply study funded by the USGS Cooperative Ecosystem Studies Units (CESU). The study is intended to assess climate and land use impacts on surface and ground water resources and the ecological response in the Cape Fear and Winyah Bay watersheds of North and South Carolina. CISA’s role is to modify and enhance the HSPF models of the Winyah Bay watersheds and provide streamflow time series at the locations for which ecological response will be assessed. Former CISA research assistant Lauren Rouen has been hired to assist with this work.

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

Team Members: Patel, Carbone

Overview: In collaboration with utility representatives, CISA team members are assessing the vulnerability of the raw water supply of a North Carolina utility (Orange Water and Sewer Authority [OWASA] in Carrboro, NC) to changing climatic conditions. The project is informed by the “Decision Scaling” approach where focus is placed on understanding a system’s sensitivity to climate and identifying climate conditions that reduce the system’s performance below acceptable thresholds, rather than starting with a top-down impact assessment based on

climate change projections from global circulation models (GCMs). The goal of this project is to facilitate the consideration of climate change in the utility's long-range planning.

Progress & Results:

- This project has involved ongoing, and iterative, engagement with water resource managers, and several steps were undertaken in 2015-2016 to advance this project. A first step was to refine researcher's understanding of the water utility's operational goals and the water supply metrics used in making operational and planning decisions. Incorporating planning-relevant measures is an important aspect of tailoring climate analyses to the information needs of the water resource managers. Second, the researcher developed a climate response model to simulate the water system's response to climate conditions. This process involved calibrating a rainfall-runoff model of streamflow to the reservoirs and connecting it with the utility's reservoir operations model. Third, the researcher used a stochastic climate model to generate a large number of synthetic replicates of temperature, precipitation, and evaporation based on observed historic records. These replicates were used as input for the hydrologic-water system model to produce corresponding replicates of reservoir inflows, firm yield, and storage. This synthetic data is being used for an exploratory investigation of potential relationships between climate variables, inflow, and water system performance metrics.

Drought Sensitivity Testing

Team Members: Boyles, Ward

Overview: Stakeholders with the NC DMAC and NC DENR Water Resources Division, in addition to other resource managers, are interested in using high-resolution drought indicators (HRDI). In particular, the NC DMAC provides weekly input to the US Drought Monitor and would like to be able to ensure accurate depictions of local drought severity. Therefore, this project was designed to test how sensitive drought estimates are to the input data set specifically by comparing drought indices derived from point-based inputs from surface gauge networks and drought products based on gridded inputs including multi-sensor precipitation estimates (MPE) and gridded temperature products. This work leveraged a partnership with Texas A&M University and support from several funding sources, including NOAA, CISA, and USDA.

Progress & Results:

- Two manuscripts related to this project are currently in revision. One describes the methodology used to develop the high resolution, daily updated Standardized Precipitation Index (HRD SPI). A second manuscript compares the HRD SPI with the US Drought Monitor and other indices and tools, using the 2012 Great Plains and 2007-2008 Carolinas droughts as case studies.
- Data and information produced through this research is used by the NC DMAC and has been incorporated in the NC State Climate Office's [Experimental High Resolution Drought Trigger Tool](#).

Coasts

Fostering a Citizen-Driven Sea Level Rise Task Force in the South Carolina Low Country

Team Members: Dow, Fly, Selvaraj

Overview: Stakeholders in the city of Beaufort and town of Port Royal, SC, have formed a [task force](#) to address the area's vulnerability to sea level rise and develop adaptation strategies to address potential impacts. The task force has thirteen members, including the mayor of Beaufort and planning administrator for Port Royal. The task force has met regularly (monthly or bi-monthly) since December 2014. The SC Small Business Chamber of Commerce, who helped to convene the group, asked CISA to provide technical assistance in the form of identifying vulnerable areas to inform flood mitigation strategies. In spring 2015, the task force presented its mission statement and recommendations to Beaufort City Council and Port Royal Town Council. Both councils encouraged the task force to continue its work and engage neighborhood groups. Local news outlets have also covered the initiative.

