

Carolinas Integrated Sciences & Assessments Annual Report

Project Progress Report: 1 May, 2012 - 30 April, 2013



CISA is 1 of 11 NOAA-funded Regional Integrated Sciences & Assessments (RISA) teams, working to integrate climate science into decision-making processes. CISA conducts applied climate research in collaboration with a wide range of water and coastal stakeholders across the Carolinas. CISA's work 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.

This progress report details activities during the second year of funding received for 2011-2016 (NOAA Award NA11OAR4310148). Year 2 activities related to CISA's core focus areas have involved disseminating information about our research and projects to stakeholders, fostering existing and building new stakeholder relationships, and working with decision makers to plan and implement new projects.

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Team Members

Principal Investigators

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Greg Carbone (University of South Carolina)
Chip Konrad (The University of North Carolina at Chapel Hill, Southeast Regional Climate Center)
Dan Tufford (University of South Carolina)
Jessica Whitehead (North Carolina Sea Grant, South Carolina Sea Grant Consortium)

Collaborating Investigators

Tom Allen (East Carolina University)
Ryan Boyles (State Climate Office of North Carolina)
John King (North Carolina State University)
Hope Mizzell (South Carolina State Climatology Office)
Burrell Montz (East Carolina University)
Jan Moore (NOAA Center for Coastal Environmental Health and Biomolecular Research)
Geoff Scott (NOAA Center for Coastal Environmental Health and Biomolecular Research)
Seth Tuler (Social and Environmental Research Institute)
Thomas Webler (Social and Environmental Research Institute)
Karin Yeatts (The University of North Carolina at Chapel Hill)



Research and Support Staff

Research Associates: Kirsten Lackstrom, Jinyoung Rhee, Vidya Samadi
Climate Outreach Specialist: Amanda Brennan (August 2012-Present), Ashley Brosius (May -June 2012)
Research Assistants: Ivetta Abramyan, Reem Deeb, Dylan Foster, Peng Gao, Benjamin Haywood, Erik Kabela, Nathan Kettle, Aashka Patel, Alison Pierce, Kim Rodgers

New Projects and Partnerships

This section highlights new projects and partnerships advanced during Year 2. These include new partnerships through the CISA minigrant program in the areas of coastal climate, public health, and adaptation; expanded interactions with the National Integrated Drought Information System (NIDIS) and regional stakeholders to support a Carolinas Drought Early Warning Pilot Program; and efforts related to public health, the newest research focus area for CISA.

Minigrant Program

After planning in Year 1, CISA began implementation of the Minigrant Program in Year 2. The purpose of the program is to augment CISA's existing research efforts, take advantage of and respond to emerging opportunities, and increase flexibility to address decision maker needs and questions in the region. Projects will receive funding for one year, beginning in January 2013. Review criteria emphasized technical and scientific merit, relevance and applicability to the CISA mission, and stakeholder engagement. Of the 18 high-quality proposals submitted, three were selected through internal and external review processes. Project information for each of the funded proposals is posted on the CISA website.

Climate Change Impacts of Air Pollution on Morbidity in Vulnerable Populations across the Life Stages in 2050 (Principal Investigator: Karin Yeatts, UNC-Chapel Hill)

Researchers will conduct a health impact assessment of future climate change-related ozone morbidity for Mecklenburg County, North Carolina in 2050. Efforts will focus 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.

Climate Change Impacts on Water Infrastructure: Vulnerability to Sea Level Rise and Coastal Storm Surge (Principal Investigators: Tom Allen and Burrell Montz, East Carolina University)

This project will assess the potential vulnerability of municipal water infrastructure to storm-related impacts. Researchers will use LiDAR data, sea level rise scenarios, and SLOSH hurricane surge ensembles for three coastal communities in North Carolina. Infrastructure vulnerability will include assessment of fresh water intakes, municipal wells, pump and transfer stations, wastewater treatment plants and outfalls, and associated supply system infrastructure (electric utilities, transportation, and communication). Stakeholder meetings will be conducted to identify possible mitigation and adaptation options.

Influence of Historical Drainage on Coastal Ecosystem Resilience to Rising Sea Levels: Implications for Natural Resource Management and Terrestrial Carbon Storage of the Alligator River National Wildlife Refuge (Principal Investigator: John King, NC State University)

Researchers will develop an early detection system for impending vegetation change in the Refuge by characterizing hydrology, carbon stocks and vegetation of the major ecosystems. The system will be designed in collaboration with Refuge managers to plan current and future management activities for wildlife habitat, carbon sequestration, recreation and education.



NIDIS Carolinas Scoping Workshop Participants (L. Darby)

Collaboration with the National Integrated Drought Information System (NIDIS): *Activities to Develop a Drought Early Warning Pilot in the Carolinas*

CISA is collaborating with NIDIS to advance drought preparedness and develop an Early Warning System pilot. The project is focused on coastal ecosystems. Activities included establishing a steering committee to guide the initial planning of the project and organizing a NIDIS-Carolinas Pilot Project Scoping Workshop in Wilmington, NC (July 31-August 1, 2013). Through our involvement with the NIDIS Carolinas Drought Early Warning Pilot Program, we have engaged with a wide range of stakeholders and decision makers invested in improved understanding of drought impacts to coastal ecosystems. The steering committee consisted of regional representatives from several NOAA programs as well as partners from the EPA, USGS, USFWS, DOI Southeast Climate Science Center, and The Nature Conservancy. Over 50 people from 40 organizations, ranging from state agencies to indigenous peoples, participated in the NIDIS Carolinas Scoping Workshop.

Since that time CISA staff has been involved in follow-up activities to further develop and refine pilot project activities. In March 2013, CISA researchers conducted interviews with local fishermen and recreational businesses in Beaufort County, SC, to learn more about observed and perceived drought impacts on coastal resources and ecosystems. In April 2013, CISA staff participated in the Gullah/Geechee Sustainability Think Tank meeting (also in Beaufort County) to share information about CISA's work related to drought impacts, the NIDIS pilot, and opportunities for citizen science engagement with the community. Specifically, CISA will be working with the Gullah/Geechee Nation to establish a community of CoCoRaHS observers. Project objectives include not only collecting precipitation data and drought impacts information from observers, but also sharing this information with the Gullah/Geechee in order that they are able to integrate this knowledge in their own planning and management activities. (See p. 7 for Drought project descriptions and additional information.)

Health and Climate

Weather and climate events, such as heat waves, heavy precipitation events, and droughts, have a broad and significant impacts on human and ecosystem health. These impacts can be felt directly through increased morbidity and mortality associated with extreme events, as well as indirectly through the alteration and redistribution of disease processes and environmental stressors. Several projects are now underway to investigate links between climate and human health including heat stress, water-borne diseases, and respiratory response to poor air quality. (See p. 15 for Health project descriptions.)

Climate-Health Toolbox. CISA team members at the Southeast Regional Climate Center are currently working to develop a web-based climate-health toolbox that will provide researchers and health officials with a platform to study, visualize, and predict the health impacts of weather and climate events. The toolbox will provide access to a suite of environmental, socioeconomic, and atmospheric data and link them with existing datasets on human and ecosystem health indicators. Using online GIS software, users will be able to construct spatially-explicit empirical relationships between various risk factors and their associated health outcomes, allowing for interactive exploration of multi-scale processes and vulnerabilities. The toolbox will also allow health officials and decision-makers to apply these empirical relationships to real-time and forecasted weather and climate conditions for the tracking and prediction of emerging health threats. Tools in development are utilizing 1) emergency department visit records to examine heat-related illness in North Carolina and 2) records of harmful algal bloom and fish kill events along the Southeast coast. Stakeholder engagements to obtain feedback from, and foster partnerships with, potential users of the toolbox were conducted in Chapel Hill, NC (February 25, 2013) and Charleston, SC (March 22, 2013).

Research Highlights

The role of ad hoc networks in supporting climate change adaptation: a case study from the Southeastern United States

CISA interviewed over 100 key opinion leaders to better understand existing and planned adaptation activities. Researchers found that there are no formal, or discrete, state or regional cross-sector climate change networks in the Carolinas. Climate adaptations and capacity-building efforts have been supported by ad hoc and decentralized networks that have emerged from collegial partnerships within and across sectors, and collaborative efforts to pool expertise and resources. These networks support intra-sector information sharing; monitoring, data collection, and research; and education and outreach. The informal regional climate networks have facilitated the development of bonding, bridging, and linking social capital supporting adaptive capacity related to climate. These findings have implications for ongoing and future efforts to build adaptive capacity by revealing the important role both informal and sector-specific networks play in adaptation activities (Dow et al., 2013).

