2017-2018

ANNUAL REPORT

State Climate Office of North Carolina

NORTH CAROLINA
CLIMATEOFFICE

State Climate Office of North Carolina

May 2017 - April 2018 Annual Report

The State Climate Office of North Carolina (SCONC) serves as the primary scientific extension resource for weather and climate science focused on North Carolina. Founded in 1976 and chartered as a Public Service Center by the UNC Board of Governors in 1998, SCONC focuses on service to public and private sectors of North Carolina through climate science extension, research, and education.

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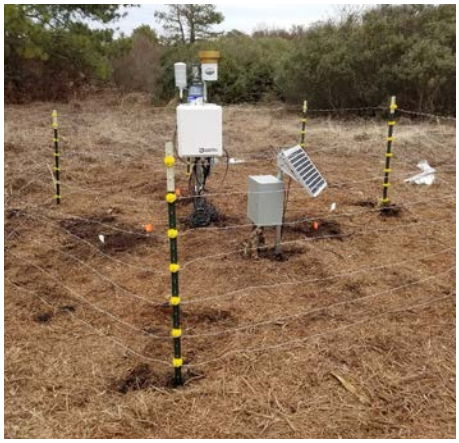


Executive Summary

HIGHLIGHTS

The State Climate Office of North Carolina (SCONC) employed 12 scientists and staff, 1 graduate students, and 5 undergraduate students during the past year.

In addition to daily climate service activities, **15** collaborative research and applied projects were funded and included effort across many sectors including health, agriculture, and transportation.

These projects and collaborations yielded **6 peer-reviewed publications** authored by SCONC staff and students. SCONC continues to provide enhanced climate services via contracts and grants with 8 contract and grant proposals submitted (6 funded; 2 pending).

ENVIRONMENTAL MONITORING

Data provided by the NC Environment and Climate Observing Network (ECONet) enhance our public service mission and support agricultural research and operations, Cooperative Extension, and educational outreach.

Over half a billion observations were recorded at NC ECONet stations, which are maintained and operated by SCONC.

SCONC scientists made 158 ECONet site visits to perform routine or emergency maintenance, covering 21,464 vehicle miles, with 272 sensors serviced or replaced.

DATA AND WEB SERVICES

More than 1.2 million visits to the SCONC website last year. Since 2009, web traffic has increased 483%. Over half of all webpage visits were to online educational content created by SCONC staff and students.

Users submitted 5 million data queries through the SCONC online data retrieval system – an increase of nearly 50% compared to the previous year (3.4 million).

Nearly 3 million data queries were made through the SCONC web-services application programming interface, which is an advanced, customizable data retrieval service.

SCONC provides access to 85 terabytes of gridded data for partners and end users, and averages over 6 terabytes of internal climate data transfarers, with about 2.2 billion data records selected, updated, or inserted each month.

RESEARCH AND EXTENSION PARTNERSHIPS

The SCONC, through a partnership with NCSU Plant Pathology that is now in its 14th year, provides routine advisories for two peanut foliar diseases.

The SCONC has been been an integral member of the NC Drought Management Advisory Council for over two decades. This interagency coordination and information exchange body is tasked with assessing conditions and issuing drought advisories for the state of North Carolina. Through its efforts on the Council, SCONC participates in weekly drought monitoring conference calls and provides public presentations and media interviews on North Carolina moisture conditions.

The SCONC contributed to engagement activities of the Carolinas Integrated Sciences and Assessments, a NOAA Research Integrated Sciences and Assessments, to improve drought monitoring and advance the science related to fire and smoldering risk in organic soils.

UNC-Chapel Hill and NCSU have partnered together on the NOAA Southeast Regional Climate Center (SERCC) since 2007. As part of this collaboration, the SCONC develops and maintains the technological infrastructure, web services, and online climate tools for SERCC. This year the SCONC and SERCC have worked on improving climate and health information related to heat stress.

For over a decade, the SCONC has partnered with NC Department of Transportation (NCDOT) to provide an operational rainfall alert system to meet their water quality permitting and storm water control requirements. This effort has been estimated to save more than 113,000 work hours each year. During the past year, this partnership has been extended to help NCDOT identify high-risk areas susceptible to extreme precipitation events.

Through a USDA cooperative agreement, the SCONC provides technical, scientific, and extension expertise for the USDA Southeast Regional Climate Hub extending climate science to support informed decision making on southeastern US forests, rangelands, and croplands. As part of this agreement the SCONC has modernized and expanded the Fire Weather Intelligence Portal, a real-time monitoring tool for weather and fire risk information.

The SCONC was part of a team of scientists, led by RTI International, that participated in the Defense Coastal/Estuarine Research Program (DCERP). This program conducted monitoring and research to understand coastal and estuarine ecosystems within the context of a military training environment. This six-year project concluded during the past year.

SCONC scientists serve as the climate focal point on the Spatial Analytic Framework for Advanced Risk Information Systems (SAFARIS) project, which is a collaboration with colleagues at NCSU's Center for Integrated Pest Management (CIPM) and USDA Animal and Plant Health Inspection Service (APHIS) working to estimate global risk to trade of agricultural products.

For over 12 years, the SCONC has partnered with the North Carolina Division of Water Resources (DWR) to provide weather and water data to DWR for their Water Resources Information, Storage, Analysis and Retrieval System (WRISARS).

OUTREACH AND EDUCATION

The SCONC regularly leads and attends educational outreach events across the state of North Carolina. In 2017-18, staff and students participated in 14 outreach events, 4 of which were large, public events including NC State College of Science's Eclipse Day and the 2018 Farm Animal Days.

More than 20 presentations on North Carolina's climate, weather, and ongoing SCONC research projects were given to community groups, professional groups, conference attendees, and visiting scientists or professionals.

Staff and students wrote 25 posts for the SCONC Climate Blog, receiving 40,740 total views.

In the past year, the SCONC gave more than a dozed media interviews on events such as evolving drought conditions, snowfall and winter weather, and seasonal outlooks.

The SCONC is continuing to host a STEM program, funded by the Burroughs Wellcome Fund, for rising 7th-grade students in rural northeastern NC. Through this program, the SCONC is engaging students and the broader community to introduce weather and climate concepts through precipitation data collection.

Students compare temperature measurements from hand-held thermometers to those recorded by research-grade sensors on SCONC's mini tower.

Mission

As approved by the UNC Board of Governors, October 8, 1998

The mission of SCONC as a Public Service Center is to define, predict and disseminate information about the climatic and environmental factors that impact the people of North Carolina. SCONC has defined the following objectives as the primary focal points of service to the people of North Carolina:

EXTENSION

- Provide the most accurate climate information to the citizens of North Carolina.
- Assist North Carolina state agencies in climate-environment interaction issues and related applications.
- Establish, operate, and maintain an extensive meteorological network across North Carolina and archive and disseminate this data to the public in a timely fashion.
- Assist other extension scientists by integrating climate information into applications such as agricultural and environmental models.
- Increase public awareness of variations in North Carolina's climate and environment.

RESEARCH

- Study North Carolina's climate and its interaction with the environment.
- Investigate the effects of climatic variations on agriculture, air pollution, and natural resources and develop forecasts that assist in resource management.