Progress & Results:

- Using graphics and visualizations developed by CISA team members, the task force has identified eight areas in Beaufort and Port Royal particularly vulnerable to sea level rise. CISA team members facilitated meetings with task force members and the public works directors for the two municipalities to discuss these areas and identify potential strategies to mitigate future flood risk.
- Following on encouragement from the City and Town councils to continue work and engage the public, task force members made presentations to seven neighborhood associations to increase awareness of the threat of sea level rise and discuss public and private strategies for adaptation.
- CISA assisted task force members with their efforts requesting that the Lady's Island Airport and Federal Aviation Administration (FAA) consider future SLR in the Lady's Island Airport improvements and design standards.

A Community-Wide Health Risk Assessment of Vulnerable Water Infrastructure in Coastal Cities

Team Members: Allen, Dow, Fly, Montz, Whitehead

Overview: This project, funded by NOAA's Coastal and Climate Applications (COCA) program, seeks to expand the capacity of decision makers, including public health officials, environmental agencies, emergency managers, and water/wastewater utility operators, around the issues of critical coastal water infrastructure and public health. To do so, the team will analyze water and wastewater infrastructure vulnerability to extreme events, engage stakeholders to develop a community-level susceptibility index of vulnerable populations, test the index through a table top exercise, and develop a guidebook for transferability to other communities. Pilot communities include Morehead City, NC and Charleston, SC. This project builds upon methodologies developed in a previous CISA-supported project to address the potential vulnerability of municipal water and wastewater infrastructure to coastal hazards, using the towns of Manteo, New Bern, and Plymouth, NC, as case study sites.

Progress & Results:

- Team members engaged in field visits in Morehead City and Charleston, met with local officials to communicate project goals, elicited feedback and support (e.g., sharing of geospatial data), and assessed stakeholders' perceptions of water and wastewater infrastructure and public health vulnerability.
- Spatial analyses were conducted for Morehead City to characterize infrastructure vulnerability due to nuisance flooding, storm surge, and sea level rise. Preliminary results, including map visualizations depicting infrastructure threats and parcel-level quantification of onsite wastewater treatment systems at risk due to inundation or groundwater disturbance related to sea level rise, were presented at the 2016 Social Coast Forum in Charleston, SC. These visualizations will be used for the stakeholder table top exercise in Year 2.

Building Regional Resilience Capacity in Charleston, SC

Team Members: Fly, Carbone, Dow

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, critical infrastructure, and socio-economic continuity to episodic natural disasters and chronic coastal hazards. The CRN works to foster a unified strategy and provide a forum to share science-based information, educate stakeholders, and enhance long-term planning decisions that result in resilience.

Progress & Results:

- The CRN launched its website in 2015: www.charlestonresilience.net.
- On February 23, 2016, the CRN hosted a symposium in partnership with the National Academy of Sciences (NAS) Resilient America Roundtable to examine the Charleston region's resilience through the lens of the October 2015 extreme rainfall and flood event. A diverse range of stakeholders assembled to share information and lessons learned across key sectors, as well as discuss practices, partnerships, and

opportunities to enhance resilience to future events. Key topics included public safety and health, business and economic impacts, critical infrastructure/lifelines, and future planning.

- The CRN received a NOAA Regional Coastal Resilience Grant to understand the capacity of Charleston’s infrastructure to cope with nuisance and severe flooding. This information will allow the region to respond to immediate needs and enhance adaptive capacity for future issues.
- The CRN also received a National Infrastructure Protection Plan (NIPP) Security and Resilience Challenge grant from the US Department of Homeland Security to develop a multi-hazard coastal resiliency assessment and adaptation indices and tools for the Charleston region.

Health

Heat-Health Vulnerabilities in North Carolina

Team Members: Konrad, Sugg

Overview: CISA researchers Konrad and Sugg utilized the *Public Health Toolbox* to investigate the connections between heat and heat-related illness (HRI) in North Carolina. This research has informed the development of the web-based [Heat Health Vulnerability Tool](#), described in the [Climate Services](#) section.

Progress & Results:

- Sugg et al. (2015) examined the relationship between maximum temperatures and morbidity due to HRI in NC for warm seasons from 2007 to 2012. Results indicate that HRI is more prevalent in rural, agricultural areas and for males aged 15-44. The data shows that heat affects more people between 31 °C (87.8 °F) and 38 °C (100.4 °F) than temperatures above 38 °C. In contrast to most early warning systems that target the highest temperatures, this study suggests a need for awareness regarding heat-related risks at lower temperatures and with a wider range of potentially vulnerable populations.
- Decision support and engagement highlights are described in the [Climate Services](#) section.

