

Carolinas Integrated Sciences & Assessments

2013-2014 Annual Report

Project Progress Report: 1 May 2013 – 30 May 2014

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The CISA Program

The Carolinas Integrated Sciences & Assessments (CISA) program is 1 of 11 NOAA-funded Regional Integrated Science & Assessments (RISA) teams, working 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, tribal communities, and the private sector. CISA's work also includes several cross-cutting activities that seek to advance scientific understanding of climate and hydrological processes in the Carolinas, improve the assessment of climate-related vulnerabilities and impacts, and provide timely and relevant information and tools for decision makers.

Team Members

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Focus Areas

Drought

CISA's drought work seeks to improve monitoring methods, develop a more comprehensive understanding of regional impacts, and assess drought planning and early warning needs. Severe regional droughts in 1998-2002 and 2007-2008 served as the impetus for specific CISA projects, such as the Dynamic Drought Index Tool (DDIT). Over the years the CISA team has worked with the National Integrated Drought Information System (NIDIS), the National Drought Mitigation Center (NDMC), and other RISAs on many efforts to advance drought monitoring and planning on local, state, regional, and national levels. Team members are currently working on projects identified at the NIDIS Carolinas Drought Early Warning System (DEWS) stakeholder workshop held in summer 2012.

Climate Modeling and Downscaling

The acquisition, generation, and processing of climate change scenarios is interwoven with a variety of CISA projects and meets the demands of an increasingly curious group of decision makers, eager to use the latest, most constructive climate change scenarios available for the Southeast. Researchers engage with stakeholders to make global climate information locally relevant for their planning and management decisions. Recent efforts include contributions to the South Carolina Coastal Counties Low Impact Design (LID) Manual and the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH) pilot projects. Additionally, this work informs several of the ongoing watershed modeling projects.

Watershed Modeling

CISA's hydrological modeling projects address a regional need for a comprehensive analysis of watersheds to understand how climate variability and change, including drought, affects water supply and quality. Considerable climate modeling and downscaling research efforts have gone into developing approaches to process and integrate climate information into watershed modeling projects. A focus on climate as a driving force and use of models that cover large watersheds at sub-watershed scales provides meaningful information for local and regional decision making.

Coastal Climate

The purpose of CISA's coastal climate work is to provide tailored, decision-relevant information to coastal communities and decision makers about the implications of climate variability and change and strategies to increase resilience to those impacts. Team members work directly with communities to address needs related to waterfront management, sea level rise, saltwater intrusion, natural hazards, and community planning.

Public Health

CISA's health work investigates the links between climate and human health. Projects have focused on monitoring North and South Carolina estuaries for *Vibrio* and assessing heat stress vulnerability. Work by the Southeast Regional Climate Center and NC State Climate Office to develop a web-based public health toolbox will help to inform the heat vulnerability assessment. In 2012 CISA funded a minigrant project to assess climate change impacts of air quality on morbidity in vulnerable populations in 2050. Initially focused on Mecklenburg County, NC, the project has been expanded to all North Carolina counties in due to stakeholder interest.

Adaptation

Supporting improved adaptation to current climate variability and projected climate changes is a cross-cutting element of CISA's activities. Key projects include research to support the US National Climate Assessment and the development and dissemination of the Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process. VCAPS is an analytical-deliberative process designed to facilitate dialogue among researchers and community representatives as they work together to plan climate adaptation and resilience projects.

New Areas of Focus and Partnership

Carolinas Climate Resilience Conference

CISA hosted the first Carolinas Climate Resilience Conference April 28-29, 2014, in Charlotte, NC. The event, which drew nearly 200 attendees, included over 100 presentations on topics ranging from water resources management and local adaptation actions to climate model downscaling and climate trends in the Carolinas. Kathy Jacobs, former director of the National Climate Assessment, gave the keynote address and provided an overview of the 3rd National Climate Assessment and findings for the Southeast. Conference evaluation survey results and feedback from attendees was overwhelmingly positive. The conference drew press attention as well with an article published in [The Charlotte Observer](#) on the 2nd day of the event. All posters and presentations are available on the [conference website](#). Full conference details, including results of the participant evaluation survey, are available in the [final report](#).

CISA Welcomes Liz Fly to the Team

Elizabeth (Liz) Fly, Ph.D., has joined CISA and the SC Sea Grant Consortium (SCSGC) as the coastal climate extension specialist. Liz has a B.S. in biology from the University of Puget Sound and a Ph.D. in biological sciences from the University of South Carolina. Before coming to CISA and SCSGC, she spent a year in Washington, D.C. as a Knauss Fellow, working jointly with NOAA's Climate Program Office and the US Global Change Research Program on the Third US National Climate Assessment. Liz will be based at the SC Sea Grant offices in Charleston, SC. In her role as coastal climate extension specialist, Liz will work to educate and support coastal communities and decision makers in evaluating and preparing for the impacts of climate variability and change in coastal systems. She will assist communities in incorporating weather and climate information into local planning and decision making processes.

Jess Whitehead previously held the position which was jointly funded by NOAA CPO and National Sea Grant Office through a grant to CISA, NC Sea Grant and the SC Sea Grant Consortium. Jess moved to Raleigh last fall to work solely for NC Sea Grant as their coastal communities hazards adaptation specialist. With the move of Whitehead to NC Sea Grant and the addition of PI Fly as the CISA and SC Sea Grant Consortium coastal climate extension specialist, CISA has an even more active presence in the coastal Carolinas. Whitehead and Fly will collaborate to bring coastal climate information to communities in North and South Carolina and work together to expand their networks.

Engagement with Citizen Scientists

Two CISA projects involve new engagement with citizen scientists to understand the effects of climate variability on local environments and resources.

NIDIS-Carolinas Drought Early Warning System (DEWS) pilot project to monitor drought impacts: CISA researchers are using tools developed by the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network to recruit citizen scientists to monitor rainfall and submit weekly condition monitoring reports. These regular reports are intended to develop a baseline of local condition information in order to improve understanding of how rainfall, or a lack thereof, impacts local ecosystems and communities. As part of this effort, CISA also began new engagement with the national CoCoRaHS office, National Weather Service regional coordinators, and NDMC Drought Impact Reporter staff to ensure that reporting tools and methods are accessible to the citizen scientist participants and meet NIDIS pilot project needs.

Collaborative project with SC blue crab fishermen: Coastal climate extension specialist Liz Fly and SC Sea Grant colleague Julie Davis are initiating a citizen science collaborative project with blue crab fishermen in Beaufort County, SC. This is a new component of the project to promote climate change awareness and adaptive planning in Atlantic fisheries communities. Interviews and workshops held in 2013 to assess the effects of drought on the blue crab industry in Beaufort County, SC, revealed a large knowledge gap in the fishery as it relates to drought and other climate impacts. Researchers and fishermen agree that more data is crucial in order to identify potential climate adaptation options. The citizen science initiative is providing refractometers to experienced crabbers to support a collaborative data-gathering process. The research is coordinated with Michael Childress (Clemson), who is working on a NIDIS-funded project to model blue crab responses to salinity changes.

Working with Decision Makers to Produce Locally Relevant Downscaled Climate Information

Decision makers and stakeholders in the region are showing increasing interest in learning how downscaled climate information can be made applicable and relevant to various planning processes. The two new projects described below showcase work CISA researchers have conducted over the past year to produce tailored products to meet the specific needs of stakeholders interested in potential climate change impacts.

Generation of Climate Change Scenarios Appropriate for Low Impact Design

CISA is providing technical support to the ACE Basin and North Inlet-Winyah Bay National Estuarine Research Reserves, the Center for Watershed Protection, and South Carolina Sea Grant Consortium, who were funded through a NERRS Science Collaborative grant to develop a Low Impact Development (LID) Manual for Coastal South Carolina. From a stormwater management perspective, LID practices have been promoted as an effective way for reducing runoff from urbanized landscapes and reducing water quality contamination. Though this practice emerged for different needs, it has in more recent years also been suggested as an adaptive management technique for dealing with the uncertain and variable impacts of climate change impacts on localized precipitation regimes. This project is one of the first instances, however, where a group is specifically concerned with ensuring that LID practices can withstand potential climate changes over the expected 30-50 year lifetime of LID site designs. CISA's participation with this group aims to aid in the understanding of the variability, trends, and potential future changes in precipitation in a manner that is particularly important for stormwater/LID engineering practices and design.

NERRS Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH)

The goal of this effort is to provide regionally-specific climate change information for Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH). This tool is being developed by several members of the National Estuarine Research Reserve System (NERRS). CCVATCH is designed to assess relative habitat vulnerabilities under a given set of climate change stressors. CISA provided scenarios of change in ecologically relevant variables for pilot testing of this tool for coastal habitats in North Inlet-Winyah Bay and Chesapeake Bay, VA NERR sites. These scenarios came from the CMIP5 data archive.

Expansion of the Health Focus Area

Project Expansion: Climate Change Impacts of Air Pollution

A project led by CISA collaborating investigators at the UNC Gillings School of Global Public Health to improve understanding of potential future air quality health impacts on vulnerable populations was funded as part of CISA's minigrant program in 2012. The study area for the original minigrant project was limited to Mecklenburg County, NC. Estimates of projected future ozone levels and related emergency department visits produced by researchers for this project are of great interest to various stakeholder groups. In particular, the NC Climate Ready program requested better estimates of climate change health effects in different regions of North Carolina (e.g. urban vs. rural). Therefore, additional funding was provided in 2013 to expand analysis from Mecklenburg County to all of North Carolina.

Vibrio: DNA analysis

During 2011/12 CISA funded a collaboration with the NOAA Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) to quantify the occurrence, if any, of the marine bacteria *Vibrio vulnificus* and *V. parahaemolyticus* in the Waccamaw River and to evaluate empirical relationships with potential environmental drivers such as temperature and salinity. These bacteria pose health threats through both wound infection and ingestion from shellfish. Information about the occurrence, abundance, and spatial and temporal dynamics of *Vibrio* spp. is therefore important for commercial and recreational shellfish harvesters and public health officials. It is known, however, that not all organisms are equally likely to cause disease. Thus understanding virulence is the next focus of attention by researchers. Additional funding has been provided to begin DNA sequencing and assessment of the genes known to be associated with virulence in *Vibrio*.