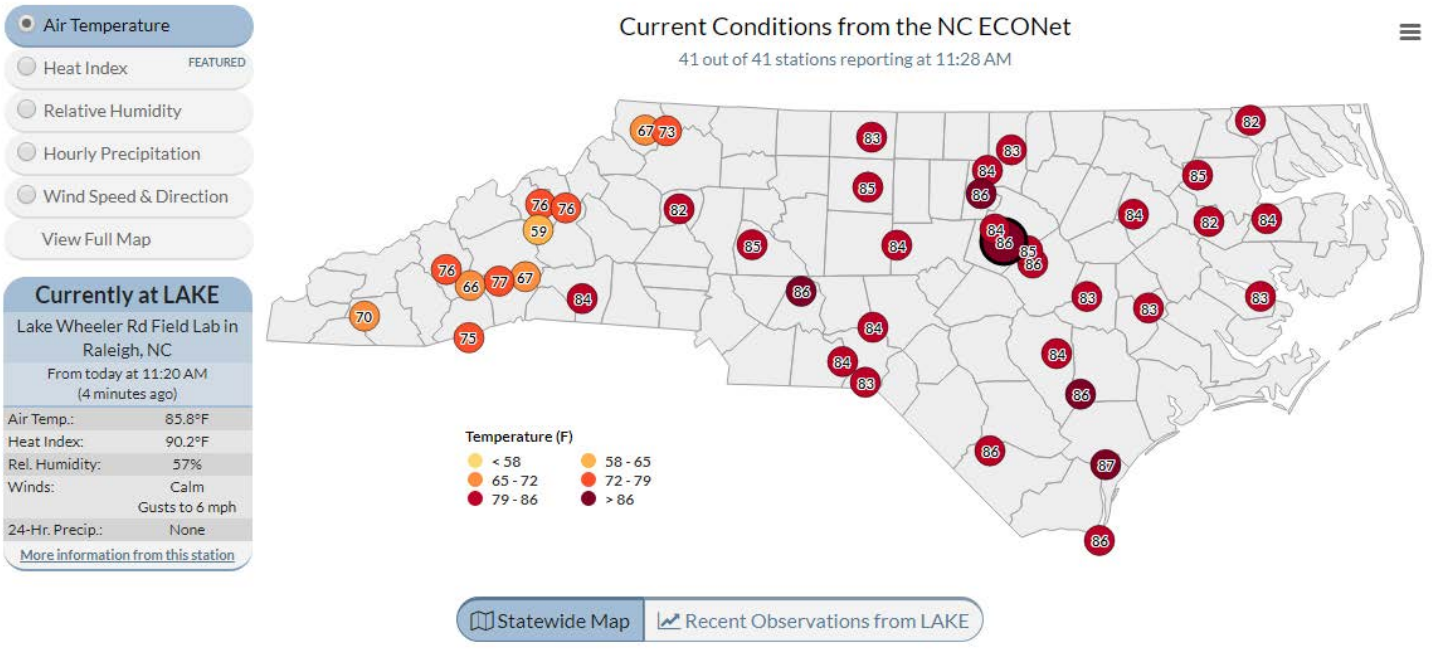
EDUCATION

- Interact with K-12, community college teachers and students, and with other community organizations on different aspects of North Carolina's climate and environment.

Highlights from Last Year

NEW WEBSITE LAUNCHED

In late 2017, SCONC launched a new website designed improve the accessibility of climate information. The new website was built as part of several user-engagement and feedback sessions to inform the design, functionality, and usability. Because the ways in which users access the website has evolved, SCONC used a responsive design to improve the experience and accessibility for users with various sized screens, including smartphones. The new website features a lighter, modern color scheme and updated fonts. Menus were restructured and simplified to feature the most-viewed content, such as climate education materials, data request and retrieval options, and web services including maps and tools. A new map and graphing tool was added to the homepage, allowing visitors to quickly view a snapshot of current conditions across the state and download recent data measured by SCONC's ECONet. Every staff and student had the opportunity to participate in this enormous undertaking.



The map pictured above is from the new SCONC homepage, where near-real-time conditions from the NC Environment and Climate Observing Network (ECONet) are displayed. Users can toggle between several parameters to the left of the map, or view more parameters by clicking "View Full Map." Finally, clicking the "Recent Observations" button beneath the map shows a time series of information for the station closest to the user's location.

FIVE-YEAR REVIEW

SCONC completed its five-year review process of the Center in January 2018. Over the past five fiscal years (2013 – 2017), SCONC developed decision support systems and information portals for multiple sectors including forestry, fire weather, and water resources. Services provided to stakeholders include pest and disease alerts and forecast services for agricultural resource management. SCONC has also sustained engagement and service to the public health community in North Carolina.

SCONC has a 41-year history of serving the citizens of North Carolina. Over this period, the demand for weather and climate information and services has grown exponentially, and subsequently, the program has expanded to meet this demand, both in personnel capacity and technology development. Its core mission (applied research, extension, and education focused on climate-environment interactions), identified by the UNC Board of Governors in 1998, laid out a roadmap that has contributed to the development and success of the Center over the past 20 years. SCONC continues to have substantial growth potential as climate science evolves and end-user requests increase in complexity.

Future efforts of the SCONC include ongoing service as the resource for weather and climate information for the citizens of North Carolina as well as state agencies, and continued facilitation of cross-disciplinary development of applications influenced and driven by climate-environment interactions. SCONC also plans to continue to serve as a climate science focal point for regional and federal partners, and contribute to multi-state environmental needs.

NEW TEAM MEMBERS

SCONC welcomed two new members to our staff over the last year.

Darrian Bertrand is an Applied Climatologist joining us from Oklahoma. She received a B.S. in Meteorology with minors in mathematics and GIS, and an M.S. in Geography from the University of Oklahoma. During her graduate studies, she used statistically downscaled climate projections to analyze the future frequency of heavy rainfall and severe drought events in the south-central US. Other studies she has completed include a climatology of prescribed burn days in the south-central US and a visual drought scale. She is currently working on products for the Fire Weather Intelligence Portal and assessing wet bulb globe temperature in relation to heat-related illness.

Joseph Taylor is an Instrument Technician who rejoined SCONC during the last year. He previously worked as an undergraduate research assistant at SCONC before graduating from NC State in 2013 with a B.S. in Meteorology and Marine Science. He recently received his M.S. in Soil Science with a certificate in GIS. During his graduate studies, he used lightweight cameras mounted on small unmanned aircraft to detect nitrogen levels in wheat and corn. He is now providing maintenance and data quality control for the ECONet. He has worked on a statistical model to forecast soil moisture and is currently working on developing a multi-level soil temperature model for use in data quality control routines.

Climate Extension Services

Providing climate services through direct contact, online databases and analysis tools, environmental monitoring, and routine climate summaries is part of SCONC's core mission of extension. SCONC partners closely with scientists in agriculture, natural resources, public health, water resource management, and other sectors to develop and deliver custom products and tailored climate services. SCONC also supports regional climate services across the southeast in partnership with the NOAA Southeast Regional Climate Center and USDA Southeast Regional Climate Hub.