NARCCAP Model Assessment and Future Projections for the Southeast United States

In this project downscaling efforts centered on regional climate model (RCM) output from the North American Regional Climate Change Assessment Program (NARCCAP). We evaluated NARCCAP data in the Southeast, including summer and winter maximum and minimum temperature, and precipitation for nine pairs of general circulation models and regional climate models during a control period, 1970-1999. The historical analysis set the stage for interpreting future projections (2040-2069) of minimum and maximum temperature and mean precipitation change, and helped to quantify associated uncertainties in these scenarios.

- Most models demonstrated high skill for temperature during the historical period, but precipitation skill was mixed due to the overestimation of the frequency of extreme precipitation events by several models.
- Downscaling generally improves projections of minimum temperature and mean precipitation at local scales for RCMs run with the Community Climate Model (CCSM) and Canadian Global Climate Model version 3 (CGCM3), while adding value for CCSM-based runs with respect to maximum temperature.
- Projected minimum temperatures show an ensemble mean increase between 1° and 2°C in the winter and early spring, and an increase between 2° and 3°C for all other months.
- Maximum temperatures show an ensemble mean increase between 1° and 2°C in winter and early spring with increases between 2° and 4°C from mid spring through fall.
- Precipitation increases up to 10% in the eastern part of the region from late summer through early spring. Ensemble mean decreases of up to 10% occurred in January, April, June, and July.
- In western portions of the region, precipitation increases up to 10% in January through March, May, August, September, and November with an up to 12% decrease in precipitation in March, May through July, and October.

Integrating Statistically Downscaled Global Climate Models and Hydrological Models

In this project CISA is using statistical downscaling to assess the regional impacts of climate variability and change on water resources, including streamflow and water quality. Efforts have centered on processing and using statistically downscaled data from the Department of Interior/United States Geological Survey (DOI/USGS) as input for two of CISA's modeling projects: 1) the Winyah Bay watershed project and 2) a collaborative project being conducted for Congaree National Park. We have processed downscaled data from four GCMs, including CCSM3, ECHO-2, GFDL2.0, and PCM. The four statistically downscaled GCMs project modest (<1°C) to considerable (>3°C) warming, and from very little (<±5-10%) precipitation change to significantly wetter (>+30%) conditions. General conclusions that can be drawn from streamflow simulations under these climate change scenarios are:

- Temperature increases above 2°C cause evapotranspiration rates to rise enough to reduce simulated flow in some watersheds even when accompanied by extremely wet conditions.
- In several cases, moderately warmer temperatures are offset by increases in precipitation resulting in no significant change in simulated future flows.

These results are relevant to some of the challenges in climate change analysis. While regional-scale precipitation scenarios are less reliable than regional-scale temperature scenarios, the substantial role of temperature alone on streamflow can provide useful information.

Supporting Improved Natural Resource Planning through Climate Workshops

The Climate Connection Workshop series, hosted by the SC State Climatology Office with support from CISA, consisted of three workshops in Charleston, Columbia and Greenville, three different geographic regions of the state. In preparation for the workshops, research was conducted to highlight SC climate trends and variability as well as the influence of ENSO cold and warm event cycles on SC's winter weather.

- Findings show that SC La Niña winters are warmer and drier than El Niño winters.
- The Arctic Oscillation (AO) has a stronger winter temperature signal predominately yielding colder temperatures in the negative phase and warmer temperatures in the positive phase.
- However, unlike ENSO which affects precipitation as well, the AO precipitation signal is not significant.
- Other regional experts presented on climate issues specific to ecosystems, species, water resources, fire risk, and forestry.

Lower Cape Fear Watershed Study

Using the Lower Cape Fear watershed (NC) and its subwatersheds as a study area, this project assessed water availability and use over time, under different scenarios, at several temporal and spatial scales. Activities included evaluating the amounts, nature, and location of water deficits; identifying the causes of the deficits; identifying alternatives (other than increasing supply) for addressing those deficits; evaluating the impacts of alternatives using past data to determine water "saved"; and applying the results to different future scenarios.

- Initial analysis in the Lower Cape Fear basin has indicated potential water stress in the basin and many systems where demand will surpass supply by 2060. Watersheds showing potential stress in the future resulted from population growth and impervious cover projections, not only on varying climate predictions.
- A thorough review of the local water supply "plans" (published by the North Carolina Department of Environment and Natural Resources) aided researchers in identifying potential at-risk areas in the future. Research was presented to stakeholders and planners in New Hanover County, which was shown to be a major area of concern in the stress analysis.
- Supply data does not account from some water uses, such as water system maintenance, and are likely to underestimate the full effects of demand on future supplies.
- Increased stress in the basin is expected if measures to monitor the supply and demand are not taken in the future.

Selected Accomplishments

Climate Communications and Outreach

This position was established to enhance CISA's ability to support state and local adaptation projects by providing opportunities for information exchange, translating scientific data into a useable format for decision-makers and the public (e.g. fact sheets, newsletters), and integrating local information needs into tools and products. In Year 2, Amanda Brennan began regular publication of a quarterly newsletter entitled the "Carolinas Climate Connection." Each newsletter highlights a different CISA focus area and includes syntheses of recent publications, information on relevant resources and tools, highlights of CISA's work in that particular focus area, and links to upcoming events, funding opportunities, or other stakeholder-relevant news. She also participated in many meetings throughout the region showcasing CISA activities through posters and presentations.

Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS)

Supporting the development of adaptive capacity to address current climate variability and projected climate change is a cross-cutting element of CISA's efforts. As adaptation efforts need to fit within local decision contexts, one aspect of CISA work involves integrating local knowledge with more generalized scientific findings. To facilitate dialogue among researchers and community representatives, CISA researchers and partners from the Social and Environmental Research Institute (SERI) developed the Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process. The tool is intended to help decision makers explore the potential outcomes and consequences of climate change in their communities, along with pathways through which they and individuals may respond.

VCAPS has been used in several community climate adaptation and resilience projects in the Carolinas, including Sullivan's Island and McClellanville, SC and Plymouth, NC. In June 2012 the Town of Plymouth was awarded NOAA's Walter B. Jones Sr. Memorial Award for Coastal and Ocean Resource Management for its efforts to promote economic growth while preserving the region's environmental quality and diversity. As part of the town's efforts, VCAPS was used to help community leaders identify and explore mitigation options in addressing flooding and other environmental stresses. SERI has conducted additional VCAPS projects with communities in Massachusetts and Alabama. Building on these early successes, VCAPS projects continue to expand.

- *New Projects.* Jess Whitehead and the Social and Environmental Institute are partnering on two new projects. First, the team is working with the Beaufort County (SC) Planning Department to develop a plan for making the county's zoning more resilient to climate change. This project will use participatory tools to write a plan for priority actions to update zoning and form-based codes and encourage climate resilience in the community. In a second project, the team will use VCAPS to understand how fisheries and fisheries-dependent communities, including shore-side infrastructure, may be vulnerable to climate change. The project will explore the feasibility of adaptation and planning options in three working waterfront communities where fishing is a major occupation - South Thomaston, Maine; New Bedford, Massachusetts; and Beaufort, South Carolina.
- *VCAPS Training.* The research team has developed training materials and guidance documents for other facilitators and extension specialists to use the VCAPS process with other communities. This training will enable VCAPS to be part of a long-term sustainable process that facilitates discussions on the outcomes and consequences of climate hazards for coastal user groups, particularly local and regional governments and resource managers. With support from NC Sea Grant, an expanded VCAPS training module was beta tested in spring 2013 and a larger training workshop will be conducted in fall 2013. Dow and Webler provided a VCAPS introductory training session at the National Adaptation Forum in April 2013.

Fostering Regional Collaborations

Collectively, CISA seeks synergy, not duplication, across projects and activities. As a RISA, a key responsibility of team members is to identify user needs for climate information, conduct research that is shaped by, and done in collaboration with users, and establish an iterative process that refines our investigations, leads to effective communication of results and, where appropriate, long-term access to decision-support tools. Fostering supportive and effective relationships is an important component of CISA's research and engagement agenda.

- The CISA program office works with PIs and the CISA Advisory Committee to regularly evaluate current projects, determine opportunities for coordination and collaboration, and carefully plan for project next steps and future research direction to align with broader RISA goals and objectives. In February 2013 CISA PIs met for their annual meeting to evaluate current project progress and discuss new opportunities for their respective focus areas. Synergies between current projects were identified and methods for systematic evaluation throughout project periods were discussed.
- Alongside internal planning and evaluation, CISA seeks external guidance from our Advisory Committee members in developing regional collaborations, identifying and addressing key decision maker needs in the Carolinas, and implementing new projects. Committee members represent a diverse group of organizations throughout the Carolinas and engage with CISA through an annual meeting and involvement with individual CISA projects. Activities include serving on the NIDIS-Carolinas Pilot Project steering committee, participating in the Minigrant proposal review process, and attending CISA-sponsored stakeholder workshops and engagements.
- In addition, CISA team members regularly engage with other members of the NOAA community (for example, through NOAA in the Carolinas, NOAA's Southeast and Caribbean Regional Team, Coastal Services Center, Regional Climate Service Directors-Eastern and Southern Regions) to ensure that CISA projects and activities integrate with other efforts in a holistic way and reach audiences through the Carolinas.