Public Health and Climate Change: Focusing NC Forward

CISA researchers based in NC participated in a two-day workshop on climate change and public health sponsored by the Research Triangle Environmental Health Collaborative and held in Raleigh, NC, October 29-30, 2013. The workshop convened individuals from federal, state, and local governments, academia, and industry to discuss the research, policy, and communication gaps involving climate change and public health in North Carolina. Attendees participated in small work group discussions focused on the health effects, climate drivers, and research and policy gaps specific to urban, rural, and coastal communities in North Carolina. The [final workshop report](#) includes recommendations for policy and other decision makers on how to address the public health implications of climate change across the state.

Research Highlights

Drought-Related Research

Improving Understanding of Drought Impacts in Coastal Ecosystems through Stakeholder Interviews

In order to improve understanding of drought impacts on coastal resources-dependent sectors and needs for drought information, CISA team members conducted interviews in the Beaufort County, SC, and Carteret County, NC, areas with individuals involved in commercial and recreational fishing, land and resource management, outdoor recreation, and non-profit conservation. Interviewees were specifically asked about: their experiences with drought and drought impacts, how they cope with or adapt to drought, their needs for drought information or resources, and other stressors that interact with drought to exacerbate impacts, create other resource pressures, or otherwise affect their ability to cope with drought. Key themes which emerged from the interviews are summarized below.

- All groups are affected by drought although impacts vary by sector and are context-dependent (i.e. local social-economic conditions, climate, and coastal processes). For example, commercial fisheries (shrimpers and crabbers, in particular) are affected by altered salinity levels and low freshwater flows during drought, as such conditions affect the movement and accessibility of those species. Natural resource managers (i.e. conservation land and refuge) reported a range of drought-related impacts to managed areas such as lower water levels in impoundments, vegetation stress, decreased soil moisture, increased fire risks, and increased susceptibility to diseases, pests, or other stressors.
- While drought (i.e. too little rain) negatively affects coastal resources and stakeholders, interviewees reported that too much rain is also a concern for many industries and decisions. The timing, duration, and seasonality of precipitation are all salient issues for these communities.
- In general, interviewees did not report using formal sources of drought information in their decision making on a regular basis. Fishing and recreation stakeholders rely on their personal observations and local knowledge about coastal resources. Their decisions about activities (i.e. fishing, recreational trips) are made on a short-term basis (daily to weekly) and consider a wide range of information related to the weather, tides, salinity, fishing conditions, financial costs, and regulations. Natural resource managers exhibited a greater use of climate, hydrological, and other environmental information for resource management and planning. They reported using in-house and external sources of (e.g. state- and federal agency) data to monitor conditions and develop management plans.
- Interviewees indicated a need for: better baseline data so they can improve understanding of what is “normal” (e.g. frequency of drought events, recovery periods, and groundwater recharge rates); research and monitoring efforts that would provide them with better information about the ecological indicators of drought (i.e. the biological impacts, thresholds, and responses to extreme events); and continued work with stakeholders to evaluate the types of early warnings and forecasts that might be useful for seasonal and annual decisions. These needs will be addressed in ongoing NIDIS-Carolinas pilot projects.

Climate Modeling and Downscaling Research

Climate Change Scenarios for CCVATCH

CISA researchers worked with the pilot project coordinators to understand the type of information they needed to assess habitat vulnerabilities under a given set of climate change stressors using CCVATCH. This communication drove decisions about the choice of climate projections dataset, spatial and temporal scales of aggregation, and the graphical format for communicating the results. Of all the publicly available datasets surveyed, the Bias-Corrected CMIP5 projections by Ed Maurer were found to be the most suitable option. The team produced graphics showing the spread of projections for seasonal changes in temperature and precipitation for mid-21st century (relative to 1980-2010 baseline) for two RCP scenarios (see Figure 1).

Valuable insights regarding the usefulness and application of downscaled climate information emerged through this effort. The project illustrates that decision makers may not always require highly refined or localized climate information, particularly in the early stages of considering climate change vulnerability. While it may be easy to assume that the plethora of publicly available climate data and tools would meet the information needs in such cases, this is not always true. Team members learned that NERR resource managers required significant guidance on choosing the source of information as well as how to use it. In the end, climate projections data was used to produce information specifically tailored for the vulnerability assessment tool.

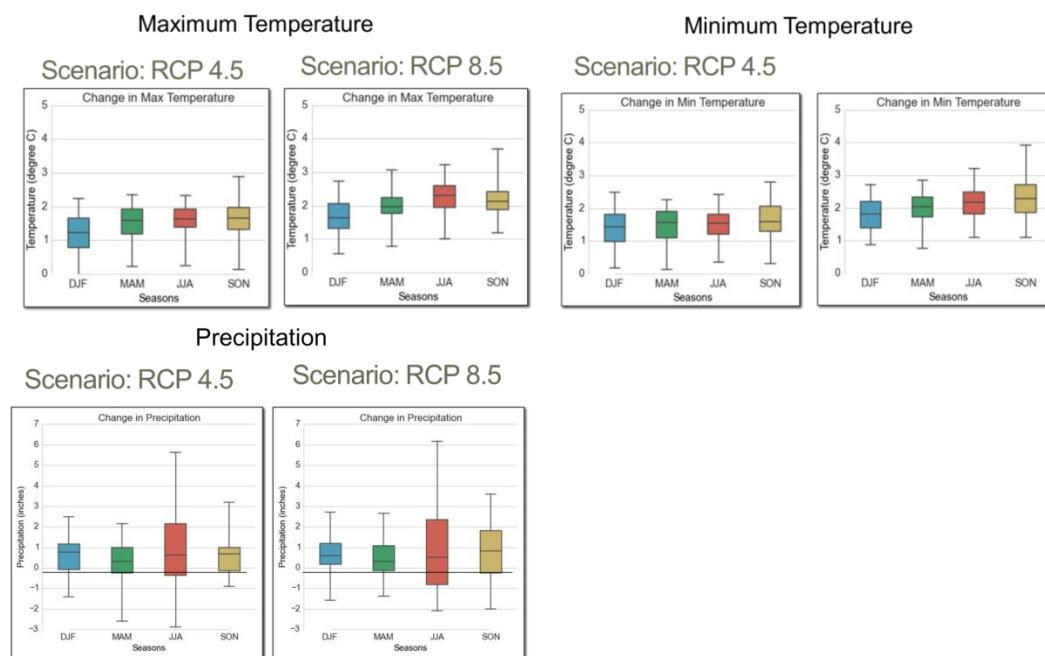


Figure 1: Examples of RCP scenarios produced for the CCVATCH process

Climate and Public Health Research

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

This project investigated the human health threats posed by the marine bacterium *Vibrio*. While there are several studies on the distribution of *Vibrio vulnificus* and *Vibrio parahaemolyticus* in estuarine waters around the world, there is little information on the distribution of these organisms in South Carolina waters. Monthly sampling of surface and bottom water from 9 sites in Winyah Bay was conducted over the period April-October 2012. The *Vibrio vulnificus* counts were the highest when salinity ranged between 5 ppt and 20 ppt. *Vibrio parahaemolyticus* did not show a clear pattern with salinity, indicating the possibility of other factors that interact to control its occurrence and abundance. Turbidity on the other hand

showed a positive association with both bacteria. Temperature values were within *Vibrio*'s optimal range for growth and seemed to have a lesser effect. The PRISM2 model, which integrates predictions of future streamflow and sea level in an artificial neural network model, was used to estimate future conductivity upper levels and the potential for increased *Vibrio* occurrence in the Winyah Bay estuary. Results show that the increased relative risks of optimum *Vibrio* growth based on specific conductance will increase up to 36X based upon location and range of sea level rise. These increased periods of optimal growth conditions for *Vibrios* may result in increased risk for swimmers and shellfish consumers, if virulent forms occur with more regularity.

Assessing Heat Stress Vulnerability

Goals of this research are to 1) identify climate-public health vulnerabilities across different regions (e.g. coastal plain, piedmont, mountains) and populations (e.g. rural vs. urban) of North Carolina and 2) develop empirical relationships that can be exploited to build tools that translate recent, current, and predicted weather/climate conditions across North Carolina into useful information regarding the probability of public health emergencies (e.g. spikes in heat related morbidity/mortality). Current work focuses on the temporal and spatial patterns in heat morbidity across the North Carolina using a unique emergency room admission data base. Efforts are underway to identify temperature thresholds across which heat morbidity rates increase markedly. Thresholds are being calculated for different demographic groups (e.g. teenagers vs. elderly) across various rural and urban regions of the state. Findings to date indicate that the highest rates of heat vulnerability are found in rural areas where labor-intensive crops are grown, rather than urban areas where there may be a perception that the heat island effect contributes to higher risk of heat stress. The biggest differences in vulnerability are between low and high-income groups, especially at the highest temperatures (Figure 2).