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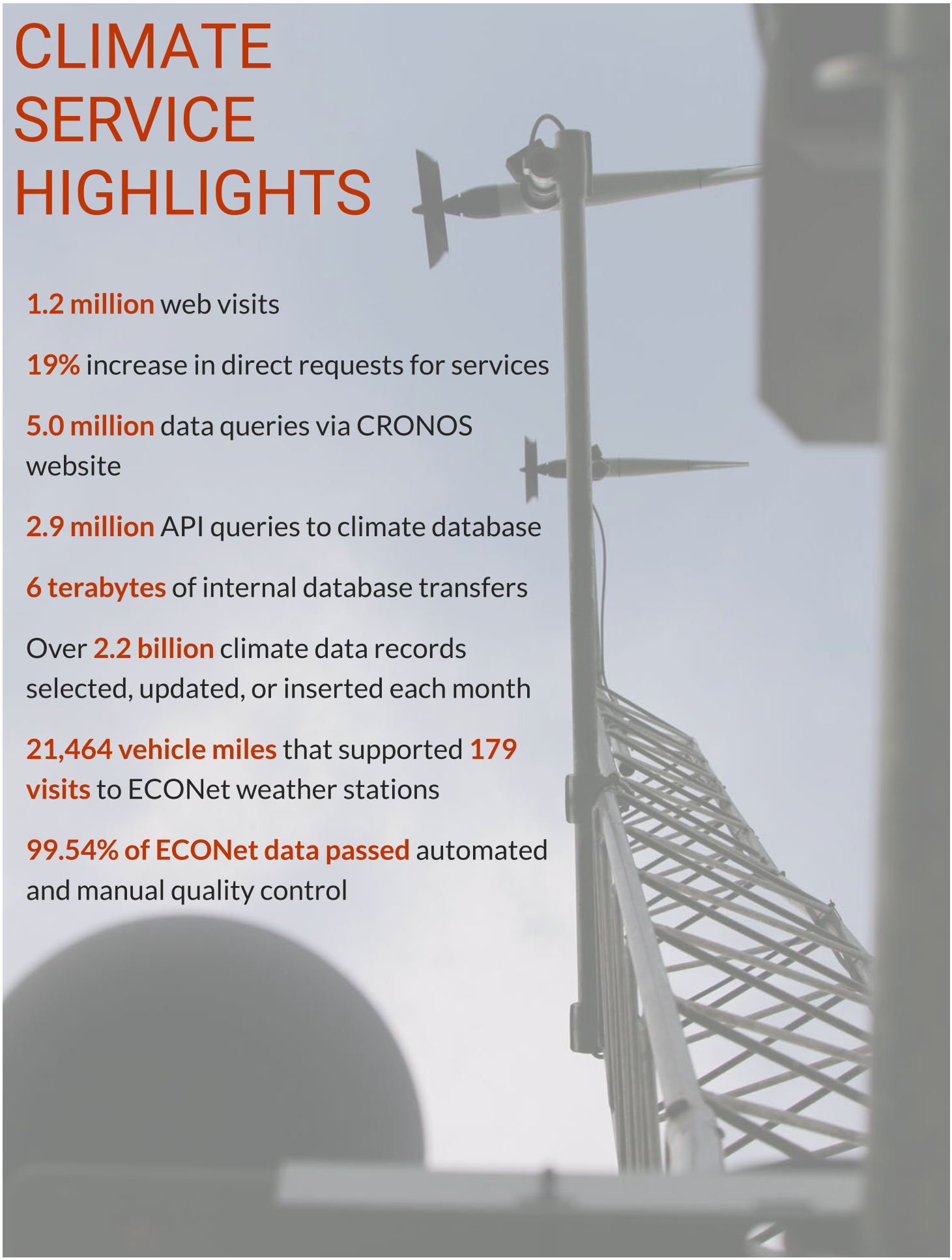
CLIMATE SERVICE HIGHLIGHTS



1.2 million web visits

19% increase in direct requests for services

5.0 million data queries via CRONOS website

2.9 million API queries to climate database

6 terabytes of internal database transfers

Over **2.2 billion** climate data records selected, updated, or inserted each month

21,464 vehicle miles that supported **179 visits** to ECONet weather stations

99.54% of ECONet data passed automated and manual quality control

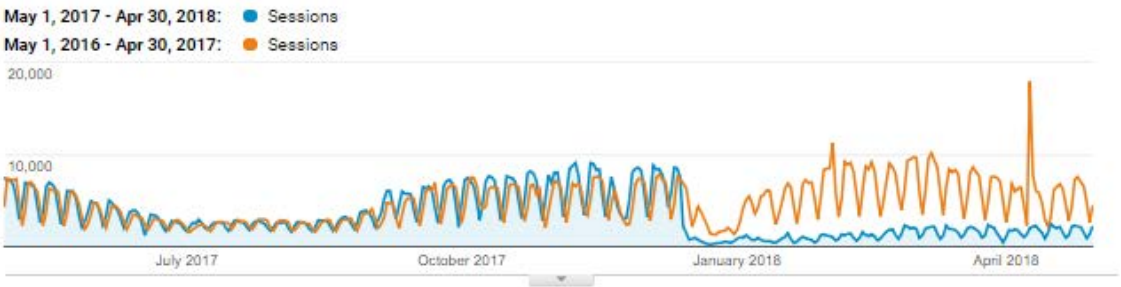
Climate and Information Services

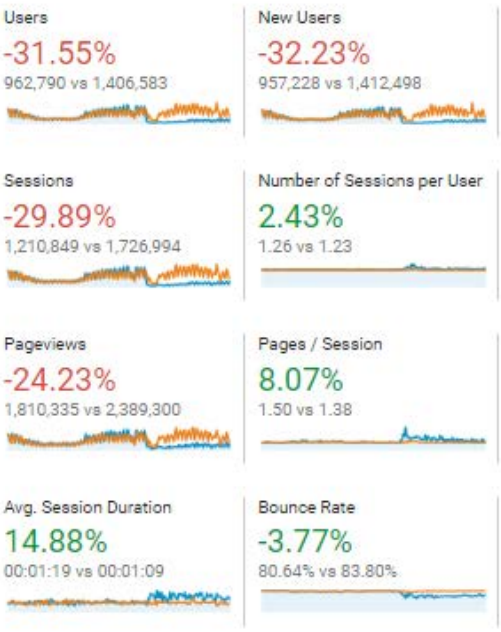
CLIMATE SERVICES

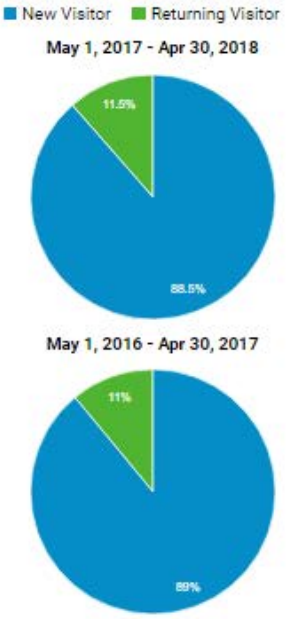
SCONC provides many climate services to clients and partners. Climate services is a broad concept, but fundamentally involves interaction between a client or stakeholder who needs climate information and SCONC scientists who are experts in climate data and climate science. Many users are not sure what data or information is best for their needs, and often need guidance on how to properly use and interpret climate information. SCONC staff and students interact directly with users to ensure responsive and reliable climate information services. The SCONC website is often the first point of contact with clients who need climate information. Effort continues to focus on developing web products and tools based on weather and climate data to provide dynamic products and services.