Deliverables

The team participated in over 40 presentations, trainings, and other stakeholder engagement activities, listed with their respective projects in the following sections. Audiences ranged from education and outreach communities, to agencies, academics, and stakeholders. CISA team members also hosted or sponsored several workshops throughout the reporting year. Notable events included the NIDIS-Carolinas Pilot Project Scoping Workshop, the SC Department of Natural Resources Climate Connection Workshop Series, and Climate-Health Toolbox Stakeholder Engagements. More detailed information is provided with the project summaries in each focus area of the report.

Selected Publications

- Brennan, A. K. Dow, K. Lackstrom, L. Darby, and C. Ott. 2012. NIDIS Carolinas Drought Early Warning System: Supporting Coastal Ecosystem Management-Scoping Workshop Report. Columbia, SC: Carolinas Integrated Sciences and Assessments (CISA) and the National Integrated Drought Information System (NIDIS). 29 pp.
- Carolinas Integrated Sciences and Assessments and South Carolina Sea Grant Consortium. 2012. Assessing the Impact of Saltwater Intrusion in the Carolinas under Future Climatic and Sea Level Conditions. Columbia, SC. 25 pp.
- Dow, K. B. Haywood, N. Kettle, and K. Lackstrom. 2013. The role of ad hoc networks in supporting climate change adaptation: a case study from the Southeastern United States. *Regional Environmental Change* 13(1). DOI: 10.1007/S10113-013-0440-8
- Dow, K., F. Berkhout, B. Preston, R. Klein, G. Midgley, and R. Shaw. 2013. Limits to Adaptation. *Nature Climate Change* 3 (April):305-307 DOI:10.1038/nclimate1847
- Dow, K. and L. Carter, eds., with contributions from A. Brosius, E. Diaz, R. Durbrow, R. Evans, S. Fauver, T. Hayden, B. Howard, K. Jacobs, G. Landers, S. McNulty, J. Nicholson, D. Quattrochi, L. Rimer, S. Shuford, S. Stiles, and A. Terando. In press. "Climate Adaptation in the Southeast." In. KT Ingram, K. Dow, L. Carter and J. Andersen, eds. *Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability*. Island Press.
- Griffin, M., B. Montz, and J. Arrigo. 2013. Evaluating climate change induced water stress: A case study of the Lower Cape Fear basin, NC. *Applied Geography* 40(1): 115-128. DOI: 10.1016/j.apgeog.2013.02.009
- Ingram, K.T., K. Dow, L. Carter, and J. Andersen eds. *Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability*. Island Press, in press
- Kabela, E.D. 2012. NARCCAP Model Assessment and Future Projections for the Southeast United States. PhD dissertation, University of South Carolina, Columbia, SC.
- Kettle, N.P. 2012. Coastal Climate Change Adaptation: The Influence of Perceived Risk, Uncertainty, Trust and Scale. PhD dissertation, University of South Carolina, Columbia, SC.



North Carolina National Estuarine Research Reserve (NOAA NERRS)

Areas of Focus

Drought

CISA's drought work seeks to improve monitoring methods, to develop a more comprehensive understanding of regional impacts, and to assess drought planning and early warning needs.

Implementation of a Drought Mapping Tool in the Eastern United States (Carbone, Rhee, Dow)

Partners: Northeast Regional Climate Center (NERCC), Southeast Regional Climate Center (SERCC)

Abstract: The Carolinas Dynamic Drought Index Tool (DDIT) provides a prototype that allows the display of multiple drought indices for different time scales and across user-specified regions. Project goals include expanding the coverage of the tool from the Carolinas to the states served by the Northeast and Southeast Regional Climate Centers, integrating the tool with the stable, near-real time Applied Climate Information System (ACIS) database, and adjusting the interface and functionality of the tool to ongoing user response.

Progress & Results:

- Researchers are currently in the process of gridding the standard precipitation index (SPI). This has required exploration of unintended biases that may result from mixing periods of record. To that end, researchers have explored the sensitivity to using mixed-length data records vs. a common period of record for all stations. The continuity of SPI between durations has also been investigated (e.g. do abnormal jumps occur between 30 and 60 day SPI as an artifact of the computation procedure as opposed to real differences in drought).
- The Northeast Regional Climate Center has hired a research associate to work on this project. In the meantime, the original code writer, Jinyoung Rhee, has tailored programs to work with gridded raw variables that are currently available (e.g. temperature). This will allow efficient adjustments once gridded drought indices become available.
- The DDIT was demonstrated at the NERCC ACIS Version 2 Web Development Workshop, at Cornell University, Ithaca, NY, August 7-9, 2012.

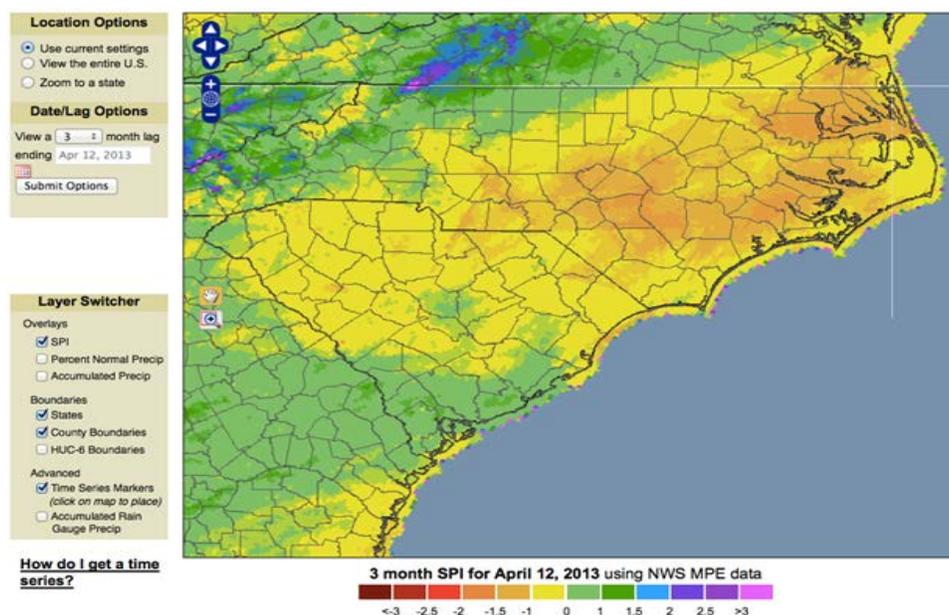
Drought Sensitivity Testing (Boyles)

Partners: Southeast Regional Climate Center (SERCC), Texas A&M University (TAMU), Purdue University

Abstract: The objective of this project is to test the sensitivity of the DDIT with a variety of new data sets, to include high resolution data sets not currently used, long-lead forecast information, and radar-based precipitation estimates. Activities include: providing access to surface and ground water data sets to enhance the spatial resolution and range of the DDIT's drought indicators, developing methods to operationalize the DDIT's use of long-lead forecast data, and using research on radar-based SPI estimates to evaluate the methods and if appropriate make radar-based SPI available for the DDIT.

Progress & Results:

- A working prototype of the tool is now available for testing. (<http://www.nc-climate.ncsu.edu/drought/>)
- Development of SPI using NWS multi-sensor precipitation estimates (MPE) has been implemented and tested based on methodology developed by partners at TAMU. Testing is still ongoing with partners, but researchers anticipate a publicly available product in summer 2013 with THREDDS direct services available by the end of 2013. Once the tool is fully operational, the SPI grids will be shared with the NERCC and protocol established for integrating these SPI estimates into the DDIT.
- A web tool to visualize daily updates of SPI will be available for the SC Climate Office, NC Climate Office, CISA, and SERCC. Other states and regions will also be able to embed the SPI monitoring tool into their own sites with appropriate default geographic boundaries as desired.
- Planning for development of a next generation web services Application Programming Interface (API) to provide climate and hydrology data (including groundwater and streamflow) is complete, but API development has not yet begun. Once complete, this will enable direct feed of data into future DDIT products.



A working prototype of the web tool designed by researchers at the North Carolina State Climate Office is now available for testing.
(<http://www.nc-climate.ncsu.edu/drought>)

Collaboration with the National Integrated Drought Information System: Activities to Develop a Drought Early Warning Pilot in the Carolinas

(Dow, Tufford, Lackstrom, Brennan, Haywood)

Partners: National Integrated Drought Information System (NIDIS), NC and SC State Climate Offices

Abstract: CISA engages with a range of stakeholders to determine their decision-support needs, prioritize and initiate projects, develop ways to transfer tools and information to stakeholders, and identify opportunities and regional activities through which NIDIS can support those needs.