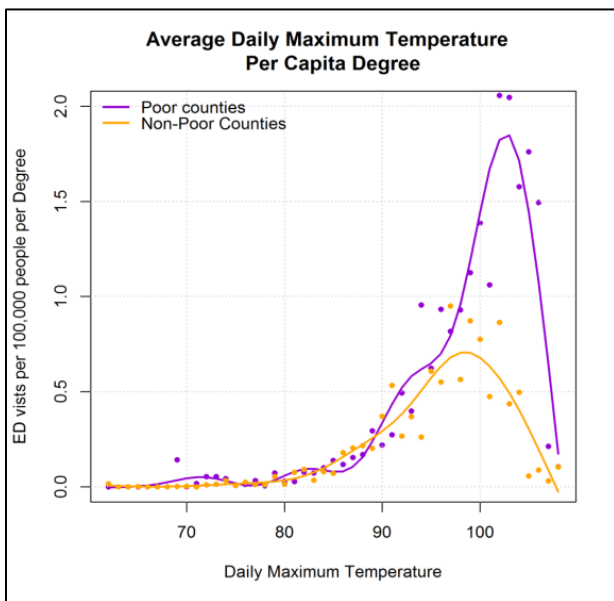


Figure 2: Emergency room visits in poorer versus wealthier NC counties

Outreach Activities

Climate Communications and Outreach in the Carolinas

CISA's climate outreach specialist, Amanda Brennan, plays a key role in CISA's work 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 (e.g. fact sheets, newsletters). Specific outreach tools include:

- The [Carolinas Climate Connection](#), a quarterly newsletter which includes syntheses of recent publications, information on relevant resources and tools, highlights of CISA's work, and links to upcoming events, funding

opportunities, and other stakeholder-relevant news. The newsletter is currently circulated to 1030 stakeholders throughout the region.

- The Carolinas Climate Listserv, which was launched in June 2013. Listserv postings are circulated at least once each week. Content focuses on climate-related issues and news relevant to the Carolinas. There are currently 152 listserv subscribers.
- A social media presence, to share relevant news and events with stakeholders in the Carolinas. Social media accounts were established at the time of the Carolinas Climate Resilience Conference to promote that event and continue to be used to promote the newsletter and listserv items to a broader audience.

CISA's Coastal Climate program was established as the Carolinas Coastal Climate Outreach Initiative (CCCOI) in 2007. This position was designed to strengthen collaboration between CISA and the Sea Grant programs in North and South Carolina and to provide coastal stakeholders with a trusted source of climate information and products. CCCOI efforts are currently led by the coastal climate extension specialist held by CISA PI Fly. Whitehead, the coastal hazards extension specialist with NC Sea Grant, works jointly with Fly to assist coastal communities in evaluating climate-related concerns, assessing potential vulnerabilities to climate-related impacts, and incorporating climate information into planning and decision-making processes. 2013-2014 CCCOI projects include:

- Developing a workshop to train facilitators and diagram scribes in using the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process. The first training workshop was held in Beaufort, NC, in December 2013. It was organized and funded by NC Sea Grant and based on training initially developed by SERI, CISA, and the NC and SC Sea Grant programs. The workshop also included basic facilitation training provided by NOAA's Coastal Services Center. CISA is committed to provide training as needed in the Carolinas.
- Working with the Kitchen Table Climate Study Group and local government of McClellanville, SC, to develop an adaptation outreach plan and materials. Informational panels on local climate hazards and adaptation options will be displayed outside of McClellanville's town hall.
- Providing assistance and a local perspective in the planning of a Department of Homeland Security Office of Infrastructure Protection Climate Change Adaptation Exercise in Charleston, SC, in June 2014.

Brennan, Fly, and other team members regularly participate in regional conferences, workshops, meetings to share information about CISA projects. Audiences include project stakeholders, government agencies, academics, and other outreach communities. The report appendix provides a full list of CISA's 90+ outreach, communications, and engagement efforts.

Regional Communications and Outreach

In order to identify opportunities for collaboration and to seek synergies with other efforts, CISA team members share research findings and interact with other climate practitioners and stakeholders throughout the Southeast region and at the national level as well. Specific efforts include:

- Participation at the Governors' South Atlantic Alliance annual meeting held September 4-5, 2013
- Partnership on the new USDA Southeast Regional Climate HUB proposal, led by Steve McNulty
- Participation in the NIDIS Salinity Workshop held January 7, 2014
- Participation in media events to announce the launch of the book Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability, a contribution to the Third National Climate Assessment (NCA)
- Regular participation in collaboration calls with NCAnet, a network of organizations working with the NCA to engage producers and users of assessment information across the United States
- Coordination with NOAA in the Carolinas organizations on various projects and communications efforts
- Participation in the Southeast and Caribbean Climate Community of Practice steering committee (PI Fly is committee chair). More information on this partnership is provided below.

Southeast and Caribbean Climate Community of Practice

The Southeast and Caribbean Climate Community of Practice (CoP) was formed in 2010 to explore the state of climate science, learn how coastal communities can adapt to climate change impacts; and share lessons learned related to climate communication and adaptation. Comprised of individuals from state and federal agencies, academia, non-profits, and local communities, the CoP strives to understand and address the needs of the climate community in the region. Two workshops (2010 and 2012) have been held in which participants discussed various regional needs and ways that the CoP could address these. In 2013 with CoP support, CISA developed and administered a survey that was distributed to all CoP participants to identify priority climate concerns, information needs, and resources in the region and to gauge interest in engagement and ideas for the future of the CoP. In addition to this survey, CISA developed a [resource directory](#) that includes information about individuals, organizations, websites, and documents which can serve as climate resources for practitioners in coastal regions of the Southeast. The Carolinas Climate Resilience Conference offered an opportunity for CoP members to meet in a roundtable session and identify three priority actions to make progress on in the coming year: 1) offer trainings and workshops; 2) work with communities using tools, understand their next steps; and 3) broaden and strengthen the CoP. Fly will lead these efforts as chair of the steering committee while other CISA team members are maintaining an active role in the CoP, offering technical assistance as needed. CoP is also providing some travel support for Fly and Brennan around these activities. Working with the CoP provides a unique opportunity for CISA to engage with decision makers throughout the region on coastal climate issues of most concern.

Stakeholder Engagement to Develop a Heat Stress Vulnerability Tool

The Southeast Regional Climate Center, led by CISA PI Konrad, presented and received feedback on a prototype of the web-based Heat Vulnerability tool at several stakeholder events over the past year. The most recent meeting was held April 21, 2014, with the UNC Climate Change-Public Health working group. This group includes participants in the UNC School of Public Health and Emergency Medicine, the North Carolina Department of Public Health, the NC State Climate Office, and the Environmental Protection Agency (EPA). The tool predicts the number of emergency room visits (ERVs) using National Weather Service daily temperature forecasts and empirical relationships identified between ERVs and temperature. The tool will allow the user to estimate levels of heat morbidity for different demographic groups across various regions of NC.

Outreach to Engage Citizen Scientists for the NIDIS-Carolinas Pilot

CISA team members worked throughout the year to recruit citizen scientists in the Carolinas to participate in a condition monitoring project which aims to improve understanding of the impacts of rainfall, or the lack thereof, on ecosystems and communities. Information and training materials were produced in a variety of formats to solicit participation in the project. These materials include 2-page FAQ sheets, a volunteer notebook, and volunteer training PowerPoint slides. Trainings were held both in-person when possible and via webinar in order to reach a more geographically dispersed set of possible volunteers. Regular communication is maintained with volunteers through e-mail correspondence, semi-regular online feedback surveys, a monthly newsletter, and a blog. These efforts build on lessons learned from other citizen science projects about recruiting participants and maintaining engagement with volunteers.

CISA Impacts

Development and Use of an Experimental High Resolution Drought Trigger Tool

The NC State Climate Office has developed an online [Experimental High Resolution Drought Trigger Tool](#) for decision support. High-resolution drought information is available in the form of updated-daily maps of the Standardized Precipitation Index (a precipitation-based drought index), percent of normal precipitation, and accumulated precipitation for a variety of durations, with an archive that goes back to 2005. This tool was designed for use by drought experts and is being used by the North Carolina Drought Management Advisory Council and US Drought Monitor authors as guidance for the weekly US Drought Monitor. Users can bookmark a URL containing their selections or iframe the tool within their own website, allowing personalized and usable information at their fingertips.

Use of downscaling information: CISA contributions to the LID manual and CCVATCH pilot program

LID manual: From a stormwater management perspective, low impact design (LID) practices have been promoted as an effective way for reducing runoff from urbanized landscapes and improving water quality. Though this practice emerged for existing challenge, it has in more recent years also been suggested as an adaptive management technique for dealing with the uncertain and variable impacts of climate change impacts on localized precipitation regimes. This is one of the first instances; however, in which a group is specifically concerned with ensuring LID practices can withstand potential climate changes. Through the development of the LID manual, CISA helped provide local decision makers with LID design reference tailored to the conditions of the South Carolina coast. CISA synthesized and provided information on observed or anticipated changes to the coastal climate, specifically in regards to changes in precipitation intensity, design storm depth, and frequency of the water quality design event. The manual is intended to provide engineers and planners with information for use in the design and implementation of future LID sites.

CCVATCH: CISA provided climate model output and climate change information that was incorporated in the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH) and used in pilot study areas during the developmental stages of the tool. This tool will be used to help coastal resource managers identify 1) habitats that are likely to be adversely affected by climate change and 2) management options for adaptation to or mitigation of climate impacts. Pilot study areas are located in the North Inlet-Winyah Bay and Chesapeake Bay National Estuarine Research Reserves.

Contributions to Local Climate Adaptation Planning Efforts

Engaging Local Stakeholders in Climate-Resilient Planning in the Coastal Carolinas: This project provides a participatory opportunity for a South Carolina community that has acknowledged the need to plan for sea level rise but not yet engaged in climate change adaptation planning. A report containing recommended adaptation actions is being developed with partnership with the Beaufort County (SC) Planning Department. While this project was originally intended to help inform Beaufort County's update of its Comprehensive Plan, several other opportunities have arisen from this work. For example, the County's Disaster Recovery planner has asked for help in updating the Disaster Recovery Plan with sea level rise projections. The County is also creating a list of Capital Projects they will prioritize and fund. There are also opportunities for the project to serve as a demonstration for other communities in North and South Carolina.