WEB SERVICES USAGE

Last year, the SCONC website received 1,210,849 visits (graphic below), a decrease of nearly 30% over the previous year (1,726,994). This decrease resulted from the new website design that consolidated and streamlined many products and services, making them easier to access and more intuitive to use. The overall bounce rate, or percentage of visitors who leave a site after visiting only one page, decreased by 3.77%. Of the total number of visits, 957,228 (88.6%) were from new visitors, a decrease from 1,412,498 in the previous year. Despite this one-year dip in the number of visitors, overall web traffic has increased by 591.5% since 2008-09.







Pictured left are Google Analytics for the SCONC's website visits over the report period.

MOST VISITS ON A SINGLE DAY

13,563 on October 24, 2017. The SCONC's K-12 Education page on Climate Change Causes had 59.9% of daily traffic on this day (8,118 visits)

STATION MOBILE WEBSITE

At each of our ECONet stations, a sign is posted with a QR code and website address that link to a page showing the station's current weather data. This page is designed for mobile devices so users visiting our stations can view the latest conditions on their smartphones. Airport weather stations are also included on the mobile site, allowing users to also view recent conditions at these locations. The Station Mobile Websites received 7,183 total page views for the period; the most frequent visits by station are:

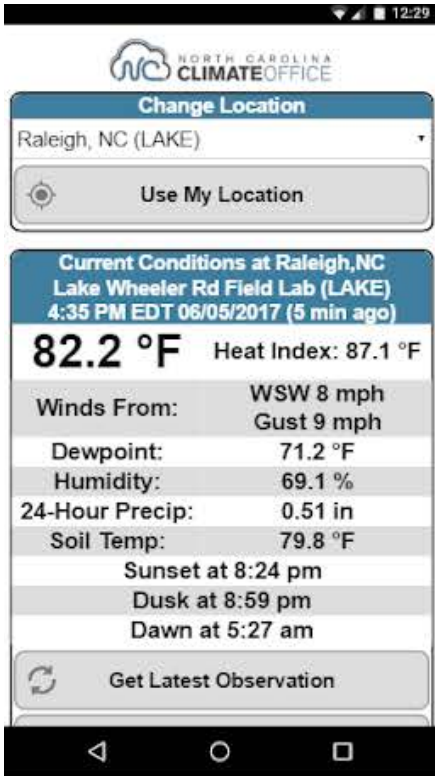
- 19.6% for Sassafras Mountain (SASS)
- 18.2% for Frying Pan Mountain (FRYI)
- 14.8% for Mount Jefferson JEFF)
- 5.8% for Bahama (BAHA)
- 5.7% for Clayton (CLAY)

CONTENT HIGHLIGHTS

What were visitors looking at?

60% of all page views on the SCONC website were K-12 Education Content,followed by 12.3% for Aspects of NC Climate. 7.7% of all page views were data requests. Data requests visits by station (7.4% of all page views)

- 17% for Mount Mitchell ECONet (MITC) (1.3% of all page views)
- 5.5% for Grandfather Mtn. ECONet (GRANDFATHR)
- 3.0% for Lake Wheeler ECONet (LAKE)
- 2.4% for Bald Head Island ECONet (BALD)
- 1.6% for Sassafras Mountain ECONet (SASS)
- 1.4% for Bear Wallow Mountain ECONet (BEAR)
- 1.3% for Goldsboro ECONet (GOLD)



WEB TRAFFIC SUMMARY

How are visitors getting to the SCONC website?

- 79.9% of website visits came from a search engine (e.g., Google)
- 15.3% of website visits came from direct sources (e.g., bookmarks, direct URL)
- 0.5% of website visits came from social media
- 4.2% of website visits came from non-search engine referring sites such as news articles

VISITS BY LOCATION

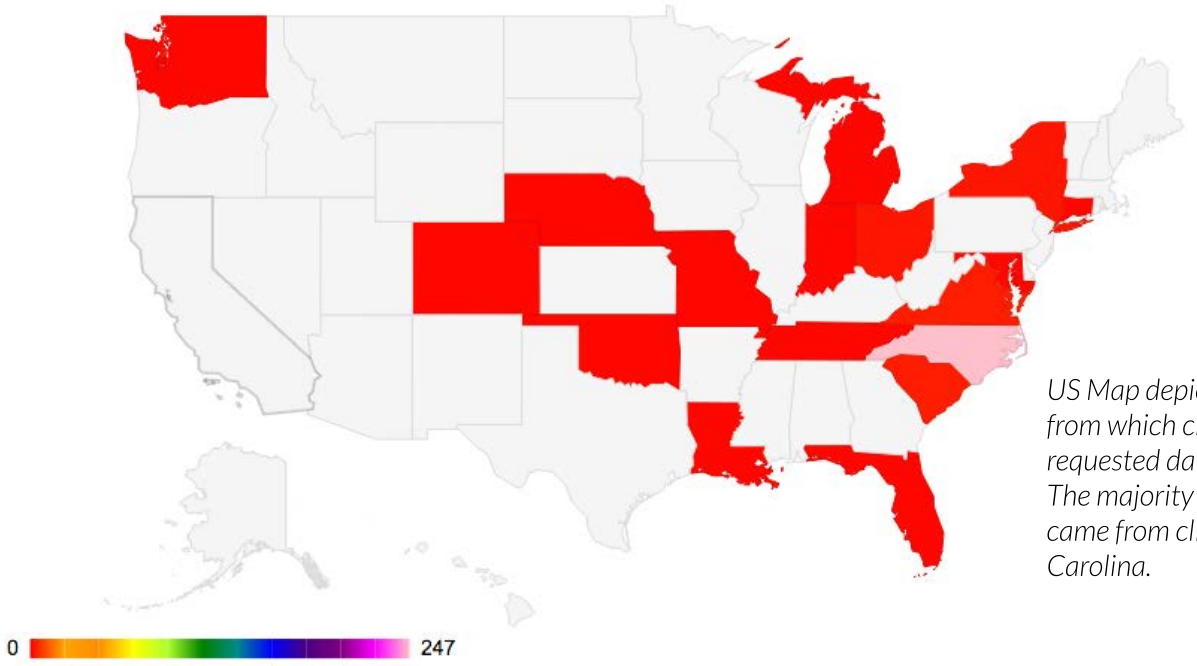
Where are website visitors from?