Progress & Results

- *NIDIS-Carolinas Drought Early Warning Pilot Program.* A “kick-off” meeting with the NIDIS-Carolinas steering committee was held at Fort Johnson, SC, on May 1, 2012. Conference calls were held regularly to prepare for a stakeholder workshop. The NIDIS-Carolinas Pilot Project Scoping Workshop was held July 31-August 1, 2012, in Wilmington, NC, with over 50 participants representing more than 40 organizations. Four projects out of over 25 project ideas generated by workshop participants were selected to move forward for further development. Project plans are currently in various stages of development, with initial efforts oriented towards projects which will provide additional understanding of drought in coastal ecosystems.
- *Interviews with drought-sensitive stakeholders in Beaufort, SC.* In March 2013, Lackstrom and Haywood interviewed local fishermen and recreational businesses in Beaufort County to learn more about observed and perceived drought impacts on coastal resources and ecosystems. Interview information will be used to write a white paper as well as to inform other stakeholder engagement activities.
- *Engagement with the Gullah/Geechee Nation in Drought Impacts Reporting.* Brennan, Haywood and Lackstrom attended a meeting of the Gullah/Geechee Sustainability Think Tank on April 6, 2013, to share information about CoCoRaHS drought impacts reporting and opportunities for citizen science engagement with the community. Project objectives include not only collecting precipitation data and drought impacts information from observers, but also sharing this information the Gullah/Geechee in order that they are able to integrate this knowledge in their own planning and management activities.
- *Establishment of an intra-RISA Drought Impacts Working Group.* Dow, Lackstrom and Brennan helped to organize and attended a two-day Drought Working Group meeting in Tucson, AZ March 5-6, 2013. Other attendees represented CLIMAS, the Southwest CSC, NIDIS, NDMC, CoCoRaHS, SECC, and SCIPP. The working group was designed to provide a forum to share information and integrate activities related to drought impacts research and reporting.

Deliverables:

Webinar:

- Brennan, A. 2013. “CoCoRaHS Coastal Drought Impacts Reporting.” National Weather Service CoCoRaHS North Carolina and South Carolina Regional Coordinators, March 22, 2013.

Presentations:

- Brennan, A. 2012. “NIDIS Carolinas Drought Early Warning System Pilot Program.” The Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina’s Natural Resources, Charleston, SC, September 13, 2012.

Posters:

- Brennan, A. L. Darby, K. Dow, K. Lackstrom, D. Tufford. 2012. “NIDIS Carolinas Drought Early Warning Pilot Program.” South Carolina Water Resources Conference, Columbia, SC, October 10-11, 2012.
- Brennan, A. L. Darby, K. Dow, K. Lackstrom, D. Tufford. 2013. “NIDIS Carolinas Drought Early Warning Pilot Program.” North Carolina Water Resources Research Institute Annual Conference, Raleigh, NC, March 20-21, 2013.
- Tufford, D. S. Gilbert, K. Lackstrom. 2012. “The Impact of Drought on Coastal Ecosystems in the Carolinas.” South Carolina Water Resources Conference, October 10-11, 2012, Columbia, SC.

Domestic Water Quality Monitoring Project (Tufford)

Partners: Georgia Tribe of the Eastern Cherokee (Dahlongega, GA), Lower Muskogee Creek Tribe (Whigham, GA)

Abstract: Drought is known to affect groundwater quantity and quality on both short- and long-term time scales. Rural populations dependent on household wells for domestic water supply may be especially vulnerable to elevated pollutant concentrations. CISA is conducting well monitoring and data analysis activities in order to investigate the relationships between drought and shallow groundwater quality, which has the potential to become a domestic water quality issue.

Progress & Results:

- Tufford and a field technician installed shallow monitoring wells at the two locations in April 2012. Representatives from each community were trained to use the instruments. Water samples from the wells were also collected at that time and brought to USC for laboratory analysis.
- Water sampling and testing began in summer 2012 and will continue through May 2013, conducted mostly by the local people with periodic site visit by Tufford for quality control. Data analysis will begin upon completion of sampling.



Stakeholders at the NIDIS Carolinas Drought Early Warning Scoping Workshop engaged to develop pilot project ideas that represented coastal drought issues and concerns.

Climate and Hydrological Modeling

Stakeholders have expressed interest in the development of climate scenarios and watershed modeling for regional planning. CISA is using dynamical downscaling to assess the impacts of climate variability and change in the Southeast. CISA's hydrological modeling projects address a need for a comprehensive analysis of watersheds to understand how climate variability and change, including drought, affects water supply and quality from the mountains to the coast. CISA's focus on climate as a driving force and use of models that cover large watersheds at sub-watershed scales provide meaningful information for local and regional decision making. The projects and modeling work described below are interrelated and have evolved as researchers have received feedback from decision-makers about their interests in understanding the plausible range of climate change scenarios for the region.

Modeling of the Winyah Bay Watersheds (Tufford, Carbone, Patel, Gao, Samadi)

Abstract: Researchers use EPA's BASINS Hydrologic Simulation Program-Fortran (HSPF) model to address hydroclimatological variability in the Winyah Bay watershed. HSPF simulation models for the Yadkin Pee-Dee, Waccamaw, and Black Rivers at the 8-digit HUC level have been calibrated in order that local variability within each watershed can be adequately addressed. The Soil and Water Analysis (SWAT) model, which implements streamflow generation somewhat differently than the HSPF model, is being used to model streamflow in the Waccamaw River watershed. This watershed is of particular interest in the study area due to development activity and existing issues relating to streamflow and water quality. This basin-wide approach to hydrological modeling appeals to a range of stakeholders, including water managers, natural resource managers (e.g. National Wildlife Refuges, state parks), Riverkeepers, citizen-advocates, Native American peoples, and state and national regulatory agency staff.

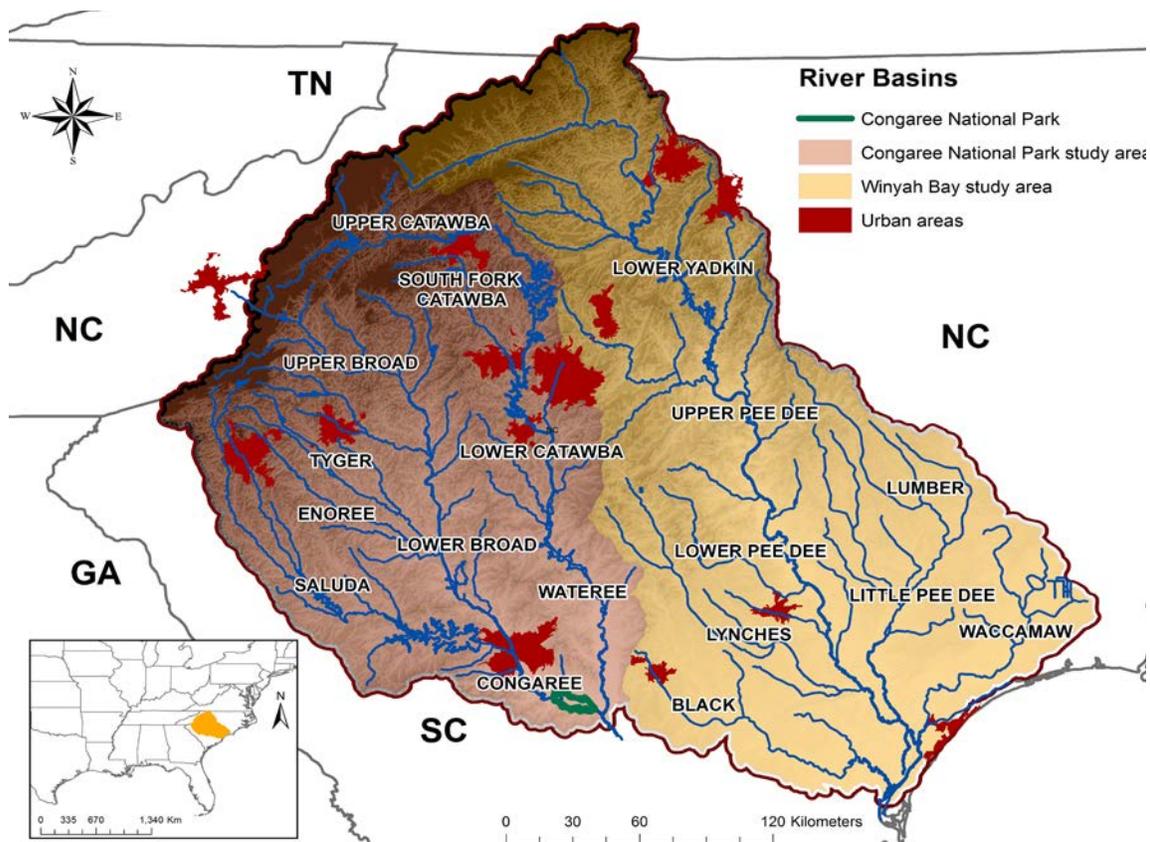
Progress & Results:

- During this reporting period, a great deal of time was spent on issues related to downscaling global and regional climate models. The fundamental issue is the need to have meteorological data for input to HSPF at a local spatial scale and hourly temporal scale. More information on these efforts can be found in the *Integrating Regional Downscaling and Hydrological Models* section.
- Researchers also conducted data analysis of model output to understand what the models appear to predict about the impacts of future climate on streamflow at the HUC8 scale. These analyses were the core information for presentation at three conferences (SC Water Resources, NC WRRRI annual conference, AAG).
- The SWAT model has been calibrated for three different intervals representing differing hydroclimatic conditions. Uncertainty analysis is complete and two manuscripts are in preparation. A joint analysis of the HSPF and SWAT results for the Waccamaw River watershed is underway.