Climate Change Impacts on Water Infrastructure: This project addresses the issue of the potential vulnerability of municipal water and wastewater infrastructure to coastal hazards. Study sites are located in the North Carolina coastal communities of Manteo, New Bern, and Plymouth. The team produced a series of detailed maps that include infrastructure location as well as the potential sea level rise, storm surge, and riverine flooding risks to those sites for the three communities. Community planners consulted for this project identified the need to assess risks to water lines and pump stations. Based on their advice, these infrastructure components were included in the analysis. While these communities can, to some degree, contract individual risk assessments, they are recipients of an aggregated benefit because this project allows multiple jurisdictions to be seamlessly assessed and a range of vulnerabilities visualized and compared. As such, the maps and graphics will be provided to NC Sea Grant for future activities to communicate climate change risks to coastal communities. Also, the data layers (e.g. floodplain maps, SLOSH MOMs, and SLR scenarios) generated for the project will be published in the NC Coastal Atlas, a collaborative effort to provide public access to geospatial data, visualization tools, and thematic maps focused on coastal resources and hazards.

The Carolinas Climate Resilience Conference – Fostering a Network of Climate Adaptation Practitioners

Conference evaluation survey questions were designed to solicit information about what conference participants might change or do as a result of attending the conference. Many participants identified networking and future work with potential new partners as a key take-away from the conference. Survey questions also sought to learn how participants would use or share the knowledge gained during the conference in their workplace, communities, and homes. These responses ranged from specific tools or resources that will be taken back to the workplace to more general information use such as changes in communications strategies or integrating stakeholder feedback into decision making processes. Below are several quotes from survey respondents sharing their plans:

- “Most valuable part of the conference was making new contacts. I learned about organizations that I hadn’t been familiar with before and discovered tools that I didn’t know about prior to the conference. I now have many new potential partners to consider when working on climate adaptation.”
- “I have begun educating myself on aspects of climate change (other than sea level rise which we consider currently in our projects) which I did not previously consider. I also have begun researching some of the outreach strategies employed by the Sea Grant program to adapt into our processes.”
- “As a business, we will continue to look for opportunities to be able to provide climate change consulting expertise to our clients – it was good to hear about the various initiatives that groups are considering.”

Key Publications

- Carbone, G. 2014. Managing climate change scenarios for societal impact studies. *Physical Geography* 35 (1). 22-49.
- Haywood, B., A. Brennan, K. Dow, N. Kettle, and K. Lackstrom. 2014. Negotiating a Mainstreaming Spectrum: Climate Change Response and Communication in the Carolinas. *Journal of Environmental Policy & Planning* 16 (1): 75-94.
- Ingram, K.T., K. Dow, L. Carter, and J. Andersen, eds. 2013. Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability. Island Press, Washington.
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- Lackstrom, K., A. Brennan, D. Ferguson, M. Crimmins, L. Darby, K. Dow, K. Ingram, A. Meadow, H. Reges, M. Shafter, and K. Smith. 2013. *The Missing Piece: Drought Impacts Monitoring*. Workshop Report. Tucson, AZ. 23 pp.
- Lippmann, S.J., C.M. Fuhrmann, A. Waller, and D.B. Richardson. 2013: Ambient temperature and emergency department visits for heat-related illness in North Carolina, 2007-2008. *Environmental Research*, 124: 35-42.

Metrics for Success

CISA is currently completing Year 3 of its 5-year (2011-2016) grant. At this year’s annual meeting of the principal investigators and full-time staff, the team decided to conduct a program evaluation to assess overall program progress but also to identify opportunities to continue to strengthen the program. There will be two components to the evaluation. The internal aspect of the evaluation, to be conducted by CISA team members, will seek to solicit feedback from stakeholders to determine the value of products such as the Carolinas Climate Listserv and quarterly newsletters. Results of these surveys will be used to improve content and circulation of these communications and outreach materials.

There will also be an external evaluation component. Three external reviewers will conduct 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. Key questions posed for the external evaluation include:

- How is CISA doing in terms of developing decision-relevant science and information for the Carolinas?
- What has been accomplished? What progress has been made?
- Should research focus areas continue in the same direction, should existing projects and partnerships be expanded, or should new or alternate paths and partnerships be pursued?

External evaluators will produce a final report based on their interviews. This report will be shared with the CISA advisory committee at an in-person meeting in fall 2014 in order to discuss results and next steps for the research team.

Project Overviews

Drought

Dynamic Drought Index Tool (DDIT)

Team Member: Carbone

Partners: Northeast Regional Climate Center (NERCC), Southeast Regional Climate Center (SERCC), South Carolina State Climatology Office of the South Carolina Department of Natural Resources (SC DNR)

Overview: The Dynamic Drought Index Tools (DDIT) was developed by CISA researchers as a response by state climatologists, Duke Energy, state drought response committees, and other drought management groups for an interactive tool that allows drought monitoring with user control of index, time frame, and spatial aggregation unit. The tool is maintained by the SC DNR and currently provides the ability to examine historical droughts up to 2009. Meanwhile, CISA is working with the Northeast Regional Climate Center to implement a near-real time, grid-based version of the DDIT, for access through their ACIS data base (http://www.rcc-acis.org/docs_gridded.html). This tool will cover eighteen states in the eastern United States, including those covered by the Northeast and Southeast Regional Climate Centers.

Drought Sensitivity Testing

Team Member: Boyles

Partners: NC State Climate Office, Texas A&M University

Stakeholders: National Integrated Drought Information System, NC Department of Environment and Natural Resources Water Resources Division, NC Drought Council, Forest Managers

Overview: Stakeholders with the NC Drought Council, NCDENR Water Resources, and forest managers are interested in using high-resolution drought indicators (HRDI). In particular, the NC Drought Council provides weekly guidance 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 leverages a partnership with Texas A & M University.

Progress & Results:

- The HDRI web tool deployed last year has been enhanced for stability and to enable animations and user-defined transparency. The tool was presented to the American Association of State Climatologists (including State Climatologists and Regional Climate Centers) and refined based on feedback in July 2013. Adjustments have been made that allow for user-defined map extents and product views to be incorporated and embedded directly into stakeholder websites while maintaining the look and feel of stakeholder pages. As an example, the Texas State Climate Office now also includes this tool embedded in their site but focused on Texas: <http://atmo.tamu.edu/osc/drought/>.
- The NC Drought Council now uses the current HRDI SPI products routinely in weekly drought discussions. As new drought indices come online, these will also be included in weekly drought guidance from the Council to the US Drought Monitor.

NIDIS-Carolinas Drought Early Warning System Pilot Program Projects

CISA's current drought work builds on stakeholder-identified needs and recommendations from the 2012 NIDIS Carolinas Drought Early Warning System Scoping Workshop. Projects conducted by the CISA team in 2013-2014 are intended to improve understanding and monitoring of drought impacts in the coastal Carolinas (see information below). These drought impacts projects will also inform other efforts in the NIDIS-Carolinas pilot program, including the projects listed below. These projects are in their initial stages.

- CISA PI Tufford will assess ecological drought indicators in coastal ecosystems, a project funded through the NOAA Sectoral Applications Research Program (SARP).
- Additional work is being conducted by CISA collaborating investigator Paul Conrads (USGS SC Water Science Center) to develop a real-time salinity drought index. Ultimately this index will be linked to ecological impacts or outcomes in order to inform the ecological indicators project and to support adaptation planning for coastal resource managers.
- Michael Childress' (Clemson University) work examines the sensitivity of blue crabs to salinity changes and projections for future landings given current and projected changes in freshwater discharge.
- Ryan Boyles' (State Climate Office of NC) project aims to develop and evaluate a drought index which better represents the local fire risk in the organic soils of the coastal Carolinas.

Drought Impacts Reporting through Citizen Science Engagement

Team Members: Dow, Brennan, Davis, Haywood, Lackstrom, Sayre

Partners: Community Collaborative Rain, Hail and Snow (CoCoRaHS) network, National Integrated Drought Information System (NIDIS), National Drought Mitigation Center, NC and SC National Weather Service Offices, State Climate Office of NC, SC State Climatology Office

Stakeholders: CoCoRaHS Observers, Master Gardeners and Master Naturalist groups, drought managers and decision makers in NC and SC

Overview: CISA researchers are engaging citizen scientists in on-the-ground data collection in order to improve understanding of the impacts of rainfall, or a lack thereof, on local ecosystems and communities. Using tools developed by the CoCoRaHS network, CISA team members are recruiting volunteers to take daily precipitation measurements and enter weekly status reports about the condition of ecosystems and communities in their area. The focus on regular condition monitoring instead of drought monitoring is an innovation intended to establish a full baseline of conditions and avoid forcing volunteer observers to determine difficult transitions, such as if conditions are dry or drought. The project seeks to build on existing knowledge about the reliability of citizen scientists as a viable means of data collection to improve understanding of drought impacts in coastal ecosystems. Researchers will also work with decision makers to understand how the information collected could be used for resource management by various stakeholder groups.

Progress & Results:

- Both in-person and webinar trainings were held with observers throughout North and South Carolina with 48 project participants recruited between August 2013 and May 2014.
- 363 condition monitoring reports have been submitted to the CoCoRaHS website since September 2013. These reports are also uploaded to the National Drought Impact Reporter database.
- CISA team members worked directly with staff at CoCoRaHS national headquarters and the National Drought Mitigation Center during the initial development of information and training materials for the citizen science condition monitoring initiative. The condition monitoring checkbox and an information sheet which describes condition monitoring (in contrast to drought impacts reporting) are now part of the online CoCoRaHS Drought Impact Report form, which is available to over 12,500 CoCoRaHS volunteers throughout the US and Canada.

Improving Understanding of Drought Impacts in Coastal Ecosystems through Stakeholder Interviews

Team Members: Dow, Lackstrom, Brennan, Davis, Haywood, Patel, Rodgers, Sayre

Partners: National Integrated Drought Information System

Stakeholders: Coastal stakeholders in Beaufort County, SC and Carteret County, NC areas who are affected by drought: fishing sector (crab, oysters, shrimp, etc.), outdoor recreation businesses, private and public land and wildlife refuge managers

Overview: CISA team members conducted interviews in the Beaufort County (SC) and Carteret County (NC) areas with individuals involved in commercial and recreational fishing, land and resource management, outdoor recreation, and non-profit conservation. The goal of these interviews is to improve understanding of drought impacts on those sectors and their needs for information. Interviewees were specifically asked about: their experiences with drought and drought impacts, how they cope with or adapt to drought impacts, their drought information use and related needs for information or resources, and other stressors that interact with drought to exacerbate impacts, create other resource pressures, or otherwise affect their ability to cope with drought.