US State Visits (58.3%)

- 23.4% of all visits came from North Carolina (165,022)
- Among other states, the most visits were from CA (9.5%), TX (5.4%), FL (5.2%), NY (4.9%), GA (3.6%), and VA (3.1%)
- 19 states had 10,000+ visits
- 1,000+ visits from every state but WY

Global Visits (41.7%)

- Most visits were from India (10.9%), Philippines (4.3%), UK (4.1%), Canada (3.9%), and Australia (2.7%)
- Overall, 1,000+ visits from 53 countries and 100+ visits from 136 countries



US Map depicting the states from which clients have requested data in the past year. The majority of data requests came from clients in North Carolina.

LOCATIONS OF CLIENTS REQUESTING DATA

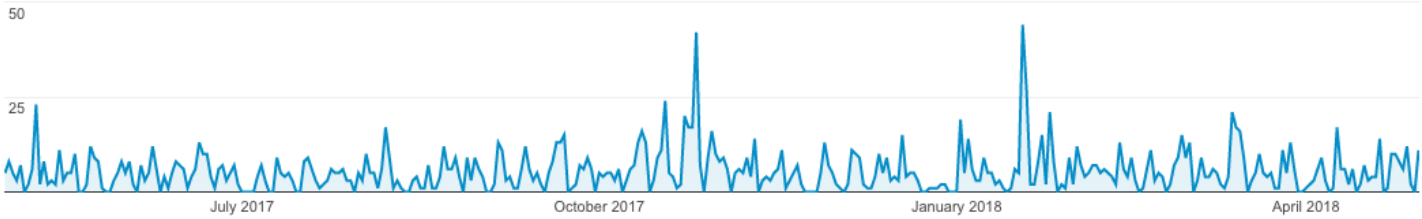
Most clients requesting data were from North Carolina (78.9%) while 12.1% of clients did not specify their location when submitting a request. The remaining requests were put in by clients from 16 other states averaging 1 to 4 requests each. The previous year had roughly the same distribution in client locations.

DATA REQUESTS FOR SERVICES

The past year saw a 19% increase in direct requests from clients via email and phone, as well as a 10% increase in time spent directly responding to requests for services from clients compared to the previous year. As with most years, a large percentage of time was devoted to supporting educational requests (68%), while remaining effort went largely to support government (15%) and private industry (11%). Formal personal interest requests accounted for 6% of effort. A detailed breakdown of request-driven climate services is provided in Appendix A.

DATA REQUEST FORM STATISTICS

The data request form retrieved 1,404 unique sessions (or page views, pictured in the time series below) from May 1, 2017 through April 30, 2018. The average user spent roughly 2 minutes and 7 seconds on the page, while the page itself had a bounce rate of 48.5%, which suggests just over 50% of the users who visit the page fill out the request form. These numbers were slightly higher than for the previous year, in which fewer data requests were submitted overall.

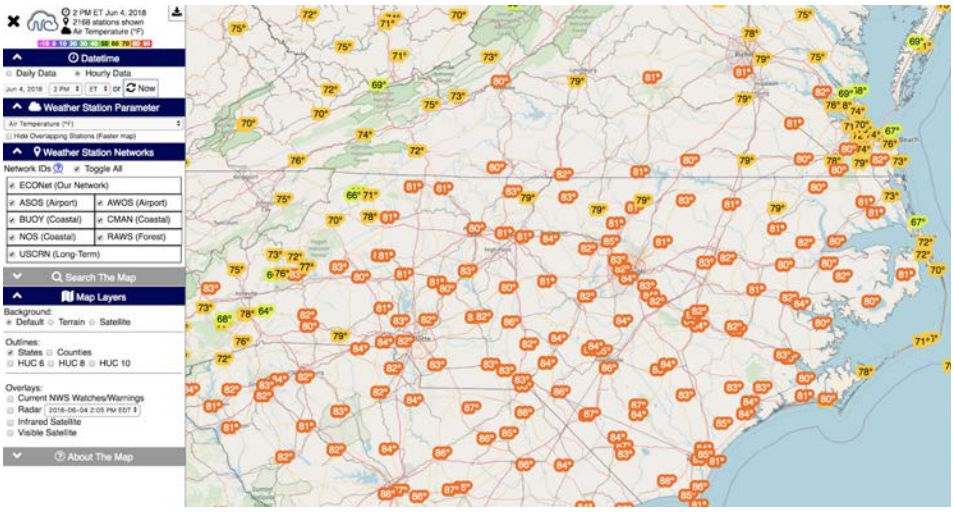


The graph above shows daily submissions to the data request form over the annual reporting period. A weekly signal is evident, with few to no request submitted over the weekends.

Climate Data Access and Management

WEATHER DATA VISUALIZATION

An updated mapping interface has been developed as part of the new website. This tool provides a large full-screen map with updated graphics and navigation abilities. Weather parameters from multiple networks measuring hourly and daily data are available through this mapping interface, and both past and current conditions can be displayed. In addition to point-based observations, overlays of radar, satellite imagery, and watches and warnings are available through a variety of geospatial layers.



Hourly air temperatures are displayed from multiple networks across NC and surrounding regions. Additional weather parameters and lays can be selected from the menus on the left.

DATA ACCESS

As part of SCONC's new website launch, data accessibility for mobile devices has been improved. Nearly 40% of all web site traffic now comes from moble devices. This is a substantial increase from less than 15% five years ago. Most tools and website content were converted to a responsive layout to accommodate screens of various sizes, allowing these resources to be functional on smartphones and tablets. The Station Mobile Website is also a mobile-friendly way for visitors at ECONet stations to directly retrieve the latest weather conditions at a given station. Airport weather stations are also included on the mobile site allowing users to also view recent conditions at these locations.

In addition, a new Application Program Interface (API) is in beta testing, adding many important and user-requested features such as data aggregation, variable calculation, and unit conversion to the existing API's functionality. This new API will enhance data accessibility for advanced users and automated applications. Future features planned for the API include a nearest station lookup and an option for "best-estimate" data.

API work over the past year improved both the server-side and client-side usability. On the server side, the focus has been on updating and adding new data sources and linking variables to different data tables, network types, and formula calculations. For the client side, a query builder interface is being developed to allow API clients easier access to data streams.

The API incorporates parameter metadata such as units, sensor information, and date of first observation of each variable at a given station. This information will allow the API to generate a best estimate where data is unavailable or missing based on other observed parameters or using gridded data such as analyses or forecasts as a surrogate. The API is being written to use a variety of universal output formats, such as JavaScript Object Notation (JSON) and comma separated values (CSV), which will allow the output to be easily incorporated into various programming languages such as PHP, Python and Perl.

DATA USAGE

Users submitted 5.0 million data queries through the CRONOS website interface – an increase of 47% compared to last year. More than 2.9 million additional queries were requested through the web services API. Along with those point data retrieval options, SCONC provides access to 85 terabytes of gridded data to partners and end users. Network and data support for CRONOS users has shown a significant increase in the amount of internal data ingest, management, and transfer. Each SCONC database averages more than 6 terabytes of internal climate data transferred each month with about 2.2 billion data records selected, updated, or inserted each month.

DATA MANAGEMENT

New database modernization efforts are ongoing. New storage engines have been deployed on SCONC's back-end database infrastructure. These upgrades will allow for improved transaction monitoring as well as faster backup and recovery protocols. As demand for large gridded datasets continue to increase, SCONC is working to seamlessly integrate multiple workflows and enhance data accessibility.