Climate and Waterborne Disease in North Carolina

Team Members: Konrad, Hartley

Overview: Expanding use of the public health toolbox, Konrad and Hartley conducted research to assess relationships between climate variables and waterborne disease. The study analyzed patterns of gastrointestinal illness (GI) and their relationship with various demographic groups and precipitation patterns across NC.

Progress & Results:

- Research results show the strongest demographic relationships between poverty indicators and GI. Several clusters of high disease occurrence were identified at the county level, including seven counties across the state with 300%+ increases in average rates of emergency department admissions after heavy rainfall events.
- The study does identify increases in rates of gastrointestinal illness after periods of heavy rainfall, which vary with different lag periods and rainfall intensities.

Assessing the Impacts of Climate Variability on Water Quality Conditions and *Vibrio* in a South Carolina Estuary

Team Members: Tufford, Moore, Scott

Overview: This project integrates work on watersheds, coastal climate, and drought to investigate the health threats posed by the marine bacterium *Vibrio*, the spread of which is believed to be associated with changing temperature and salinity conditions. In 2012 CISA researchers and partners at the NOAA Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) conducted monthly sampling of surface and bottom water in the Winyah Bay and Waccamaw River for *Vibrio vulnificus* and *Vibrio parahaemolyticus*. They examined

these samples to evaluate empirical relationships with potential environmental drivers such as temperature and salinity. In 2014, CISA allocated funding to conduct DNA sequencing to assess the virulence of the *Vibrio* samples.

Progress & Results:

- CISA is collaborating with a lab in the USC Department of Biological Sciences with experience in DNA sequencing and analysis of *Vibrio* spp. The DNA analysis should be complete in summer 2016. Additional analysis will integrate the results with the earlier work to assess risk of exposure using estimates of the abundance of virulent organisms.
- A manuscript is in progress and will include results from the initial field sampling and *Vibrio* identification, as well as the additional data- and modeling analysis.

Adaptation

Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process

Team Members: Dow, Fly, Schiavinato, Tuler, Webler, Whitehead

Overview: CISA uses VCAPS to support community-led adaptation and continually works to improve the process by assessing the learning that emerges as communities engage in collaborative decision making and planning.

Progress & Results:

- In 2015-2016 CIs Schiavinato and Whitehead conducted VCAPS exercises in Hyde County and the Town of Nags Head, NC. The goal of the Nags Head project is to help that community investigate the potential impacts of sea level rise and consider how to address those impacts in local planning.
- PI Fly and CI Whitehead helped the Eastern Shore Land Conservancy in Maryland conduct VCAPS trainings to prepare them to conduct a VCAPS workshop with key stakeholders in Kent County, MD.

The four South Atlantic Sea Grant programs (GA, FL, NC and SC) have received funding from the NOAA Office of Coastal Management to begin a new South [Atlantic Regional Research](#) on Coastal Community Resilience: “Advancing understanding of risk: Increasing accuracy of hazard damage assessment tools by improving base data and analyzing opportunities and barriers for use in adaptation planning”. The overall goal of the project is to conduct and evaluate a participatory process to help local governments build capacity to better visualize, understand, and plan for local coastal hazard risks.

Vital Futures Project: Supporting the Southeast Conservation Adaptation Strategy

Team Members: Dow, Chin, Gao, Lackstrom, Westerkam

Overview: The Vital Futures project is designed to support development of the Southeast Conservation Adaptation Strategy (SECAS), a broad collaboration intended to create a new vision for sustaining fish and wildlife in a changing future landscape. The Southeast is undergoing high rates of population growth, urbanization, and land use changes, and is expected to experience changes in climate that will place additional stress on fish and wildlife populations and their habitats. Most existing conservation efforts focus on protecting and managing systems to maintain current conditions or return to a desired, historic state. With large, landscape-scale transformations already occurring, adaptive conservation strategies are needed that can account for changing conditions.

Progress & Results:

- CISA is partnering with the National Wildlife Federation and North Carolina State University faculty on this project. The project is funded by the DOI Southeast Climate Science Center and builds on existing collaborations between CISA and the SE CSC.
- CISA researchers began work in fall 2015 and are currently: 1) assessing existing conservation goals and objectives across the Southeast through a formal review of wildlife action plans and targeted interviews and 2)

developing future change scenarios in order to help resource agencies evaluate the implications of future change on conservation goals and strategies.