Progress & Results:

- 42 total interviews, involving 50 individuals, were conducted between spring and fall 2013. Interview transcripts were coded and analyzed using NVivo. The project summary report and a manuscript are in progress. Several of the key themes from this report can be found in the Research Findings section on page 5.
- As part of this project, CISA team members have engaged with other RISA, National Drought Mitigation Center, and CoCoRaHS partners to identify best practices and needs for a drought impact reporting and monitoring system. To this end, CISA participated in a 2-day workshop in Tucson, AZ, in March 2013, and developed a workshop report. CISA team members participated in webinar presentations as part of the “Engaging Preparedness Communities Webinar Series”.
- Because both below- and above-normal precipitation events can affect the sectors consulted in this project, as a next step, CISA researchers will develop an atlas of hydroclimate extremes for the Carolinas. The atlas will provide a spatially explicit historical record of drought using SPI indices, streamflow, and precipitation extremes and be used to investigate the relationships between drought and water quality in coastal areas. This project will address the need for an improved baseline understanding of drought recurrence as well as the water quality impacts that have been noted by stakeholders in interviews and the NIDIS-Carolinas Scoping Workshop.

Climate Modeling and Downscaling

Climate Change Scenarios for Low Impact Design

Team Members: Carbone, Gao, Rodgers

Stakeholders: ACE Basin and North Inlet-Winyah Bay National Estuarine Research Reserve (NERR), Center for Watershed Protection, SC Sea Grant Consortium

Overview: This project was initiated to inform the development and generate material to be included in a "Low Impact Development Manual for Coastal South Carolina." The development of the manual is being coordinated by the stakeholders listed above. In order to provide climate information needed for the manual, CISA researchers have investigated the intensity, duration, and frequency of extreme precipitation events using historical data from stations and from the North American Regional Reanalysis (NARR) database. They have also investigated precipitation intensity from climate models during the historic period and for future scenarios using data sources at regional scale in the Southeast. These include output from the North American Regional Climate Change Assessment Program (NARCCAP) and the Center for Ocean-Atmospheric Prediction Studies (COAPS) Land-Atmosphere Regional Reanalysis for the Southeast at 10-km resolution (CLARRes10).

Progress & Results:

- CISA engaged with project participants at a climate and stormwater roundtable in September 2013. PI Carbone gave a presentation about climate projections for coastal South Carolina. PI Dow led a discussion on thresholds and adaptation, specifically prompting a conversation about risk management, how to decrease sensitivity to climate stressors, and addressing the limits of existing stormwater management strategies.
- During this reporting period, researchers examined the Intensity-Duration-Frequency (IDF) curves of extreme precipitation events during the historic period using data from meteorological stations and NARR, estimated the impact of climate change on extreme precipitation events using global and regional climate models, and employed a

regionalization method to differentiate the nature of precipitation intensity in coastal and inland regions using Intensity-Duration-Frequency (IDF) curves of extreme precipitation events. NARCCAP more closely represents extreme rainfall events than CLARRes10 during the historic period. Future projections of extreme precipitation events vary regionally for both NARCCAP and CLARRes10, based on the models examined so far. In contradiction to the universal belief that extreme precipitation will be intensified in the future, this project found little change or even a slight decrease in intensity in some regions.

- Planned activities include completing the investigation of the IDF curves and parameter changes during the long historic record to detect whether or not there is evidence for intensity changes and the assessment of model performance with respect to precipitation intensity. In addition to exploring methods for deriving information on climate change impacts on future precipitation, continued work will also focus on identifying what the climate thresholds of concern are for LID site designs.

Providing Regionally-Specific Climate Change Information for CCVATCH

Team Members: Carbone, Patel

Stakeholders: Chesapeake Bay and North Inlet-Winyah Bay National Estuarine Research Reserves (NERR)

Overview: The goal of this effort is to provide regionally-specific climate change information for the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH). CCVATCH is designed to assess relative habitat vulnerabilities under a given set of climate change stressors. CISA team members provided scenarios of change in ecologically relevant variables for pilot testing of this tool for coastal habitats in North Inlet-Winyah Bay and Chesapeake Bay, VA National Estuarine Research Reserve (NERR) sites.

Progress & Results:

- The main accomplishment of this project to date has been the processing of CMIP5 data for the region. The graphs presented in the Research Findings section on page 6 are derived from analysis of output for approximately 40 GCMs for each emissions scenario.

Watershed Modeling

Modeling of the Winyah Bay Watersheds

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

Overview: CISA researchers work with EPA's BASINS Hydrologic Simulation Program-Fortran (HSPF) and the Soil and Water Analysis Tool (SWAT) models. They have simulated the Yadkin Pee-Dee, Waccamaw, and Black Rivers at the 8-digit HUC level and have calibrated the models in order that local variability within each watershed can be adequately addressed. CISA's climate modeling and downscaling projects are integrated into these hydrological models to assess the potential impacts of climate variability and change on water resources in the Southeast. This basin-wide approach to climate and hydrological modeling appeals to a wide variety of stakeholders. For example, the 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. Planned activities include work with stakeholders to incorporate information about future climate impacts into adaptation planning at the Waccamaw National Wildlife Refuge and further investigate climate impacts on public water supply availability and water quality throughout the Waccamaw River watershed.

Progress & Results:

- This year was spent polishing the SWAT model of the Waccamaw River watershed and preparing manuscripts for peer review. Three manuscripts covering aspects of the SWAT work were prepared; two have been submitted for peer review. A fourth manuscript covering HSPF work is in preparation.

Coastal Climate

Using Participatory Scenario Building to Encourage Climate-Resilient Planning in the Coastal Carolinas

Team Members: Fly, Whitehead, Bath

Partners: NC Sea Grant, SC Sea Grant Consortium

Stakeholders: Beaufort County (SC) Planning Department

Overview: The goal of the project is to write a plan for priority actions to update planning and form-based codes to encourage climate resilience in Beaufort County, SC. This has been accomplished through stakeholder interviews and workshops using the Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process.

Progress & Results:

- In June 2013, Whitehead conducted 15 interviews to gauge climate-related concerns in Beaufort County. These interviews provided background information for a VCAPS workshop (see Adaptation section) in August 2013, where 18 attendees participated in a facilitated discussion to identify impacts of sea level rise on county planning and potential adaptation options.
- In February 2014, participants met again to view maps of sea level rise impacts on Beaufort County and discuss a report summary of the VCAPS workshop.
- Participants met for a final workshop in May 2014 to rank the adaptation actions identified in the VCAPS workshop. Fly and Whitehead will continue to engage stakeholders as they work towards a final report of recommendations for the Beaufort County Planning Department.

Promoting Climate Change Awareness and Adaptive Planning in Atlantic Fisheries Communities

Team Members: Fly, Whitehead

Partners: SC Sea Grant Consortium

Stakeholders: Beaufort County (SC) blue crab fishermen

Overview: This project aims to improve understandings of how a changing climate will affect fishing communities' abilities to maintain marine fisheries and the local economies historically dependent upon them. It also investigates the role of a structured dialogue and participatory modeling process to support decision makers in fishing communities addressing consequences, vulnerabilities, and adaptive strategies in the context of climate stressors. At the end of the project, the methodology will have been demonstrated in three diverse fishing communities: South Thomaston, ME; Wellfleet, MA; and Beaufort County, SC.

Progress & Results:

- In SC, interviews, VCAPS workshops, and a system dynamics (SD) workshop took place. At the SD workshop, the group recognized data gaps and South Carolina Sea Grant Consortium began to implement a collaborative data-gathering process with some experienced fishermen.

Addressing Short- and Long-Term Weather and Climate Impacts on a South Carolina Barrier Island

Team Member: Fly

Partners: SC Sea Grant Consortium, City of Folly Beach, SC

Overview: This project was initiated in February 2014 when the members of the Planning Commission for the City of Folly Beach, SC, contacted CISA's coastal climate extension specialist, Fly. Folly Beach is a small barrier island city just outside of Charleston, SC, that experiences chronic erosion issues on its beach due to the placement of jetties in the Charleston harbor. Folly Beach is typically renourished every 5-7 years. The city wishes to become more knowledgeable on the state of their beach erosion and the variety of options available for erosion control, as well as to address longer-term climate issues in the update of both their Beachfront Management Plan and Comprehensive Plan.

Progress & Results:

- Fly met with several members of the Planning Commission in February 2014 to discuss a potential project to incorporate the impacts of climate variability and change into Folly Beach's long-term planning.
- In April 2014, Fly was invited to speak formally at the monthly Planning Commission meeting on the role of climate extension and how CISA and SC Sea Grant Consortium could help Folly Beach. At this meeting, Planning Commission members, City of Folly Beach staff, and private citizens agreed this was a timely and important topic and planned to participate in more detailed discussions on the goals of the project.

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**Team Members:** King, Brown**Partners:** DOI Climate Science Center, NASA, USDA Forest Service, NC State University Department of Forestry and Environmental Resources (Domec, Noormets), USDA National Institute of Food and Agriculture, US Department of Energy**Stakeholder:** Alligator River National Wildlife Refuge (ARNWR)

Overview: This project will quantify the carbon (C) contained in vegetation and soils of the predominant ecosystems that occur at ARNWR and quantify thresholds of salinity and hydro-period (number of days per year the soil is flooded) resulting in transition from one ecosystem type to another. Focus is being placed on the effects of historical ditching and drainage on soil water dynamics and salinity, quantifying the role of extreme events such as flood tides and hurricanes. The information gathered will be combined with a GIS-remote sensing analysis of ecosystem vulnerability (to transition) across the Refuge, which will allow managers to implement mitigation procedures (e.g. planting flood tolerant tree species) or adapt (e.g. start managing for future conditions of wildlife habitat). In addition, researchers will host a public outreach event at ARNWR headquarters (Roanoke Island) to discuss the science of the CISA/Refuge project to the public and solicit input from local constituents.