Changes over Past Year:

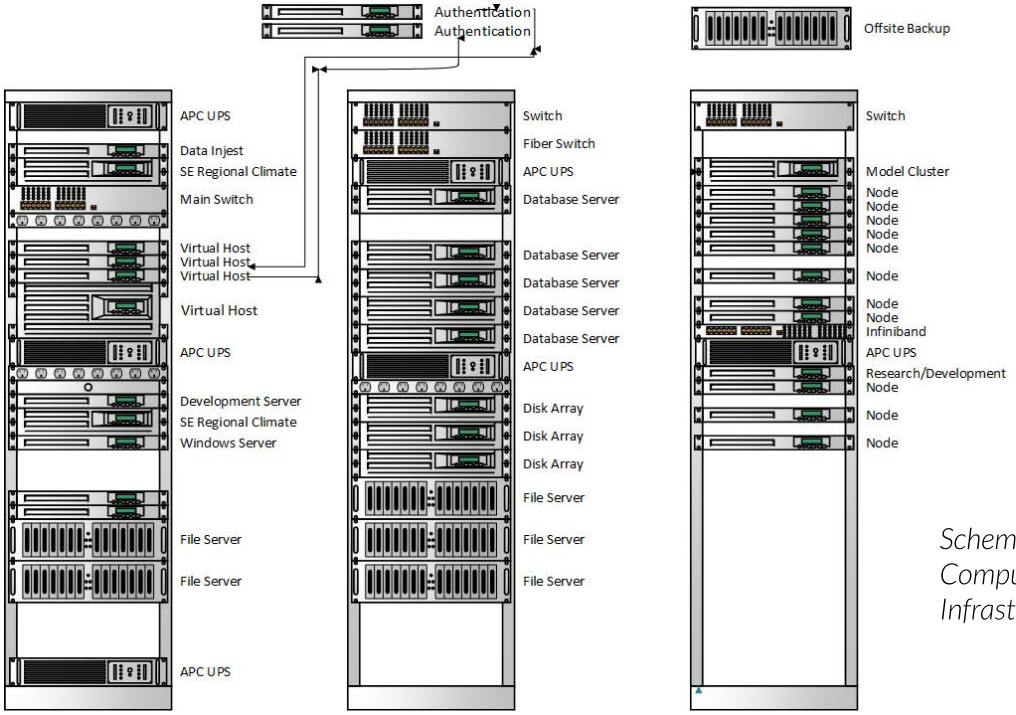
- Continued migration into a virtualized services environment
- Added additional off-site systems for redundancy and backup
- Added more versatile iSCSI storage

Computing Environment Statistics over Past Year:

- Total Processing Core - 413 Cores
- Total Memory Available - 1.87 TB
- Total Storage Allotment - 257.28 TB
- Average Daily Write Network Throughout - 7.02 TB

Performance Statistics over Past Year:

- Web Services Uptime - 99.962%
- Average Database (DB) Availability Uptime (across all DB servers) - 99.922%
- Primary Database Availability Uptime - 99.98%
- Storage Uptime - 99.968%
- Computational Uptime - 99.973%



Schematic of SCONC Computing Infrastructure.

NC Environment and Climate Observing Network (ECONet)

The SCONC operates and maintains an extensive monitoring network, the Environment and Climate Observing Network (ECONet) that provides high-quality, real-time observations that support state, local, and federal agencies. Base funding for the ECONet is provided by the NC Agricultural Research Service, which supports the maintenance of sensors at agriculture research stations. Additional support is provided by the National Mesonet Program and individual local partners. The ECONet uses research-grade sensors to deliver unique, comprehensive observations, such as solar radiation, soil temperature, and soil moisture, to sectors that are sensitive to weather and climate information .

STATION MAINTENANCE

Each station was visited multiple times for routine maintenance over the past year. These visits help keep the stations operating efficiently and providing high quality data. In total, **158 site visits** were made to perform routine or emergency maintenance covering **21,464 vehicle miles** – a **12% decrease in site visits** and a **15% decrease in vehicle miles** from the previous year. Proactive station maintenance has helped optimize network operations, increase efficiency, and reduce maintenance costs. Sensor maintenance activities of the past year included:

- 44 wind monitors serviced and 4 wind monitors replaced
- 31 all-season precipitation gauge sensors serviced and 11 sensors replaced
- 54 radiation sensors serviced for calibration
- 19 leaf wetness sensors serviced and 28 leaf wetness sensors replaced
- 29 soil temperature sensors serviced and 5 soil temperature sensors installed or replaced
- 13 soil moisture sensors serviced and 5 soil moisture sensors replaced
- 23 integrated probes (measuring wind, temperature, humidity, pressure, and precipitation) serviced and 5 probes replaced
- 3 data loggers replaced and re-calibrated
- 10 temperature/relative humidity sensors serviced and 11 sensors replaced
- 6 black globe thermometers installed

Even wildlife can't get enough of our weather towers! Two tree frogs were found hanging out by our solar radiation sensors during one routine maintenance visit to our Goldsboro, NC, station.

NEW STATION INSTALL

On February 1, 2018, the 41st station in our network was installed and activated in Bahama, NC, at the Butner Beef Cattle Laboratory. This station is sponsored by the NC Agriculture Research Service and the NC State College of Agriculture and Life Sciences. This station was the first in our network to have a black globe thermometer installed to better understand heat stress among humans and livestock.

Staff working on installation at SCONC's Bahama, NC, station.

NEW SENSOR DEPLOYMENT

Over the course of the reporting year, two new sensors were installed at a few locations to help monitor temperature. Black globe thermometers have been installed at six of our ECONet stations to help calculate Wet Bulb Globe Temperature (WBGT), which can quantify heat stress. For the 2018/19 reporting year, SCONC plans to install more of these thermometers throughout the network.

The second new sensor is an infrared thermometer used to monitor skin temperature, or the temperature at the ground surface. This sensor was tested at our Lake Wheeler Road site during winter 2018 to monitor ground temperatures during wintry weather events. While this sensor is still considered experimental, it could be deployed at more stations next winter to better monitor ground temperatures.

This black globe thermometer was installed at the Rocky Mount ECONet tower on March 3, 2018.

QUALITY ASSURANCE & QUALITY CONTROL

QAQC routines are run twice per hour and help scientists spot erroneous values and failing sensors across the ECONet. Over the past year, ECONet data passed automated and manual quality control routines **99.5% of the time**, while **only 0.2% of all data failed** all QC checks.

Most of the QC checks were enhanced this year to account for new sensor deployments. Ongoing QC development is focusing on inter-sensor comparisons – especially between soil temperature probes and temperature/humidity probes. A new inter-sensor comparison was implemented this year that models soil temperatures at multiple depths and compares those values with observations. Inter-sensor tests are currently being developed for our co-located temperature/humidity sensors and wind speed sensors.

Undergraduate students continue to assist scientists with the daily examination of ECONet data using the QC interface. This manual QAQC has led to improved data quality and earlier detection of sensor failures.