- The CISA team organized a stakeholder engagement workshop in November 2015 to kick off the project. This meeting was held in conjunction with the Southeast Association of Fish and Wildlife Agencies annual conference.

Appendix: CISA Deliverables, 2015-2016

Journal Articles

- Buizer, J., K. Dow, M. E. Black, K. L. Jacobs, A. Waple, R. H. Moss, S. Moser, A. Luers, D. I. Gustafson, T. C. Richmond, S. L. Hays, C. B. Field. 2016. Building a sustained climate assessment process. *Climate Change* 135: 23-27. DOI 10.1007/s10584-015-1501-4
- Fuhrmann, C. M., Sugg, M. M., Konrad, C. E., and Waller, A. 2015. Impact of Extreme Heat Events on Emergency Department Visits in North Carolina (2007 to 2011). *Journal of Community Health*, 1-11. DOI: 10.1007/s10900-015-0080-7
- Gao, P., G. J. Carbone, and D. Guo. 2015. Assessment of NARCCAP model in simulating rainfall extremes using a spatially constrained regionalization method. *International Journal of Climatology*. DOI: 10.1002/joc.4500
- Nolan, C. B., D. L. Tufford, and D. R. Chalcraft. 2016. Needs Assessment of Coastal Land Managers for Drought Onset Indicators in the Southeastern United States. *Journal of Coastal Research*. DOI : 10.2112/JCOASTRES-D-15-00182 .1
- Sugg, M. M., C. E. Konrad II, and C. M. Fuhrmann. 2015. Relationships between maximum temperature and heat-related illness across North Carolina, USA. *International Journal of Biometeorology*, 1-13. DOI 10.1007/s00484-015-1060-4

Edited Books

- Parris, A., G. Garfin, K. Dow, R. Meyer and S. Close, eds. 2016. *Climate in Context: Science and Society Partnering for Adaptation*. Wiley and Sons: New York.

Book Chapters

- Carbone, G.J., A. DeGaetano, K. Dow, J. Fowler, G. Garfin, H. Hartmann, E. Lay, and J. Rhee. 2016. Challenges, pitfalls, and lessons learned in developing a decision-support tool. In *Climate in Context: Science and Society Partnering for Adaptation* Parris, A.S., G. Garfin, K. Dow, R. Meyer, and S.L. Close eds. Wiley and Sons: New York. pp. 173-190.
- Parris, A., S. L. Close, R. Meyer, K. Dow and G. Garfin. 2016. Evolving the practice of Regional Integrated Sciences and Assessments. In Parris, A., G. Garfin, K. Dow, R. Meyer and S. Close, eds. *Climate in Context: Science and Society Partnering for Adaptation*. Wiley and Sons: New York. pp. 255-262.
- Simpson, C. F. , L. Dilling, K. Dow, K. J. Lackstrom, M.C. Lemos and R. E. Riley. 2016. Assessing needs and decision contexts: RISA approaches to engagement research. In Parris, A., G. Garfin, K. Dow, R. Meyer and S. Close, eds. *Climate in Context: Science and Society Partnering for Adaptation*. Wiley and Sons: New York. pp. 3-26.
- Stevenson, J., M. Crimmins, J. Whitehead, J. Brugger, and C. Fraise. 2016. Connecting climate information with practical uses: Extension and the NOAA RISA program. In Parris, A., G. Garfin, K. Dow, R. Meyer and S. Close, eds. *Climate in Context: Science and Society Partnering for Adaptation*. Wiley and Sons: New York. Pp. 75-97.
- Tuler, S., K. Dow, T. Webler, and J. Whitehead. *In press*, 2016. Learning through participatory modeling: Reflections on what it means and how it is measured. In S. Gray, M. Paolisso, R. Jordan, and S. Gray, eds. *Environmental Modeling with Stakeholders*. Springer.