Progress & Results:

- Sampling transects were set up in three ecosystems to quantify effects of ditching on hydroperiod and salinity dynamics and are currently being sampled for C content in vegetation and soils. Additional ecosystems will be added and sampled during fall months.
- Team meetings were held with ARNWR staff to ensure project outcomes are aligned with Refuge objectives, and to seek further Refuge (in-kind) support.
- Funding was received from US DOE to become part of the Ameriflux Core Site program. The flux tower sites use eddy covariance methods to measure the exchanges of CO₂, water vapor, and energy between terrestrial ecosystems and the atmosphere. Data from the flux towers are made available to the larger scientific community in exchange for long-term operational funding support making the project part of an international C monitoring network.
- Significant funding has also been received from the NASA-administered multi-agency Carbon Cycle Science program to expand emphasis on belowground C cycling at ARNWR.

Climate Change Impacts on Water Infrastructure**Team Members:** Allen, Montz, Oyer**Partners:** NC Sea Grant**Stakeholders:** City of New Bern, NC; Town of Manteo, NC; Town of Plymouth, NC

Overview: The goal of this project is to assess the vulnerability of municipal water infrastructure to coastal hazards in North Carolina communities. The project brought together GIS and water management expertise as well as experience modeling

sea level rise and future climate change impacts to produce a series of detailed maps visualizing the vulnerability of water and wastewater infrastructure.

Progress & Results:

- Maps and graphics produced for the participating communities are comparative across jurisdictions using a common symbology and reporting format. The approach focuses on individual hazards and a multi-hazard symbolization, which can aid individual jurisdiction as well as intercomparisons.
- Over-arching results reveal increasing risk at the fine spatial scale detailed on the maps, as well as a relative improvement of the temporal contrast of risk (particularly sea-level rise implications). That is, the maps illustrate what height of relative sea level rise exposes serious risk to various infrastructure components. Graphics also highlight the relative quantity of assets that are vulnerable. Further consultation with local officials and planners will help to draw site-specific implications.

Public Health

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

Team Members: Tufford, Dow, Deeb

Partners: NOAA Center for Coastal Environmental Health and Biomolecular Research

Stakeholders: SC Department of Health and Environmental Control

Overview: This project integrates work on watersheds, coastal adaptation, and drought and is investigating human health threats posed by the marine bacterium *Vibrio* in shellfish, the spread of which is believed to be associated with changing temperature and salinity conditions. Researchers conducted monthly sampling of surface and bottom water in the Winyah Bay and Waccamaw River for the species *Vibrio vulnificus* and *Vibrio parahaemolyticus*. Monitoring results were assessed in the context of changing salinity gradients using the PRISM2 Decision Support System (DSS) which CISA researchers developed for the NOAA/SARP-funded saltwater intrusion project.

Progress & Results:

- Analysis of samples collected from 9 sites along Winyah Bay and the Waccamaw River to determine the spatial and temporal distribution of the two marine bacteria, *Vibrio vulnificus* and *Vibrio parahaemolyticus*, was completed this year. Additional information on research findings are detailed on page 6.
- Research findings were published in Deeb's Master's thesis, which was successfully defended in May 2013. Preparation of a manuscript for peer review has begun.

Assessing Heat Stress Vulnerability

Team Members: Konrad, Fuhrmann, Kovach

Partners: NC Division of Public Health, NC State Climate Office, Southeast Regional Climate Center, UNC Chapel Hill School of Emergency Medicine, UNC School of Public Health

Stakeholders: Farmworker organizations, the National Weather Service, NC Division of Public Health

Overview: CISA is collaborating with the Southeast Regional Climate Center (SERCC) to investigate heat stress vulnerability and assess methods to improve existing heat warning systems. They are working with data from the North Carolina Disease Event Tracking and Epidemiologic Collect Tool (NC DETECT) to examine relationships between heat and morbidity across North Carolina. Goals of this research are to 1) identify climate-public health vulnerabilities across different regions (e.g. coastal plain, piedmont, mountains) and populations (e.g. rural vs. urban) of North and South Carolina and 2) develop empirical relationships that can be exploited to build tools that translate recent, current, and predicted weather/climate

conditions across the Carolinas into useful information regarding the probability of public health emergencies (e.g. spikes in heat related morbidity/mortality).

Progress & Results:

- The first working version of a web-based heat vulnerability tool is under development. This tool predicts the number of emergency room visits (ERVs) using National Weather Service daily temperature forecasts and empirical relationships identified between ERVs and temperature. The tool will allow the user to estimate levels of heat morbidity for different demographic groups across various regions of NC.
- Work continues on the investigation of temporal and spatial patterns in heat morbidity across the state. Efforts continue on the identification of temperature thresholds across which heat morbidity rates increase markedly. Thresholds are being calculated for different demographic groups (e.g. teenagers vs. elderly) across various rural and urban regions of the state.
- Research to date has shown that the highest rates of heat vulnerability are found in rural areas where labor-intensive crops are grown. The biggest differences in vulnerability are identified between low and high-income groups across NC, especially at the highest temperatures.

Climate Change Impacts of Air Pollution on Morbidity in Vulnerable Populations across the Life Stages in 2050

Team Members: Yeatts, Lippmann

Partners: Environmental Protection Agency, NC Division of Public Health Climate Ready Program (Thie), UNC Gillings School of Global Public Health (Waller, Hanna, McCann)

Stakeholders: Charlotte Area Air Awareness, Clean Air Carolina, NC Division of Public Health Climate Ready Program, NC Hospital Association, Piedmont Together, Triangle Air Awareness

Overview: Researchers have conducted a health impact assessment of future climate change-related ozone morbidity for Mecklenburg County, North Carolina in 2050. Efforts focused on identifying impacts among vulnerable populations, such as the elderly, children, and those with chronic cardiopulmonary diseases. By advancing understanding of ozone-related morbidity impacts at a local scale, stakeholder engagement efforts will work to inform and guide future local public health planning and adaptation efforts.

Progress & Results:

- Results for analysis in Mecklenburg County revealed that 39,515 eligible ED visits (19,812 cardiovascular, 19,703 respiratory) occurred during the 2006-2011 baseline study period, with a mean daily count of 31.5 (SD 7.6). Daily maximum 8-hour average ozone concentrations ranged from 3 to 127 ppb, with a median of 51 ppb. May-August 2050 ozone projections indicate decreasing ozone levels, with a median of 36 ppb and range of 18-62 ppb influencing the number of projected future ED visits.
- Additional funding received has allowed researchers to expand analyses from Mecklenburg County to all of North Carolina. Stakeholders have expressed an interest in using the study results to help educate the public and the specific groups of people they work with. For example, Piedmont Together would like to use results to demonstrate what the air quality will be like in the Piedmont of North Carolina in 2050.

Adaptation

Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) Process

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

Partners: Social and Environmental Research Institute

Stakeholders: Beaufort County, SC; South Thomaston, ME; Wellfleet, MA

Overview: VCAPS is an analytical-deliberative dialogue process designed to help communities work with scientists to think through the potential impacts of climate change on their communities and to identify vulnerabilities and management options. The VCAPS process is an important part of CISA's approach to working with decision makers to understand problems and what sorts of resources are needed. It serves as a basis for building shared understanding the implications of climate variability and change and opportunities for adaptation. It is an instance in which understanding is truly coproduced as multiple kinds of expertise about a community is synthesized along with information about climate variability and projected change.

Progress & Results:

- VCAPS workshops have been held in Beaufort County, SC; South Thomaston, ME; and Wellfleet, MA over the last year. Additional information about participants at these exercises can be found in the Coastal Climate section of this report.
- Researchers have also learned that many Sea Grant extension agents and others involved with adaptation planning processes are interested in this engagement approach. This has led to the development of a workshop to train facilitators and diagram scribe in using the VCAPS process. Trainings were held in December 2013 (15 people) and in April 2014 at the Carolinas Climate Resilience Conference (12 people).

US National Climate Assessment Activities

Team Members: Dow, Brennan, Haywood, Lackstrom

Overview: One of CISA's major contributions to the Third US National Climate Assessment, released in May 2014, was an analysis of stakeholder information needs, concerns, and networks in the Carolinas. We reviewed documents and conducted over a 115 interviews and surveys with stakeholders from the forestry, water resources, tourism, wildlife management, and municipal sectors. This effort resulted in a technical report to the NCA and three peer-reviewed journal articles listed below. The document review component of the project was a joint project with two other RISAs (Western Water Assessment, Great Lakes Integrated Sciences and Assessments). A manuscript developed based on this work discusses the degree of regionalization found in the decision contexts has been revised and resubmitted to *Weather, Climate, and Society*. PI Dow has also been involved with national activities including serving as a lead author and editor to the regional input report and book, *Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability*, lead author on the Research Needs Chapter of the Third National Climate Assessment as well as lead author on the report, *Preparing the Nation for Change: Building a Sustained National Climate Assessment Process*. CISA team members also participate in the national network of organizations working to promote the publication and findings in the Third National Climate Assessment.