Deliverables:

Presentation:

- Tufford, D. "Climate and Water Resources in South Carolina: Science for Decision-Making" SC Association of Environmental Professionals monthly meeting, Columbia, SC, April 18, 2013.



CISA researchers have modeled watersheds covering a substantial portion of the Carolinas (A. Patel)

Integrating Regional Downscaling and Hydrological Models (Carbone, Tufford, Gao, Patel)

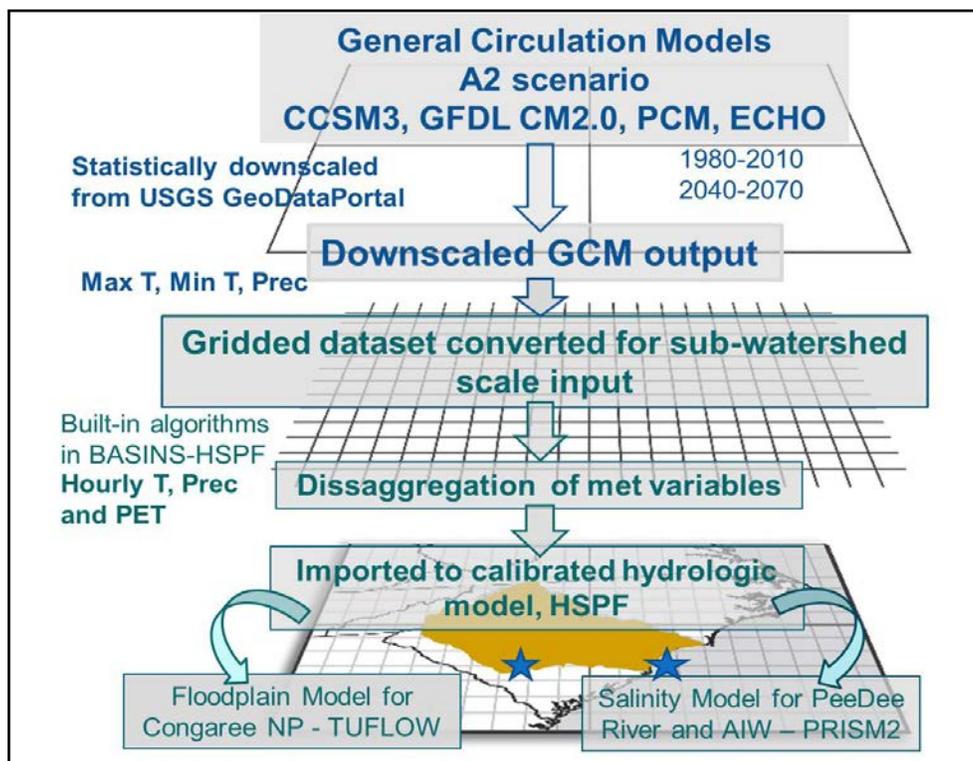
Partner: USGS South Carolina Water Science Center

Abstract: Researchers are using statistical downscaling to assess the regional impacts of climate variability and change on water resources, including streamflow and water quality. Efforts have centered on processing and using statistically downscaled data from the Department of Interior/United States Geological Survey (DOI/USGS) as input for two different HSPF modeling projects: 1) CISA's Winyah Bay watershed project and 2) a collaborative project being conducted for Congaree National Park (Santee Basin). A fundamental issue has involved understanding how to disaggregate data to a local spatial scale and hourly temporal scale for input into the HSPF model. This work also includes analysis of model output to understand potential impacts of future climate at the HUC8 scale.

Progress & Results:

Exploration of disaggregated data and assessment of HSPF simulation sensitivity to different aggregation methods

- Researchers have been working with climate change scenarios produced for the USGS (Geo Data Portal). These data are derived from nearly 20 general circulation models (GCMs) as part of Intergovernmental Panel on Climate Change (IPCC) modeling efforts. Values of maximum and minimum temperature and precipitation were downscaled to a 12 km grid, commensurate with a widely-used observed gridded data set (Maurer et al. 2007)¹. Downscaled data has been processed from four GCMs, including CCSM3, ECHO-2, GFDL2.0, and PCM.
- Work has begun with a statistical downscaling data set from the DOI/USGS which represents the historical period, 1980-2009 and includes daily precipitation, daily maximum and minimum temperature for the Southeast.
- Data has been processed as it becomes available and has been conformed to serve as input for the hydrological modeling work. The gridded downscaling has been aggregated to sub-basins within and beyond the Santee Basin. Aggregation at this scale matched that required for hydrological modeling with HSPF. Data preparation also required disaggregating daily precipitation to hourly time steps. Extensive testing has been conducted to evaluate HSPF performance with various disaggregation methods.
- Research has been presented to diverse stakeholders at several regional meetings.



The process of integrating climate information into hydrological models involves multiple stages of data processing. (A. Patel adapted from P. Conrads)

Deliverables:

Presentations:

- Gao, P. 2012. "Assessing Methods to Disaggregate Daily Precipitation for Hydrological Simulation." South Carolina Water Resources Conference, Columbia, SC, October 10-11, 2012.
- Gao, P., G. Carbone, D. Tufford, A. Patel, and L. F. Rouen 2013. "Assessing Methods to Disaggregate Daily Precipitation for Hydrological Simulation." Annual Meeting of the Association of American Geographers, Los Angeles CA, April 13, 2013.
- Patel, A., D. Tufford, G. Carbone, P. Gao, and L. Felker, 2013. "Assessing Climate Change Impacts on Streamflow in South Carolina River Basins." 2012 SC Water Resources Conference, Columbia, SC, October 10-11, 2012.
- Patel, A., D. Tufford, G. Carbone, P. Gao, and L. Felker, 2013. "Assessing Climate Change Impacts on Streamflow in North Carolina Watersheds." 2013 NC Water Resources Research Institute Annual Conference, Raleigh, NC, March 20-21, 2013.
- Patel, A., D. Tufford, G. Carbone, P. Gao, and L. Felker, 2013. "Assessing Climate Change Impacts on Streamflow in NC and SC Watersheds." 2013 Association of American Geographers Annual Meeting, Los Angeles, CA, April 9-13, 2013.

¹ Maurer, E.P., L. Brekke, T. Pruitt, and P.B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies, *Eos Trans. AGU*, 88(47), 504.

NARCCAP Model Assessments for the Southeast (Carbone, Kabela)

Partner: North American Regional Climate Change Assessment Program (NARCCAP)

Abstract: Downscaling efforts centered on regional climate model (RCM) output from the North American Regional Climate Change Assessment Program (NARCCAP). This work provides users of NARCCAP data with in-depth validation of commonly used climate variables from several ensemble members against observations, determines the “value added” by RCMs in the downscaling process, and assesses atmospheric processes internal to each RCM which feed back into the climate system. Additionally, recommendations are made for selecting NARCCAP members based on the intended assessment by stakeholders of climate information. Lastly, this work serves as a template for the type of in-depth analysis needed for climate models to provide added confidence in a models’ ability to simulate all aspects of the climate system.

Progress & Results:

- Researchers evaluated NARCCAP data in the Southeast, including summer and winter maximum and minimum temperature, and precipitation for nine pairs of general circulation models and regional climate models during a control period, 1970-1999. The historical analysis set the stage for interpreting future projections (2040-2069) of minimum and maximum temperature and mean precipitation change and helped to quantify associated uncertainties in these scenarios. (See Research Findings for more information on the results of this analysis.)
- This analysis will inform many other CISA efforts.

Deliverables:

Dissertation:

- Kabela, E. 2012. NARCCAP Model Assessment and Future Projections for the Southeast United States. PhD dissertation, University of South Carolina, Columbia, SC.