Reports

- Fly, L., C. Acres, A. Farris, and A. Hanks. 2016. [*Building Adaptive Capacity in the Southeast and Caribbean through a Climate Community of Practice*](#). Workshop report. April 13 – 15, 2016, Tybee Island, GA.
- Green, C. 2016. *Westwood High Climate Change Video Project*.
- King, J. 2016. [*Influence of historical drainage on coastal ecosystem resilience to rising sea level – Implications for natural resources management and terrestrial carbon storage of the Alligator River National Wildlife Refuge*](#). Final Report submitted for the CISA Mini-Grant Program.
- Lackstrom, K. and A. Brennan. 2016. [*The NIDIS Coastal Carolinas DEWS Program Progress Report*](#). Submitted to NIDIS and the NOAA Climate Program Office, March 2016.

Theses and Dissertations

- Eckhardt, D. 2015. Improving Citizen Science Condition Monitoring Reporting: Condition Monitoring Scale Bar. Master's Project, Department of Geography, University of South Carolina.
- Hartley, J. M. 2016. Spatial and Temporal Patterns of Gastrointestinal Illness and Their Relationship with Precipitation Across the State of North Carolina. Master's Thesis, Gillings School of Global Public Health, University of North Carolina at Chapel Hill.
- Rodgers, K.G. 2015. Sensitivity of temporal variability and trends in design storm rainfall estimates to selection of the observed precipitation record. Master's Thesis, Department of Geography, University of South Carolina.

Web-based Tools

- Condition Monitoring Web Map. 2016. Developed by David Eckhardt, CISA, University of South Carolina. <http://cisa.sc.edu/webmap/>
- Heat Health Vulnerability Tool. 2015. Developed by the State Climate Office of North Carolina and the Southeast Regional Climate Center, University of North Carolina at Chapel Hill. <http://www.sercc.com/hhvt/>

Project and Research Information Documents

- Brennan, A., K. Bogan, R. Boyles, M. Childress, P. Conrads, K. Lackstrom, G. Carbone. NIDIS Carolinas Drought Early Warning Project Information Sheets. Columbia, SC.
- Brennan, A. 2015. *CISA Fact Sheet*. Carolinas Integrated Sciences & Assessments, Columbia, SC.
- Brennan, A. 2015. [*CISA Focus Area: Water & Climate Fact Sheet*](#). Carolinas Integrated Sciences & Assessments, Columbia, SC.
- Brennan, A., G. Carbone, K. Dow, L. Fly, C. Konrad, K. Lackstrom, and D. Tufford. [*The South Carolina Floods of October 2015*](#). Carolinas Integrated Sciences & Assessments, Columbia, SC.
- CISA and the Beaufort and Port Royal Sea Level Rise Task Force. 2015. *Sea Level Rise, Storm Surge, and Planning for the Future*.

Newsletters

- Brennan, A. 2016. *Carolinas Climate Connection*, 1st Quarter, March 2016.
- Brennan, A. 2015. *Carolinas Climate Connection*, 4th Quarter, December 2015.
- Brennan, A. 2015. *Carolinas Climate Connection*, 3rd Quarter, October 2015.
- Brennan, A. 2015. *Carolinas Climate Connection*, 2nd Quarter, July 2015.

Conferences, Meetings, Trainings, and Workshops

- Brennan, A. and E. Fly. 2016. *Building Adaptive Capacity in the Southeast & Caribbean through a Climate Community of Practice*. Southeast & Caribbean Climate Community of Practice Workshop. Tybee Island, GA, April 13-15, 2016, 64 attendees.
- Brennan, A. 2015. *Ecological Drought and the NIDIS Coastal Carolinas DEWS*. Cape Fear Arch Conservation Collaborative Quarterly Meeting. Ocean Isle, NC, November 10, 2015, 15 attendees.
- Dow, K., K. Lackstrom, et al. 2015. *Realizing the Vision for Fish and Wildlife in a Changing Southeastern Landscape: A Stakeholder Engagement Workshop*. 2015 Southeast Association of Fish and Wildlife Agencies (SEAFWA) Annual Conference, Asheville, NC, November 4, 2015, 40 attendees.
- Fly, E. VCAPS training in Kent County, Maryland, November 2, 2015, 16 attendees.
- Fly, E., with the North Inlet-Winyah Bay NERR. *Coastal Vulnerability Workshop*. Georgetown, SC, September 23, 2015, 42 attendees.
- Konrad, C., with NC BRACE Program. 2016. *Heat Health Vulnerability Tool Stakeholder Engagement*. Fayetteville, NC, May 24, 2016, 25 attendees.
- Konrad, C., with NC BRACE Program. 2015. *Heat Health Vulnerability Tool Stakeholder Engagement*. Fayetteville, NC, September 1, 2015, 30 attendees.
- Lackstrom, K., with D. Bathke, B. Freeman, N. Wall, and T. Bernadt. 2016. *NIDIS Engaging Preparedness Communities Working Group Meeting*. Lincoln, NE, April 28-29, 2016, 30 attendees.