NATIONAL MESONET PROGRAM

As part of the National Mesonet Program, ECONet observational data files are sent to the NOAA Meteorological Assimilation Data Ingest System (MADIS), which is a national gateway for dissemination to operational and research groups. In addition, monthly reports summarizing the network's availability are provided to MADIS. As a courtesy, alerts were sent to MADIS if data became unavailable for an extended period.

As part of the National Mesonet Program, all ECONet stations have been upgraded to transmit data to the State Climate Office every five minutes. The data are then relayed to our partners at MADIS. Over the past year, ECONet data availability (defined as observations being received within one hour of the original observation time) is 97.9%, which is an increase of 1.7% from the previous year.

Snow lingers on the ground at the Wallace, NC, ECONet tower.

Climate Support for Agriculture

PEANUT DISEASE ADVISORIES

This is the 14th year of SCONC's partnership with Dr. Barbara Shew (NCSU Plant Pathology) to provide routine advisories for two peanut foliar diseases: peanut leaf spot and peanut sclerotinia.

From June through September, daily email alerts are sent for review by Dr. Shew, who then passes along guidance to her constituents across eastern NC and southeastern VA.

Example map output showing locations with elevated risk for Cucurbit Downy Mildew outbreaks.

Analysis from past years suggests these advisories can save 2-3 fungicide applications per year, with a value to growers of at least **$1 to 3 million per year**.

CUCURBIT DOWNY MILDEW FORECASTS

In an ongoing collaboration with NCSU Plant Pathology, SCONC provides operational, national Integrated Pest Management (IPM) forecasts for downy mildew affecting cucurbits (cucumbers, melons, squash, etc).

This includes providing weather information, technology support, and dispersion forecast guidance. SCONC continues to work with partners in NCSU Plant Pathology to maintain the website and forecasting tools.

There were 220 confirmed reports of Cucurbit Downy Mildew (CDM) this year, an increase from 163 reports during the previous year. These reports triggered 23,512 alerts sent to 406 unique phone numbers or email addresses. During the year, 47 new alert sites were added to bring the total number of active sites to 428 as of May 15, 2018.

LATE BLIGHT FOR POTATOES AND TOMATOES

In collaboration with Dr. Jean Ristaino (NCSU Plant Pathology), SCONC continues to provide technology support and website administration for monitoring and alerts of late blight affecting tomatoes and potatoes. This year, the group worked with Christopher Parker in the NCSU Masters of Geospatial Information Science and Technology (MGIST) program's Capstone Experience to develop an interactive story map that highlights seven years of confirmed alerts across the country.

Over the past year, there were 76 confirmed reports of late blight, which is an increase from 52 during the previous year. These reports triggered 7,749 alerts sent out to 370 unique phone numbers or email addresses. In addition, 35 new alert sites were added for a total of 498 active sites as of May 15, 2018.

THRIPS EXPOSURE GUIDANCE FOR COTTON GROWERS

In collaboration with Dr. George Kennedy and Thomas Chappell in the NCSU Entomology Department, SCONC has developed a Cotton Thrips Infestation Predictor tool for use by cotton growers and extension agents in North Carolina and the southeast US.

Gridded temperature estimates from the Parameter–Elevation Regressions on Independent Slopes Model (PRISM) were used in conjunction with thrips dispersal models developed by project partners to develop risk estimates for cotton growers. A series of dynamic infographics were developed to convey these risk estimates to users, with the ability to save searches and download content.

This website went live on April 1, 2017, was used throughout the spring 2017 planting season, and received minor updates in winter 2018. The tool has been positively received by growers across the southeast US and has been shared extensively through the NC Cooperative Extension Cotton portal.

FARM WATER NEEDS TOOL

In a collaboration with Dr. Garry Grabow in the NCSU Department of Biological and Agricultural Engineering, the Farm Water Needs Tool is a planning resource to determine how much water from irrigation is needed to satisfy crop water demand in addition to rainfall. The tool has been designed to provide estimates of required farm pond storage and monthly estimates of rainfall, runoff, and crop demand for users in North Carolina. Several different gridded meteorological datasets were evaluated against raw observations to determine which inputs were most accurate for North Carolina and should be used in the tool.

Once a user has provided their input data, such as location, crop, and planting date, the tool provides the user with an estimated farm pond storage capacity or a notice that the crop water demand cannot be met from rainfall and irrigation in a typical year. In addition, users are provided several graphs that show average rainfall and runoff as well as how runoff and crop demand progresses throughout the year. Several instructional videos have been developed to help users understand what the tool is, how it works, and how to interpret the output.

PINEMAP

Pine Integrated Network: Education, Mitigation, and Adaptation Project

The USDA-funded PINEMAP project ended in February 2017 after six years of effort from a team of more than 40 primary investigators at 13 institutions across the southeast US, including NC State University and the SCONC. PINEMAP researchers studied Loblolly pine genetics, management, and climate sensitivities, among other topics. SCONC provided the climate science expertise and developed the project's key deliverable, the PINEMAP Decision Support System (DSS, http://www.pinemapdss.org), which highlights future climate-based risks and opportunities for foresters.

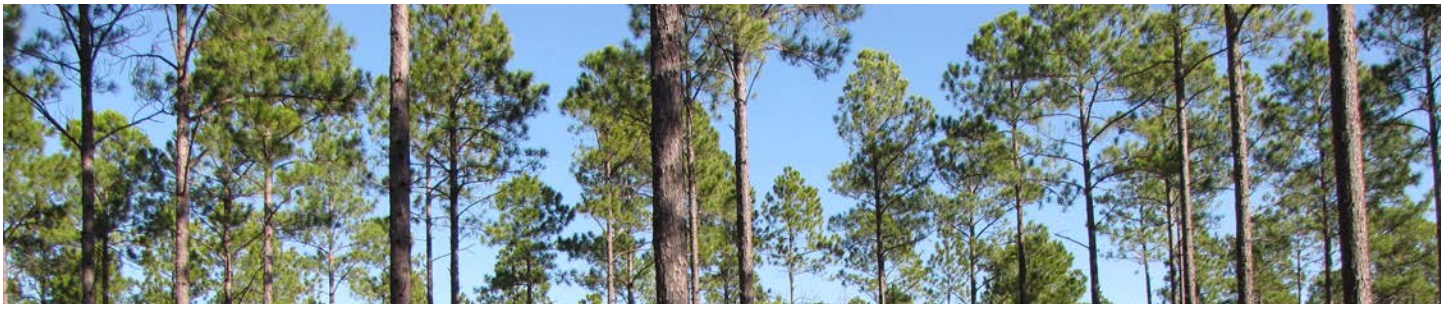
Since the end of the project, the USDA Southeast Regional Climate Hub (SERCH) has provided support for the exploration and creation of new tools in the PINEMAP DSS. In March 2018, a webinar was conducted by SCONC and SERCH

for Cooperative Extension agents and southern foresters. This included a brief demonstration of the DSS and a productive feedback session that highlighted several key information needs, including guidance on fire risk and pest risk. Work on creating such grids based on future climate projections and historical climate data is ongoing, with a tool showing the average number of dry days in the spring fire season expected to be completed and integrated into the DSS in summer 2018.