Presentation:

- Kabela, E., and G. Carbone. 2013. “NARCCAP Model Validation for the Southeast United States.” 93rd Annual Meeting of the American Meteorological Society, Austin, TX, January 7, 2013.

Poster:

- Kabela, E. and G. Carbone. 2012. NARCCAP Model Validation for the Southeast United States. American Geophysical Union Annual Meeting, San Francisco, CA, December 3-7, 2012.

Lower Cape Fear Watershed Study (Montz)

Partners: Cape Fear Public Utility Authority, Cape Fear Arch Conservation Collaboration

Abstract: Using the Lower Cape Fear watershed (NC) and its subwatersheds as a study area, this project assessed water availability and use over time, under different scenarios, at several temporal and spatial scales. This project involved documenting past, current, and potential future patterns of water availability (i.e., supply) and past, current, and potential future patterns of demand, by land use and by sector and will incorporate various climate change scenarios.

Progress & Results:

- Activities included evaluating the amounts and nature of water deficits, where they exist and are likely to exist; identifying the causes of the deficits; identifying alternatives (other than increasing supply) for addressing those deficits; evaluating the impacts of alternatives using past data to determine water “saved”; and applying the results to different future scenarios. (More information can be found in the Research Finding section.)
- This research has been presented in New Hanover County, which was shown to be a major area of concern in the stress analysis. This first was at the Cape Fear Arch Conservation Collective quarterly meeting in Kure Beach, NC on May 15, 2012. Following that, researchers attended a Cape Fear Public Utility Authority (CFPUA) meeting, with employees and county managers in attendance who were aware of the potential for future availability issues, but were intrigued by how researchers mapped the risk by HUC 12 watersheds and presented projections of supply and demand by service area.

Deliverables:

Journal Article:

- Griffin, M., B. Montz, and J. Arrigo. 2013. Evaluating climate change induced water stress: A case study of the Lower Cape Fear basin, NC. *Applied Geography* 40(1): 115-128. DOI: 10.1016/j.apgeog.2013.02.009

Poster:

- Griffin, M.T., and B. Montz. 2012. “Assessment of Fresh Water Resource Availability in Coastal North Carolina.” Southeastern Division of the Association of American Geographers Annual Meeting, Asheville, NC, November 18-20, 2012.



North Carolina Mountain Stream
(K. Lackstrom)



McClellanville, SC Waterfront

Coastal Climate

CISA partners with North and South Carolina Sea Grant to assist coastal communities and stakeholders in addressing potential impacts of climate variability and change on major coastal issues including: erosion, invasive species, land use change, salt water intrusion, health of fisheries, agriculture, tourism, coastal community development, and natural hazards. The project works with government agencies in both states to better inform those individuals and to evaluate possible impacts through an applied research program.

Coastal Climate Outreach (Whitehead, Carbone, Dow, Tufford)

Partners: NC Sea Grant, SC Sea Grant Consortium, College of Charleston, National Sea Grant Office, National Weather Service Offices (Charleston, SC), ACE Basin National Estuarine Research Reserve, NC National Estuarine Research Reserves, NC Department of Environment and Natural Resources (DENR), North Inlet-Winyah Bay National Estuarine Research Reserve, SC Department of Health and Environmental Control (SC DHEC), SC Department of Natural Resources (SC DNR), Governor's South Atlantic Alliance, NOAA/NCDC Southern Region Climate Services Director, NOAA/NCDC Eastern Region Climate Services Director, State Climate Office of North Carolina

Abstract: CISA's Coastal Climate program was established as the Carolinas Coastal Climate Outreach Initiative (CCCOI) in 2007. Since that time, CISA has worked with many different coastal stakeholders to assist them in mainstreaming climate information into decision-making processes.

Progress & Results:

Current projects include:

- creating recommendations on integrating climate factors into working waterfront management programs and providing information at a working waterfronts symposium and report (target completion: January 2014)
- working with the NC Climate Adaptation Working Group to develop and provide understandable and consistent sea level rise educational materials and communications to communities (target completion: January 2014)
- contributing to the development of a Low Impact Development manual for coastal SC, to include using climate science to inform best management practices (target completion: Fall 2013)
- working with the Kitchen Table Climate Study Group and local government of McClellanville, SC, to develop an adaptation outreach plan and materials (target completion: July 2013).

Deliverables:

Presentations:

- Whitehead, J. 2013. "South Carolina's Coastal Hazards: Past and Future." 2013 Waccamaw Conference, Myrtle Beach, SC, January 19, 2013.
- Whitehead, J. 2013. "The State of the Science." Communicating Changing Conditions at the Coast: A workshop for Communicators, Non-formal Environmental Educators & Planners, Elizabeth City, NC, April 17-18, and Jacksonville, NC, April 30-May 1, 2013.

Community Climate Adaptation and Resilience Projects (Whitehead, Dow, Carbone, Tuler, Webler)

Partners: NC Sea Grant; SC Sea Grant Consortium; Social and Environmental Research Institute (SERI)

Abstract: The purpose of these projects is to provide tailored, decision-relevant information to coastal communities and decision makers on the implications of climate variability and change and adaptation strategies that increase resilience to those impacts. Researchers work with communities to develop adaptation planning projects and pursue opportunities to transfer the tools and information gained through those processes to other communities. The Vulnerability and Consequence Adaptation Planning Scenario (VCAPS) process was created as a tool to help facilitate dialogue among researchers and community representatives. Evaluation of the utility of this adaptation support process in different settings is also a key program element.

Progress & Results:

In Year 2 CISA secured funding for and initiated two projects focusing on extending the utility of the Vulnerability, Consequences, and Adaptation Planning Scenario (VCAPS) tool to adaptation planning. In addition, VCAPS trainings are being held to further disseminate the tool.

Using participatory scenario building to encourage climate-resilient zoning in the coastal Carolinas (Beaufort County, SC) The goal of this project is to write a plan for priority actions to update zoning and form-based codes in the future to encourage climate resilience.

- For the initial scoping work for the project Whitehead met with the Beaufort County Planning Department on August 17, 2012, and the Beaufort County Northern Regional Planning Commission on March 23, 2013. This preliminary assessment of initial concerns and county plans that are relevant for climate adaptation will provide background information to inform stakeholder interviews in May 2013 and a VCAPS exercise in June 2013.

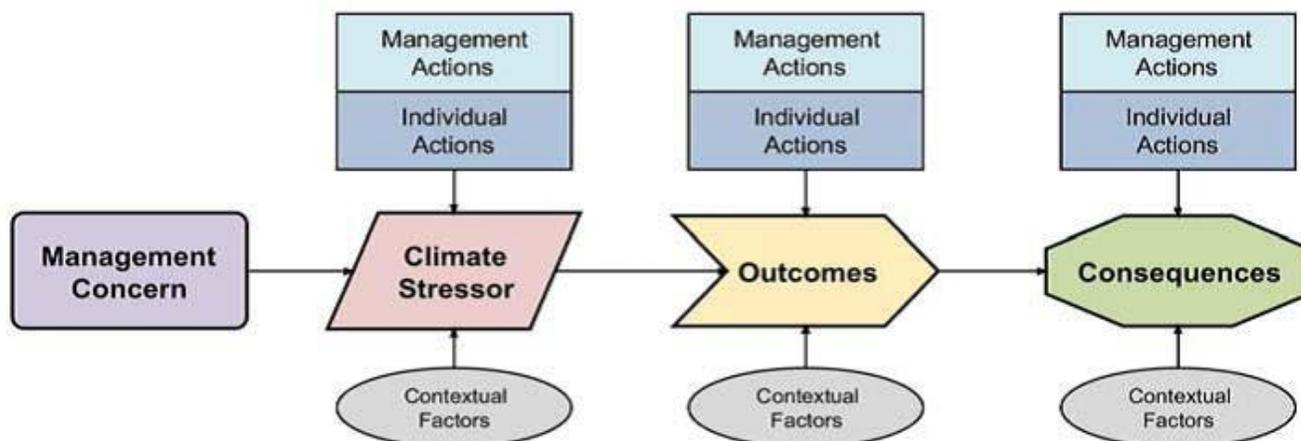
Promoting climate change awareness and adaptive planning in Atlantic fisheries communities The goal of this project is to understand how fisheries and fisheries-dependent communities, including shore-side infrastructure, may be vulnerable to climate change. Methodologies are needed that assist fishing communities with beginning to explore the range of potential climate impacts that are also robust to location-specific stressors. The research team will assess the use of a combined process using VCAPS and system dynamics (SD)-based scenario building to assist fishermen with discussing the potential outcomes of climate change in their communities and exploring the feasibility of adaptation options. At the end of the project the methodology will have been demonstrated in three diverse fishing communities: South Thomaston, ME; Beaufort County, SC; and Wellfleet, MA.