Organized Conference Sessions

- Brennan, A. 2016. Climate Implications for Water Resources Planning and Management (2 sessions). North Carolina Water Resources Research Institute Annual Conference, Raleigh, NC, March 17-18, 2016.

Videos

- Carbone, G. and C. Green. 2015. Historic South Carolinas Floods in Columbia, SC. <https://www.youtube.com/watch?v=ZP1NFyVJJNM>
- Carbone, G. and C. Green. 2015. Lost Lakes. <https://www.youtube.com/watch?v=GF0jv8BwDsk>

Presentations

- Allen, T. 2016. "Geospatial Risk Assessment for Community Water and Wastewater Infrastructure." Social Coast Forum, Charleston, SC, February 9-11, 2016.
- Bath, S. 2015. "A Participatory Approach to Preparing for Sea Level Rise in Beaufort County, South Carolina." 21st International Symposium on Society and Resource Management (ISSRM), Charleston, SC, June 15-18, 2015.
- Brennan, A. 2016. "Stemming the Tide: Global Climate Change and Local Impacts." Waccamaw Conference, Myrtle Beach, SC, March 5, 2016.
- Brennan, A. 2016. "CoCoRaHS Condition Monitoring." NC Drought Management Advisory Council Annual Meeting, Raleigh, NC, April 28, 2016.
- Brennan, A. 2015. "Introduction to CISA & the NIDIS Carolinas DEWS Program." Cape Fear Arch Conservation Collaborative Quarterly Meeting. Ocean Isle, NC, November 10, 2015.

- Brennan, A. 2015. "Regional Partners Tradeshow: The Carolinas Integrated Sciences & Assessments." Southeast Climate Consortium Annual Meeting, Athens, GA, October 19-20, 2015.
- Brennan, A., K. Lackstrom, and K. Dow. 2016. "Engaging Stakeholders to Develop a Coastal Carolinas Drought Early Warning System." Social Coast Forum, Charleston, SC, February 9-11, 2016.
- Brennan, A., K. Dow, B. Haywood, and K. Lackstrom. 2016. "What Can Citizen Scientists Tell Us about Drought?" American Meteorological Society 96th Annual Meeting, New Orleans, LA, January 10-14, 2016.
- Brennan, A., K. Lackstrom, and J. Hartley. 2015. "Climate Interactions with Water Resources in the Carolinas. 2015." Water in the World Conference, Winthrop University, Rock Hill, SC, November 7, 2015.
- Carbone, G. 2015. "October Flooding in South Carolina." Columbia Audubon Society, Columbia, SC, November 3, 2015.
- Carbone, G. J., P. Gao, and J. Lu. 2016. "The Influence and Implications of a Single Extreme Event on Intensity-Duration-Frequency (IDF) curves in South Carolina." Association of American Geographers Annual Meeting, San Francisco, CA, March 30, 2016.
- Dow, K. 2016. "Putting Climate in Context: The Social Science Role in Developing Decision-Relevant Science for Climate Adaptation." Invited presentation for the Mitigation & Adaptation Research Institute Seminar Series, Old Dominion University, Norfolk, VA, April 11, 2016.
- Dow, K. 2015. "Assessing Needs and Decision Contexts: RISA Approaches to Engagement Research." 21st International Symposium on Society and Resource Management (ISSRM), Charleston, SC, June 15-18, 2015.
- Fly, E. and D. Burger. 2016. "Building Hazard Resilience to Water-related hazards in the Charleston, SC region: A Charleston Resilience Network Initiative." Social Coast Forum, Charleston, SC, February 9-11, 2016.
- Fly, E. 2015. "The Future of South Carolina Working Waterfronts: A Community Partnership Exploring Priorities." National Working Waterfronts and Waterways Symposium, Tampa, FL, November 16-19, 2015.
- Fly, E. 2015. "Regional Partners Tradeshow: The Southeast & Caribbean Climate Community of Practice." Southeast Climate Consortium Annual Meeting, Athens, GA, October 19-20, 2015.
- Fly, E. 2015. "Getting the Conversation Started: Facilitating Community Resilience." South Carolina Beach Advocates Meeting, North Myrtle Beach, SC, September 29-30, 2015.
- Fly, E. 2015. "Global Sea Level Change and Local Impacts in South Carolina." Coastal Vulnerability Workshop, Georgetown, SC, September 23, 2015.
- Fly, E. 2015. "The Lowcountry Lowdown on Sea Level Rise." Southeast Florida Regional Climate Leadership Summit, Key West, FL, December 1-3, 2015.
- Fly, E. 2015. "Not So Lost in Translation: Communicating an Uncertain Future to An Uncertain Audience." College of Charleston Masters in Environmental Studies Core Seminar Class, Charleston, SC, January 2016.
- Fly, E. 2015. "A Participatory Approach to Preparing for Sea Level Rise in Beaufort County, SC: Land Preservation and Sea Level Rise." Beaufort Rural and Critical Lands Preservation Program, Beaufort, SC, December 2015.
- Fly, E. 2015. "Resilience." SC Conservation Voters Summit, Georgetown, SC, November 9, 2015.
- Fly, E. 2015. "South Carolina's Natural Resources and the Impacts of Climate Variability and Change." SC Nature Based Tourism Association Conference, Seabrook Island, SC, November 12, 2015.
- Fly, E. 2015 – 2016. "Stemming the Tide: Global Climate Change and Local Impacts in South Carolina." Sea Grant Study Group Project: Understanding Perceptions of Climate Change in SC Coastal Communities using Cultural Cognition and Deliberative Polling. 4 presentations between November 2015 - January 2016.