Appendix

CISA Deliverables, 2013-2014

Journal Articles

- Carbone, G. 2014. Managing climate change scenarios for societal impact studies. *Physical Geography* 35 (1):22-49.
- Haywood, B., A. Brennan, K. Dow, N. Kettle, and K. Lackstrom. 2014. Negotiating a Mainstreaming Spectrum: Climate Change Response and Communication in the Carolinas. *Journal of Environmental Policy & Planning* 16 (1):75-94.
- Lackstrom, K., N. Kettle, B. Haywood, and K. Dow. 2014. Climate-Sensitive Decisions and Time Frames: A Cross-Sectoral Analysis of Information Pathways in the Carolinas. *Weather, Climate, and Society* 6 (2):238-252.
- Lippmann, S., C. Fuhrmann, A. Waller, and D. Richardson. 2013. Ambient temperature and emergency department visits for heat-related illness in North Carolina 2007-2008. *Environmental Research* 124:35-42.
- Miao, G., A. Noormets, J. Domec, C. Trettin, S. McNulty, G. Sun, and J. King. 2013. The effect of water table fluctuation on soil respiration in a lower coastal plain forested wetland in the southeastern USA. *Journal of Geophysical Research - Biogeosciences* 118 (4):1748-1762.

Books, Book Chapters

- Corell, R.W., D. Liverman, K. Dow, K.L. Ebi, K. Kunkel, L.O. Mearns, and J.M. Melillo. 2014. Research Needs for Climate and Global Change Assessments. In *Climate Change Impacts in the United States: The Third National Climate Assessment*, edited by J. M. Melillo, T. C. Richmond and G. W. Yohe, 707-718. Washington, DC: U.S. Global Change Research Program.
- Ingram, K., K. Dow, L. Carter, and J. Andersen, eds. 2013. *Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability*. Washington DC: Island Press.

Reports

- Abramyan, I., and H. Mizzell. 2013. *2012 Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina's Natural Resources. Workshop Report*. Columbia, SC. 45 pp.
- Brennan, A. 2014. *Carolinas Climate Resilience Conference. Final Report*. Columbia, SC. 16 pp.
- Brennan, A., B. Epstein, B. Haywood, and K. Lackstrom. 2013. *Southeast and Caribbean Climate Community of Practice Member Survey. Final Report*. Columbia, SC: Carolinas Integrated Sciences and Assessments. 43 pp.
- Cumby, R. 2014. *Instructions for iframing the Experimental High Resolution Drought Trigger Tool (HiRDTT) Map and Time Series Webpages*. Raleigh, NC: State Climate Office of North Carolina. 7 pp.
- Buizer, J.L., P. Fleming, S.L. Hays, K. Dow, C.B. Field, D. Gustafson, A. Luers, and R.H. Moss. 2013. *Report on Preparing the Nation for Change: Building a Sustained National Climate Assessment Process*: National Climate Assessment and Development Advisory Committee. 73 pp.
- King, J., A. Noormets, and J. Domec. 2014. Carbon cycling and storage in forested wetlands of the Alligator River National Wildlife Refuge, North Carolina (Region 4). In *Biological Carbon Sequestration Accomplishment Report 2009-2013*, edited by K. Johnson, 22-24: US Fish and Wildlife Service.
- Lackstrom, K., A. Brennan, M. Ferguson, L. Crimmins, L. Darby, K. Dow, Ingram K., A. Meadow, H. Reges, M. Shafer, and K. Smith. 2013. *The Missing Piece: Drought Impacts Monitoring. Workshop Report*. Tucson, AZ. 23 pp.

2-Pagers

- CISA. 2014. *CISA Fact Sheet*. Columbia, SC: Carolinas Integrated Sciences & Assessments. 2 pp.
- CISA. 2014. *CISA Focus Area: Coastal Climate Fact Sheet*. Columbia, SC: CISA. 2 pp.
- SERI, CISA, and SC Sea Grant Consortium. 2013. *Vulnerability, Consequences, and Adaptation Planning Scenarios*. 2 pp.

Theses and Dissertations

- Haywood, B.K. 2014. Birds and Beaches: The Affective Geographies and Sense of Place of Participants in the COASST Citizen Science Program. Ph.D., Department of Geography, University of South Carolina, Columbia, SC.
- Altman, E.N. 2013. Drought Indices in Decision-Making Process of Drought Management. MEERM, School of the Earth, Ocean and Environment, University of South Carolina, Columbia, SC.
- Deeb, R. 2013. Climate Change Effects on Vibrio Bacteria in the Winyah Bay Estuary and the Projected Spread of Vibrio under Future Climatic Scenarios. MEERM, School of the Earth, Ocean and Environment, University of South Carolina, Columbia, SC.
- Guofang, M. 2013. A Multi-scale Study on Respiratory Processes in a Lower Coastal Plain Forested Wetland in the Southeastern United States. Ph.D., Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC.
- Radecki, A. 2013. Why Eco-Hydrologically Based Management Plans that Promote Ecosystem Resilience as well as Beneficial Ecosystem Services Through Better Soil Water Management are going to be an Important Tool to Address both the Ecological and Economic Concerns of Terrestrial Ecosystem Management in the Coming Decades. Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC.

Web-based tools

- Carolinas Integrated Sciences and Assessments. 2013. *Southeast and Caribbean Climate Community of Practice Resource Directory*. Available from <http://www.cisa.sc.edu/links-coastalclimate.html>.
- SERI (Social and Environmental Research Institute) and CISA. 2014. *Vulnerability, Consequences, and Adaptation Planning Scenarios*. Available from <http://www.vcapsforplanning.org/>.
- State Climate Office of NC. 2014. *Experimental High Resolution Drought Trigger Tool*. Available from <http://www.nc-climate.ncsu.edu/drought>.

Newsletters

- Brennan, A. 2014. *Carolinas Climate Connection 1st Quarter Newsletter: Carolinas Climate Resilience Conference Highlights*. Columbia, SC. 7 pp.
- Brennan, A. 2013. *Carolinas Climate Connection 4th Quarter Newsletter: Focus on Public Health*. Columbia, SC. 8 pp.
- Brennan, A. 2013. *Carolinas Climate Connection 3rd Quarter Newsletter: Focus on Climate Modeling*. Columbia, SC. 9 pp.
- Brennan, A. 2013. *Carolinas Climate Connection 2nd Quarter Newsletter: Focus on Coastal Climate*. Columbia, SC. 6 pp.
- Brennan, A. 2013. *Carolinas Climate Connection 1st Quarter Newsletter: Focus on Adaptation*. Columbia, SC. 8 pp.

Conferences, Meetings, Trainings, and Workshops

- Brennan, A. 2014. Citizen Science Condition Monitoring Training for Winyah Bay Master Naturalists. April 11, 2014. Moncks Corner, SC.
- Brennan, A. 2013. Citizen Science Condition Monitoring Training for Coastal Master Naturalists. November 13, 2013. Charleston, SC.
- Brennan, A. 2013. Citizen Science Condition Monitoring Training for Low Country Master Naturalists. August 28, 2013. Okatie, SC.
- Brennan, A. 2014. Citizen Science Condition Monitoring Training Webinar for Current NC CoCoRaHS Observers. February 21, 2014. Columbia, SC.
- Brennan, A. 2013. Citizen Science Condition Monitoring Training Webinar for Current SC CoCoRaHS Observers. November 7, 2013. Columbia, SC.
- CISA. 2014. Carolinas Climate Resilience Conference. April 28-29, 2014. Charlotte, NC.

- Fly, E., G. Olmi, B. Ward, S. Fauver, B. Haywood, and A. Brennan. 2014. Southeast and Caribbean Climate Community of Practice Roundtable. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Whitehead, J. C. 2013. VCAPS Facilitation Workshop December 10-11, 2013. Beaufort, NC.
- Whitehead, J. C. 2014. VCAPS Workshops to Support Climate-Resilient Planning in Beaufort County, SC. August 2013. Beaufort, SC.
- Whitehead, J. C. 2013. VCAPS Workshops to Support Climate-Resilient Planning in Beaufort County, SC: Follow-up Meeting. February 2014. Beaufort, SC.

Presentations

- Boyles, R. 2014. What Drives Climate in the Carolinas? Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Brennan, A., and H. Aldridge. 2014. Citizen Science Condition Monitoring. Web-based Presentation to NC CoCoRaHS Observers, February 21, 2014.
- Brennan, A., B. Haywood, K. Dow, and K. Lackstrom. 2014. Improving Understanding of Drought Impacts in Coastal Ecosystems. NC Water Resources Research Institute Annual Meeting, March 20, 2014, Raleigh, NC.
- Brennan, A., B. Haywood, K. Lackstrom, and K. Dow. 2014. Improving Understanding of Drought Impacts in Coastal Ecosystems through Citizen Science. American Meteorological Society Annual Meeting, February 2-6, 2014, Atlanta, GA.
- Brennan, A., and K. Lackstrom. 2014. NIDIS Carolinas Drought Impacts Projects & Citizen Science Network. National Drought Information System Engaging Preparedness Communities Webinar Series, January 8, 2014.
- Brennan, A. 2013. Understanding Drought in Coastal Ecosystems. Cape Fear Arch Conservation Collaboration Quarterly Meeting, November 12, 2013, Little River, SC.
- Brennan, A., G. Carbone, and K. Lackstrom. 2013. What Do We Know about Future Climate in Coastal South Carolina? North Inlet-Winyah Bay National Estuarine Research Reserve Climate Change Vulnerability Assessment Tool for Coastal Habitats Workshop, November 13, 2013, Georgetown, SC.
- Brennan, A., and H. Mizzell. 2013. CoCoRaHS Condition Monitoring. Web-Based Presentation to SC CoCoRaHS Observers, November 7, 2013.
- Carbone, G. 2014. El Nino Forecast. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Carbone, G. 2014. Climate Change Scenarios. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Carbone, G., and A. Patel. 2014. Climate Change Projections for Coastal South Carolina, Web-based Presentation to the CCVATCH Pilot Project Team, May 8, 2014.
- Conrads, P., E. Roehl, D. Tufford, K. Dow, G. Carbone, R. Daamen, and J. Whitehead. 2014. Availability of Freshwater Along the Carolina Coast Using Climate Change Scenarios. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Cumbie, R. 2014. Identifying Drought Conditions in Your Backyard. Carolinas Climate Resilience Conference, April 28-28, 2014, Charlotte, NC.
- Cumbie, R. 2013. Drought Tool Demonstration. Annual Meeting of AASC, July 16, 2013, St. Louis, MO.
- Darby, L., A. Brennan, K. Dow, K. Lackstrom, and P. Conrads. 2014. What is the National Integrated Drought Information System Doing in the Carolinas? Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Domec, J., A. Noormets, S. McNulty, J. King, G. Sun, S. Palmroth, J. Swenson, and R. Oren. 2013. Convergence of the Effect of Root Hydraulic Functioning and Root Hydraulic Redistribution on Ecosystem Carbon Balance and Drought-Induced Vegetation Mortality across Divergent Forest Ecosystems. DOE TES/SBR Joint Investigators Meeting, May 14-15, 2013, Potomac, MD.
- Dow, K. 2013. A Risk-Based Approach to Assessing Limits to Adaptation. Southeastern Division of the Association of American Geographers Annual Meeting, November 24-26, 2013, Roanoke, VA.
- Dow, K., A. Brennan, K. Lackstrom, and D. Ferguson. 2014. Linking Drought Impacts Information to Decision Making: Identifying Gaps and a Framework for Moving Forward. American Meteorological Society Annual Meeting, February 2-6, 2014, Atlanta, GA.
- Dow, K., B. Haywood, and N. Kettle. 2014. The Role of Ad Hoc Networks in Supporting Climate Adaptation.