- Stakeholder meetings held with lobstermen in South Thomaston on February 5 and March 27-28, 2013, focused on climate related threats to the lobster industry. The lobster fishermen found that the discussion stimulated by the SD modeling process was valuable to understanding adaptations that can assist them with improving quality control with a lobster population potentially more vulnerable to injury due to earlier shedding and shell disease.

VCAPS Training Program This project involves developing and providing VCAPS training sessions to other outreach specialists. This training will enable VCAPS to be part of a long-term sustainable process that facilitates discussions on the outcomes and consequences of climate hazards for coastal user groups, particularly local and regional governments and resource managers.

- The research team is developing training materials and guidance documents for outside facilitators who could use the VCAPS process in their communities. Expanded VCAPS trainings were beta tested in April 2013. Based on feedback, changes are being made to the training format before conducting a larger training workshop in fall 2013.

The VCAPS process uses structured diagramming to facilitate an integrated understanding of climate impacts and management options.



Regional and National Climate Outreach Projects (Whitehead)

Partners: SC Sea Grant Consortium, NC Sea Grant, NOAA Coastal Services Center, National Sea Grant Office, NOAA Southeast and Caribbean Regional Team (SECART), Governors' South Atlantic Alliance, Sea Grant Climate Network

Abstract: These projects aim to increase the capacity of the Sea Grant network, on a regional and national scale, to target and support relevant research and deliver directed outreach programs on the impacts of climate variability, climate change, and adaptation strategies for coastal stakeholders.

Progress & Results:

- Whitehead worked with other partners to secure funding and plan the “Considering Climate in Decision Support for Resilient Coastal Communities” workshop held June 12-14, 2012, in Jacksonville, FL. Chip Konrad (SERCC/CISA) presented on climate trends and projections.
- The Sea Grant Climate Network hosted a workshop on March 12-14, 2013, in Santa Monica, CA. Whitehead was part of the planning committee. The workshop focused on the national progress of Sea Grant programs' projects completed under the Coastal Communities Climate Adaptation Initiative (CCCAI) funding.

Deliverables:

Presentation:

- Whitehead, J., S. Tuler, and T. Webler. “Using the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) Process to encourage climate-resilient zoning in Beaufort County, SC.” Sea Grant Climate Network Workshop, Santa Monica, CA, March 14, 2013.

Poster:

- Putnam, G., J. Thigpen, and J. Whitehead. “Communicating Changing Coastal Conditions in NC.” Sea Grant Climate Network Workshop, Santa Monica, CA, March 13, 2013.



Wildlife at the North Inlet-Winyah Bay National Estuarine Research Reserve (NOAA NERRS)

Health

Assessing Heat Stress Vulnerability (Konrad, Fuhrmann, Kovach)

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

Abstract: Researchers at the Southeast Regional Climate Center (SERCC) are investigating heat stress vulnerability and assessing methods to improve existing warning systems. Researchers are presently 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 different types of public health emergencies (e.g. spikes in heat related morbidity/mortality).

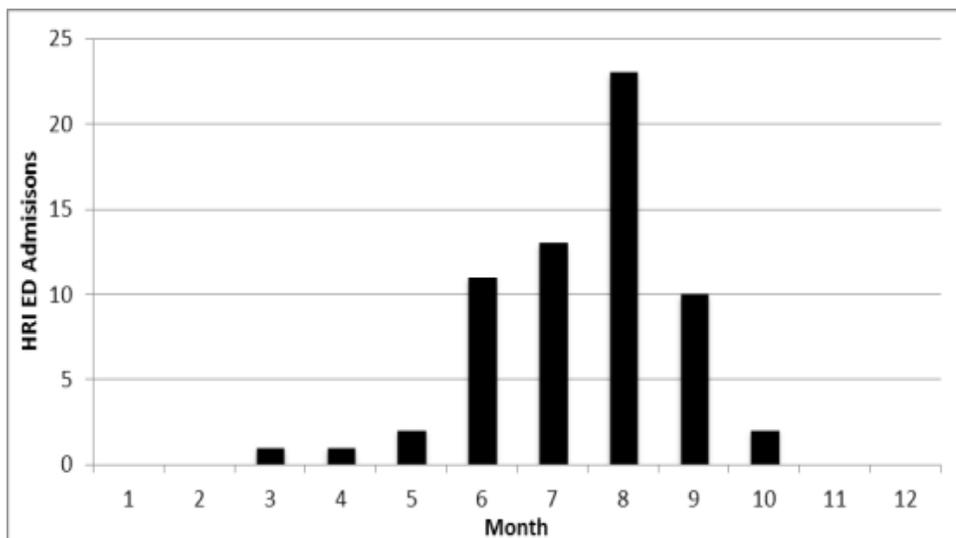
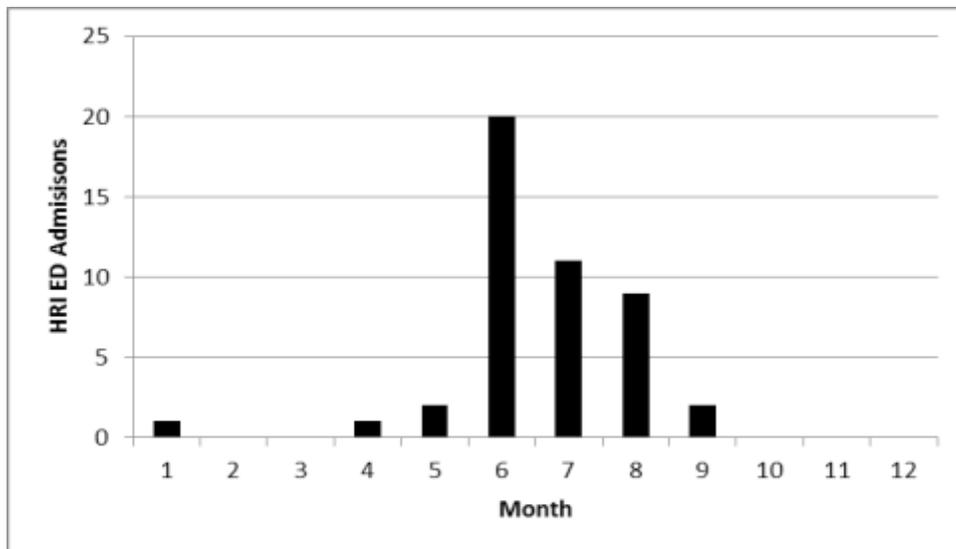
Progress & Results:

- Current investigations focus on temporal and spatial patterns in heat morbidity across the state. 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 vs. urban regions of the state. Comparisons of these thresholds will reveal spatial and demographic variations in heat vulnerability that will inform public health officials and the National Weather Service (NWS) in the issuance and communication of heat warnings.

Deliverables:

Presentations:

- Kovach, M. 2012. "Heat Related Illness and North Carolina: Linking Variations in Heat Related Illness to Land Cover and Socioeconomic Patterns." Southeastern Division of the Association of American Geographers Annual Meeting, Asheville, NC, November 18-20, 2012.
- Kovach, M. and C.E. Konrad. 2013. "Climate – Health Vulnerability: Identifying Climate Thresholds for Heat Related Illness in North Carolina." Association of American Geographers Annual Meeting, Los Angeles, CA, April 9-13, 2013.



These plots reveal the differences in the seasonal pattern of heat morbidity for elderly versus high school students in Wake County, NC. HRI ED refers to heat-related illness visits to the emergency department. The plots show the percentage of HRI ED visits by age-group during each month. Data from the NC DETECT database were used from January 1, 2007 to December 31, 2010. Preliminary findings reveal that the elderly (top graph) are much more vulnerable early in the summer while high schoolers (bottom graph) show greater vulnerability in the late summer. CISA researchers hypothesize that many of the late summer cases are associated with school athletics. (C. Konrad)

Assessing the Impacts of Climate Variability on Water Quality Conditions and Vibrio in North and South Carolina Estuaries (Tufford, Scott, Moore, Pierce, Deeb)

Partners: NOAA Center for Coastal Environmental Health and Biomolecular Research, UNC Institute of Marine Science, USC Department of Environmental Health Science

Abstract: 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. Models in North and South Carolina will be developed to monitor and assess the potential for increased exposure to *Vibrio* bacterial hazards in the southeastern U.S. coastal water under changing salinity trends.