- Fly, E. 2015. "Stemming the Tide: Sea level rise impacts in Charleston." Charleston Peninsula Neighborhood Association, Charleston, SC, December 9, 2015.
- Fly, E. 2015. "Improving Understanding of Drought Impacts in Coastal Ecosystems through Citizen Science." 21st International Symposium on Society and Resource Management (ISSRM), Charleston, SC, June 15-18, 2015.
- Fly, E. 2015. "Using participatory modeling and citizen science to help fishermen adapt to a changing climate." 21st International Symposium on Society and Resource Management (ISSRM), Charleston, SC, June 15-18, 2015.
- Gao, P., G. Carbone, and J. Lu. 2016. "The Influence and Implications of a Single Extreme Event on Intensity-Duration-Frequency (IDF) Curves in South Carolina." Geological Society of America, Southeastern Section – 65th Annual Meeting, Columbia, SC, April 1, 2016.
- Hartley, J., C. Konrad, and M. Sugg. 2016. "Spatial and Temporal Patterns of Gastrointestinal Illness and Their Relationship with Precipitation across the State of North Carolina." North Carolina Water Resources Research Institute Annual Conference, Raleigh, NC, March 17-18.
- Konrad, C. 2016. "A Web-Based Heat-Health Vulnerability Tool for North Carolina." NOAA Climate Program Office Webinar. April 28, 2016.
- Konrad, C. 2016. "Climate Change: Communicating the Science." Southeast and Caribbean Community of Practice Workshop, Tybee Island, GA, April 13-15, 2016.
- Konrad, C. 2016. "Relationships between Synoptic Scale Atmospheric Fields and Precipitation across the Eastern United States." 112th Conference of the Association of American Geographers, San Francisco, CA, March 29, 2016.
- Konrad, C. 2016. "An Overview of the Recent Weather and Climate across the Southeast and Caribbean." Southeastern and Caribbean Regional Team Webinar. January 28, 2016.
- Konrad, C. 2015. "Meteorological Overview of the Heavy Rainfall and Flooding in South Carolina in October 2015." Southeastern and Caribbean Climate Community of Practice Webinar. December 8, 2015.
- Konrad, C. 2015. "El Nino 101 and Impacts from Recent El Nino Events." Southeastern and Caribbean Regional Team Webinar, November 19, 2015.
- Konrad, C. 2015. "An Overview of Climate Change Facts." American Water Works 2015 Annual Conference. Raleigh, NC, November 15, 2015.
- Konrad, C. 2016. "Climate Change in North Carolina." Chapel Hill Garden Club meeting, Chapel Hill, NC, October 27, 2015.
- Konrad, C. 2015. "Heat-Health Vulnerability in North Carolina: The Heat-Health Vulnerability Tool." Responding to Climate Adaptation Needs in Delaware Stakeholder Roundtable, Dover, DE, September 21, 2015.
- Lackstrom, K., A. Brennan, and K. Dow. 2016. "Assessing the Usefulness of Citizen Science Information in Drought-Related Decision Making." American Meteorological Society 96th Annual Meeting, New Orleans, LA, January 10-14, 2016.
- Lackstrom, K. 2016. "Drought and Coastal Ecosystems: The NIDIS DEWS Carolinas Pilot Program." Western States Drought Coordinators and Emergency Managers Meeting, Seattle, WA, July 21-22, 2015.
- Lu, J., G. Carbone, P. Gao. 2016. "Long-Term Agriculture Drought Monitoring using AVHRR NDVI and North American Regional Reanalysis (NARR) from 1981 to 2013 in United States." Association of American Geographers Annual Meeting, San Francisco, CA, April 2, 2016.