- Association of American Geographers Annual Meeting, April 8-12, 2014, Tampa, FL.
- Dow, K., and K. Lackstrom. 2014. Understanding Drought in the Coastal Carolinas. NIDIS Coastal Drought Monitoring Knowledge Assessment Workshop, January 7, 2014, Charleston, SC.
- Fly, E. 2014. Not So Lost in Translation: Sea Grant Climate Extension. City of Folly Beach Monthly Planning Commission Meeting, April 7, 2014, Folly Beach, SC.
- Fly, E., and M.R. DeVoe. 2014. Our Communities Adapting to a Changing Climate and Coastline. 2014 South Eastern Wildlife and Environment Education Association Annual Meeting, March 29, 2014, Hasty Point Plantation, SC.
- Fuhrmann, C., M. Kovach, and C. Konrad. 2014. The Effects of Extreme Heat on Human Health in North Carolina. Association of American Geographers Annual Meeting, April 8-12, 2014, Tampa, FL.
- Fuhrmann, C., M. Kovach, C. Konrad, S. Lippmann, A. Waller, and L. Thie. 2014. The Health Effects of Heat Waves in North Carolina. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Fuhrmann, C., M. Kovach, and C. Konrad. 2013. Evaluation of National Weather Service Heat Advisory, Watch, and Warning Criteria for Triggering a Heat Emergency Response Plan in North Carolina. Annual Meeting of the National Weather Association, October 15, 2013, Charleston, SC.
- Gao, P., G. Carbone, and E. Kabela. 2014. Comparison of Rainfall Intensity in Downscaled Climate Model Output for the Carolinas. Association of American Geographers Annual Meeting, April 8-12, 2014, Tampa, FL.
- Griffin, M., and B. Montz. 2013. Fresh Water Availability in Coastal North Carolina: An Assessment and Management Plan. Southeastern Division of the Association of American Geographers Annual Meeting, November 24-26, 2013, Roanoke, VA.
- King, J., A. Noormets, and J. Domec. 2013. Assessing Hydrologic and Salinity Thresholds Driving Ecosystem Transition at Alligator River National Wildlife Refuge. Managing Forested Wetlands with Fire in a Changing Climate, USDA Forest Service Joint Fire Sciences Program Symposium, November 19-21, 2013, Manteo, NC.
- Konrad, C. 2014. The Climate of the Carolinas: Past, Present, and Future. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Konrad, C. 2014. Climate Perspectives: A Web-based Tool for Assessing the State of Climate across the Southeast U.S. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Kovach, M., C. Konrad, and C. Fuhrmann. 2014. Temperature Thresholds for Heat-related Illness in North Carolina. Association of American Geographers Annual Meeting, April 8-12, 2014, Tampa, FL.
- Kovach, M., C. Konrad, and C. Fuhrmann. 2014. Identifying Heat Vulnerability in North Carolina. Carolinas Climate Resilience Conference, April 28-29, 2014.
- Lackstrom, K., A. Brennan, J. Davis, K. Dow, and A. Patel. 2013. Local Actors' Perspectives about the Impacts of Drought on Coastal Resources and Communities. Southeastern Division of the Association of American Geographers Annual Meeting, November 24-26, 2013, Roanoke, VA.
- Lippmann, S. 2014. Public Health Impact of Projected 2050 Ozone Concentrations in Mecklenburg County, North Carolina. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Mizzell, H. 2014. 2013 Rains That Washed the Drought Away. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Mizzell, H. 2014. Carolina's Climate Report Card: Understanding Climate Trends and Variability. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Montz, B., T. Allen, and Z. Oyer. 2013. Climate Change Impacts on Water Infrastructure: Vulnerability to Sea-Level Rise & Coastal Storm Surges. Southeastern Division of the Association of American Geographers Annual Meeting, November 24-26, 2013, Roanoke, VA.
- Noormets, A., G. Sun, S. McNulty, J. Domec, M. Gavazzi, and J. King. 2013. The Effect of Management on Forest Carbon Fluxes. American Geophysical Union Annual Meeting, December 9-13, 2013, San Francisco, CA.
- Osborne, R., P. Kenel, and K. Lackstrom. 2014. Benchmarking Resilience Planning. SC Environmental Conference, March 9-11, 2014, North Myrtle Beach, SC.
- Osborne, R., P. Kenel, and K. Lackstrom. 2014. Benchmarking Resilience Planning in the Carolinas. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Tufford, D. 2014. Connecting Ecological Linkages to the USGS Real-Time Salinity Drought Index. NIDIS Coastal Drought Monitoring Knowledge Assessment Workshop: USGS Real-Time Salinity Drought Index, January 7, 2014, Charleston, SC.
- Tufford, D., S. Samadi, and G. Carbone. 2013. Incorporating Shallow Aquifer Uncertainty to Stream Flow Prediction in a Forested Wetland Coastal Plain Watershed. Annual Meeting of the Geological Society of

America, October 27-30, 2013, Denver, CO.

- Whitehead, J. 2013. Helping Coastal Communities Strategize Adaptations to Climate Change: How to Implement a Structured Dialogue Using an Interactive Diagramming Program. VCAPS Facilitation Workshop, December 10-11, 2013, Beaufort, NC.
- Whitehead, J., S. Bath, and L. Wood. 2013. Climate Change Vulnerability and Resilience in McClellanville, SC. McClellanville Risk and Resilience Town Hall Meeting, June 2, 2013, McClellanville, SC.
- Whitehead, J. C. 2014. What Gives You Hope? Carolinas Climate Resilience Conference, April 28, 2014, Charlotte, NC.
- Whitehead, J.C., S. Tuler, T. Webler, and K. Dow. 2014. Facilitating Discussions about Decisions with the VCAPS Process. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Zietlow, D., A. Noormets, G. Sun, M. Gavazzi, and J. King. 2014. Energy and Water Balance of Contrasting Wetland Uses in the North Carolina Coastal Plain. DOI Southeast Climate Science Center Grand Opening, January 22, 2014, Raleigh, NC.

Posters

- Abramyan, I., and L. Vaughn. 2014. Analysis of Extreme Negative Arctic Oscillation (AO) Values and the Relationship to Southeast Cold Air Outbreaks. American Meteorological Society Annual Meeting, February 2-6, 2014, Atlanta, GA.
- Abramyan, I., and L. Vaughn. 2013. Analysis of Extreme Negative Arctic Oscillation (AO) Values and the Relationship to Southeast Cold Air Outbreak. National Weather Association Annual Meeting, October 12-17, 2013, Charleston, SC.
- Becker, D.A., J.J. West, and K. Yeatts. 2013. Assessing the Future Human Health Impacts of Air Pollution and Heat Events Attributable to Anthropogenic Emissions and Global Climate Change. Community Modeling & Analysis System Conference, October 28-30, 2013, Chapel Hill, NC.
- Darby, L., A. Brennan, P. Conrads, D. Tufford, K. Dow, K. Lackstrom, R.S. Pulwarty, R.S. Webb, J.P. Verdin, C.A. McNutt, and V. Dehez. 2013. Developing a NIDIS Drought Early Warning Information System for Coastal Ecosystems in the Carolinas. American Geophysical Union Fall Meeting, December 9-13, 2013, San Francisco, CA.
- Kabela, E., and G. Carbone. 2013. NARCCAP Model Validation for the Southeast United States. American Geophysical Union Fall Meeting, December 9-13, 2013, San Francisco, CA.
- Lippmann, S., K. Yeatts, A. Hanna, L. Thie, and A. Waller. 2013. Climate Change Impacts of Ozone on Morbidity in Vulnerable Populations across the Life Stages in 2050, Mecklenburg County, North Carolina, USA. International Society for Environmental Epidemiology Annual Conference, August 19-23, 2013, Basel, Switzerland.
- Oyer, Z., and T. Allen. 2014. Space-Place Analysis of Water Infrastructure Vulnerability to Coastal Flood Hazards. Carolinas Climate Resilience Conference, April 28-29, 2014, Charlotte, NC.
- Oyer, Z., T. Allen, and B. Montz. 2014. Water Utility Infrastructure Vulnerability to Coastal Flooding. NC Hurricane Workshop, May 28, 2014, Greenville, NC.
- Yeatts, K. 2014. Preliminary Estimates of Future Asthma ED Visits in 2050, with Three Different Population Scenarios. UNC Climate Change Symposium, April 11, 2014, Chapel Hill, NC.
- Yeatts, K. 2013. Baseline Incidence rates for NC Detect Asthma ED data, by gender and age groups. International Society of Environmental Epidemiology Annual Conference, August 19-23, 2013, Basel, Switzerland.