Progress & Results:

- Surface water, bottom water, and sediment samples were 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*.
 - » Samples were collected once a month from April 2012 until October 2012. They were grown on CHROMagar *Vibrio* media and were quantified using TaqMan based real-time multiplex polymerase chain reaction (qPCR). A second sampling was taken in October to observe the effects of Hurricane Sandy on bacterial abundance.
 - » Two USC graduate students have assisted with this project. Pierce completed her Masters practicum based on that work. Deeb is integrating the lab results with the PRISM2 salinity intrusion model developed by USGS and CISA research partners.
- Using qPCR analysis of water samples taken in May, *Vibrio* spp. were found at all sites (even those considered to be freshwater). The detection of *Vibrio* spp. at these low salinities suggests there are other factors that may influence growth. Virulence was not determined, but should be considered to assess the potential public health risk associated with increased area of exposure. Sediment samples are currently being analyzed and a predictive model on the potential influences of climate change on *Vibrio* spp. distribution and abundance is being developed.

Deliverables:

Report:

- Pierce, A.L. 2013. Spatial and Temporal Distribution of *Vibrio vulnificus* and *Vibrio parahaemolyticus* along Winyah Bay and the Waccamaw River in South Carolina. Practicum Report. University of South Carolina, Columbia, SC.



The Waccamaw River, SC site of the Vibrio sampling. (D. Tufford)

Adaptation

Supporting Improved Natural Resource Planning through Climate Workshops (Mizzell, Abramyan)

Partners: SC Department of Natural Resources

Abstract: The SC DNR State Climatology Office hosted workshops about climate and its impacts on South Carolina's natural resources. The purpose of the workshops was to increase awareness and utilization of climate knowledge to improve natural resource management. At each workshop, discussion regarded the relationship between natural resources and climate, including the needs for new approaches and partnerships to cope with climate variability.

Progress & Results:

- Climate Connection workshops were held on September 13 (Charleston, SC), October 24 (Columbia, SC), and December 5 (Greenville, SC), 2012. The series attracted a total of 151 participants including representatives from federal, state and local government, scientists, land and water resource managers, utility representatives, NGOs, and private companies.
 - » Workshops consisted of presentations and an interactive session where participants could submit real-time responses to questions about climate concerns, impacts, action, needs, and challenges.
 - » Drought was the overwhelming priority climate change concern at all three workshops, followed by sea level rise (particularly among coastal participants) and temperature extremes. Participants suggested water quantity as the greatest threat for natural resources, followed by ecosystem integrity, shoreline change, and water quality. Research and risk/vulnerability assessments were the top two identified actions organizations are taking to address climate-related issues. NOAA entities were selected as primary sources for climate information. Lack of resources (time and funding) was noted as the greatest barrier towards addressing these concerns.
- A website, hosted by SC DNR, was launched with links to all workshop presentations, research publications, and other relevant trainings and events (<http://www.dnr.sc.gov/ccworkshops/>).
- In response to workshop participants request for more information on water resources, researchers are working with USGS on a proposal to initiate a regional investigation of historic drought patterns in Georgia, South Carolina, and North Carolina.

Deliverables:

Presentations:

- Abramyan, I. and H.P. Mizzell. 2012. "Understanding South Carolina's Climate Controls." Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina's Natural Resources. Presented at all 3 Climate Connection Workshops.
- Abramyan, I., and L. Vaughan. 2013. "Analyzing the Potential Connection of Climate Indices with Significant South Carolina Snow Events." NWS/SCO Partnership Meeting, Columbia, SC, January 16, 2013.
- Mizzell, H. 2012. "Understanding South Carolina's Climate Trends and Variability." Columbia Rotary Club Meeting, Columbia, SC, December 4, 2012.
- Mizzell, H. 2013. "Celebrating 5-Years for CoCoRaHS in South Carolina." Palmetto Mini-Technical Conference, Columbia, SC, March 21, 2013.
- Mizzell, H. 2013. "Update on South Carolina's Weather and Climate." South Carolina's Annual Conservation Partnership Conference, Columbia, SC, February 26, 2013.
- Mizzell, H. and I. Abramyan. 2012. "SC Climate Trends and Variability, 1901-2010." Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina's Natural Resources. Presented at all 3 Climate Connection Workshops.
- Mizzell, H. and I. Abramyan. 2012. "South Carolina's Climate Report Card: Understanding SC's Climate Trends and Variability." South Carolina Water Resources Conference, Columbia SC, October 10-11, 2012.

Research and Communications in Support of Adaptation (Dow, Lackstrom, Brosius, Brennan, Haywood, Kettle, Carbone)

Partners: NC Sea Grant, SC Sea Grant Consortium, Social and Environmental Research Institute

Abstract: Supporting the development of adaptive capacity to address current climate variability and projected climate change is a cross-cutting element of CISA's efforts. CISA's research and engagement efforts strive to: increase regional understanding of climate variability and change, impacts and vulnerabilities; identify climate-related data, analysis, and management needs; promote networks for sharing climate and adaptation information and expertise; develop analytical approaches and tools to aid in decision making; and improve the communication of climate risks and uncertainties. As adaptation needs to fit within local decision contexts, CISA also works to foster integration of local knowledge of communities and systems with more generalized scientific findings. These integration efforts often involve facilitating the Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS) process with community-level stakeholders.

Progress & Results: (specific activities and presentations are listed below)

- The Southeastern Technical Input to the NCA (a collaboration among 3 RISA teams – SERCC, SCIPP and CISA) will be available via free digital access through Island Press.
- The Carolinas Climate Connection CISA quarterly newsletter is distributed to over 700 individuals involved with climate activities across the Carolinas. Each edition focuses on a key issue (e.g. drought) and provides a brief introduction and connection to specific resources, tools, science findings, and upcoming events.
- The 2012 NIDIS-Carolinas Pilot Project helped advance a wide research and engagement agenda around drought and water resources, specifically in coastal ecosystems (see the Drought section for more information).
- VCAPS continues to expand. Partners Jess Whitehead, Tom Webler and Seth Tuler received COCA funding to utilize VCAPS in 3 working waterfront communities (South Thomaston, ME; New Bedford, MA; and Beaufort, SC). Funding for training (via NC Sea Grant) has been secured. Dow and Webler provided a VCAPS training session at the National Adaptation Forum. (See the 'Coastal Climate' section for more details)

Stakeholder Engagement & Interactions: (ongoing involvement)

- Brennan attends NCAnet monthly conference calls.
- Dow participates in monthly calls of the Eastern Regional Climate Team coordinated by the Regional Climate Services Director, Ellen McCray.
- Dow serves as a member of the Science Implementation Panel for the SE Climate Science Center and contributes to the proposal review processes.
- Dow serves on the NCADAC appointed Working Group on the Special Report on the Sustained Assessment.
- Mizzell was selected as chair of the American Meteorological Society Committee on Climate Services, January 2013-December 2014.
- Tufford serves on the Executive Committee of the Cape Fear Arch Conservation Collaboration.

Deliverables:Presentations:

- Carbone, G. 2012. "The Science Behind Global Climate Change." Invited webinar presentation for the Southern Alliance for Clean Energy, May 16, 2012. http://www.cleanenergy.org/index.php?Webinar-Archive-Detail.html?item_id=59.
- Carbone, G. 2012. "Presentation on Global Climate Change to US Naval Academy Alumni Association." Columbia, SC, September 20, 2012.
- Carbone, G. 2012. Three 30-minute weather and climate lectures to Fairfield Central High School students. Fairfield Co, SC: November, 16.
- Dow, K., T. Webler, S. Tuler, J. Whitehead & N. Kettle. 2012. "Developing vulnerability and consequence planning scenarios for adaptation." Climate Adaptation Futures: Second International Climate Change Adaptation Conference, Tucson, AZ, May 29-31, 2012.
- Dow, K. & T. Webler. 2013. "Initiating Adaptation Planning with the Vulnerability and Consequences Adaptation Planning Process (VCAPS)." National Adaptation Forum. Denver, CO, April 2-4, 2013.
- Dow, K. 2013. Participated in the Frog Frolic Day – Climate Change Workshop, Saluda Shoals Park, Columbia, SC, April 13, 2013.
- Dow, K. & G. Carbone. 2012. "Climate Change and Adaptation Strategies." Session at the Richland Neighborhood Planning Meeting, Columbia, SC, October 13, 2012.
- Dow, K., K. Lackstrom, A. Brennan, A. Brosius, B. Haywood & N. Kettle. 2012. 3 presentations given. Climate Adaptation Futures: Second International Climate Change Adaptation Conference, Tucson, AZ, May 29-31, 2012.
- Haywood, B., A. Brennan, K. Lackstrom, N. Kettle & K. Dow. 2012. "Framing Climate Change Response in the Carolinas: Outside the 'Climate Change' Box." 2012 Southeastern Division of the Association of American Geographers Annual Meeting, Asheville, NC, November 18-20, 2012.
- Lackstrom, K. 2012. "Climate Decision Making in the Carolinas: The Role of Information Networks in Supporting Adaptation." Southeastern Division of the Association of American Geographers Annual Meeting, Asheville, NC, November 18-20, 2012.