- McLeod, J. and C. Konrad. 2016. "Relationships between Synoptic-Scale Atmospheric Fields and Precipitation across the Eastern United States." North Carolina Water Resources Research Institute Annual Conference, Raleigh, NC, March 17-18, 2016.
- Patel, A. and G. Carbone. 2016. "Developing Tailored Climate Change Information for Strategic Water Supply Planning at a Local NC Utility." American Meteorological Society 96th Annual Meeting, New Orleans, LA, January 10-14, 2016.
- Sugg, M. and C. Konrad. 2015. "Heat-Health Impacts in North Carolina across the Rural and Urban Continuum." Institute for the Environment's Brown Bag Lunch Seminar, University of North Carolina, Chapel Hill, NC, June 2015.
- Tufford, D., J. Lu, G. Carbone, and M. Childress. 2015. "Forecasts of Future Streamflow in a Coastal Plain River using OpenNSPECT." American Water Resources Association Annual Conference, Denver, CO, November 16-19, 2015.
- Whitehead, J. 2016. "Climate Change Hazards to Coastal Community Water Infrastructure: A Geospatial and Public Health Perspective." North Carolina Water Resources Research Institute Annual Conference, Raleigh, NC, March 17-18, 2016.
- Whitehead, J. 2015. "Discussing, Imagining, Engaging, Adapting: Resilience and the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) Process." 21st International Symposium on Society and Resource Management (ISSRM), Charleston, SC, June 15-18, 2015.

Posters

- Brennan, A., K. Lackstrom, R. Boyles, G. Carbone, D. Chalcraft, M. Childress, P. Conrads, K. Dow, and D. Tufford. 2016. "Developing a Drought Early Warning Information System for the Carolinas." North Carolina Water Resources Research Institute Annual Conference, Raleigh, NC, March 17-18.
- Davis, J., S. Selvaraj, A. Brennan, K. Dow, D. Eckhardt, B. Haywood, and K. Lackstrom. 2015. "Assessing the Usefulness of Citizen Science to Support Drought-Related Decision Making." 21st International Symposium on Society and Resource Management (ISSRM), Charleston, SC, June 15-18, 2015.
- Hartley, J., C. Konrad, J. West, and M. Sugg. 2016. "Spatial and Temporal Patterns of Gastrointestinal Illness and Their Relationship with Precipitation across the State of North Carolina." UNC Chapel Hill 3rd Annual Climate Change Symposium, Chapel Hill, NC, April 22, 2016.
- Hartley, J., C. Konrad, J. West, and M. Sugg. 2015. "Associations between Precipitation and Gastrointestinal Illness: A Spatial and Temporal Study in the State of North Carolina." Water in the World, Interdisciplinary Approaches to Sustainability Conference, Winthrop University, Rock Hill, SC, November 5, 2015.
- Hartley, J., C. Konrad, J. West, and M. Sugg. 2015. "Associations between Precipitation and Gastrointestinal Illness: A Spatial and Temporal Study in North Carolina State." 2015 Water and Health Conference: Where Science Meets Policy. Chapel Hill, NC, October 26-30, 2015.