In collaboration with NCSU's Marine, Earth, and Atmospheric Sciences Geoscience Education and Geocognition Laboratory, four publications related to the PINEMAP DSS are in preparation for the following peer-reviewed journals: Weather, Climate, and Society (two of the four), the Bulletin of the American Meteorological Society, and the Journal of Usability Studies.

Over the past year, engagement has continued with PINEMAP project partners as well as external project partners via presentations and requests for weather and climate data. In addition, PINEMAP has led to several collaborations or proposal discussions including the following topics: 1) a climate-based risk assessment of non-native fish populations in Florida and the broader southeast US, 2) potential shifts in the lightning-ignited fire season in the southeast US, 3) a study on the relationship between climate and the production dynamics of Brazil nut trees, 4) a climate-based decision support system for New Zealand, and 5) a climate-based decision support system for a target audience of wildlife and fisheries.

Image: The_Gut, under CC2.0 license.



ENVIRONMENTAL MODELING

SCONC continues to produce routine experimental numerical weather and dispersion forecast guidance. These forecasts are distributed to multiple agencies, including the National Weather Service. Model output is included in SCONC's Fire Weather Portal and provides inputs to a series of agricultural products. Additionally, SCONC provides numerical guidance for cucurbit disease forecasts and efforts with smoke management.

Support for USDA Southeast Regional Climate Hub

Through a cooperative agreement with USDA, SCONC is providing technical, scientific, and extension expertise for the Southeast Regional Climate Hub (SERCH). SERCH is focused on the extension of climate science to support needs and informed decision making on working lands in the southeast US, including forests, rangelands, and croplands.

Last year, SCONC provided scientific and technical support to complete three primary tasks described in this section.

1. Information Development and Applied Support for Extension:

Three applied climate documents were completed for forestry extension agents as well as forest and land managers:

- A white paper on "Southeast Drought Impacts and Forest Management",
- A factsheet for USDA Forest Service Region 8 on "Drought Impacts in the Southern Region", and
- A paper on system drivers and stressors for the East Texas National Forests and Grassland Assessment.

In addition, a review was performed on Chapter 3 of the Global Forest Expert Panels (GFEP) assessment on Forests and Water, which highlights drivers and their pressures. Lastly, a webinar on “Climate Considerations When Developing Updated Seed Zones” was presented in April 2017 as part of the Eastern Seed Zone Forum's online lecture and discussion hours.

2. Template for Assessing Climate Change Impacts and Management Options (TACCIMO):

TACCIMO is a web-based tool containing peer-reviewed literature on climate change effects on forest ecosystems, agriculture, rangelands, and livestock with an emphasis on options for adapting management strategies and planning processes. With a target audience of land managers, foresters, extension agents, and farmers, TACCIMO allows users to search, sort, and filter text quotations and figures that are related to their areas of interest. To remain relevant and effectively inform land managers of the potential impacts of climate change on their natural resources, the literature database that drives TACCIMO is being updated with findings from the most recent peer-reviewed research.

3. Fire Weather Email Alerts:

SERCH is developing email alerts that notify subscribers about wildfire risk and prescribed burning suitability. The alerts are calculated using the Keetch-Byram Drought Index (KBDI) and are being developed in coordination with SCONC’s Fire Weather Intelligence Portal. Early user engagement with the Southern Regional Forestry Extension group was conducted to inform the subscription parameters. Technical development is wrapping up and user testing and rollout are expected in the near future.

Climate Support for Tools and Decision Applications

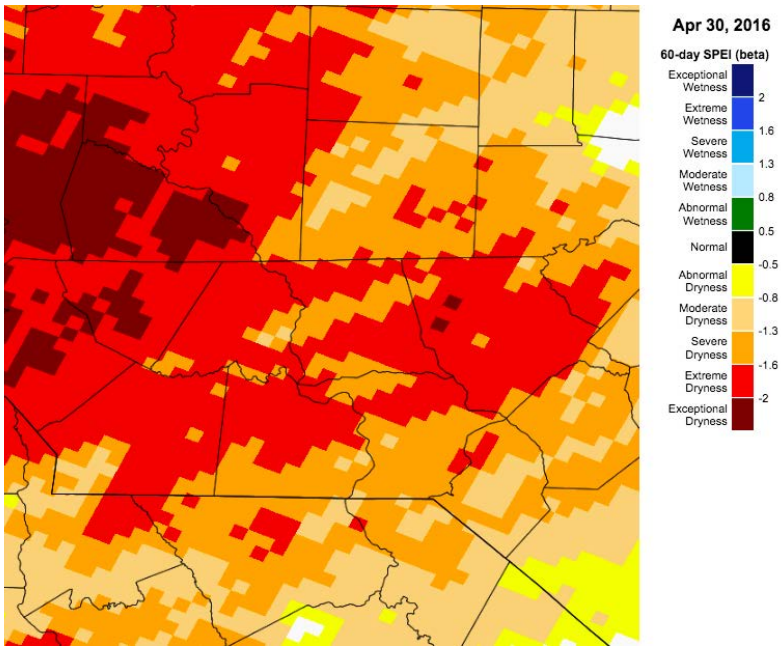
DROUGHT MONITORING & RESPONSE

SCONC is a member of the NC Drought Management Advisory Council (NC DMAC), participating in weekly drought monitoring conference calls and providing public presentations on drought in North Carolina. During the weekly calls, SCONC provides information on recent precipitation placed in a historical context, the current level of dryness as indicated by drought indices generated by SCONC, and on-the-ground information provided by citizen scientists as part of the CoCoRaHS Condition Monitoring program. SCONC has facilitated easier decision making among the NC DMAC by developing the capacity to draw drought category boundaries on web-based map displays, which is frequently used to communicate the council's consensus to US Drought Monitor authors. Through monthly climate summaries and blog posts, interviews for print and broadcast news media, and presentations to community and professional groups, SCONC provides frequent updates on drought conditions and impacts, information about the climate drivers of drought, and the NC DMAC monitoring process.

SCONC scientists participated in the NC DMAC's annual 2018 in-person meeting.

HIGH-RESOLUTION DROUGHT INDICES

SCONC continues to generate and publicly provide several drought indices: the Standardized Precipitation Index (SPI), the Standardized Precipitation Evapotranspiration Index (SPEI), the Keetch Byram Drought Index (KBDI), and percent of normal precipitation. These indices are updated daily using high-resolution data from the National Weather Service and the PRISM Climate Group. During the past year, SCONC continued to serve these indices through tools on its websites geared for monitoring drought and surface water conditions, as well as provide grids and supplemental information to researchers from academia, state, and federal government. Grids are used in weekly drought assessments in North Carolina as part of the NC Drought Management Advisory Council's activities and across the US as input into the US Drought Monitor. A manuscript describing the SPEI's calculation and evaluation for monitoring agricultural and hydrological drought is in



Gridded drought index (SPEI)indicating dry conditions in the southwestern piedmont of NC during Spring of 2016.

FIRE WEATHER INTELLIGENCE PORTAL

In 2017, the Fire Weather Intelligence Portal — a real-time monitoring tool initially developed for the NC Forest Service beginning in 2011 — was expanded for states and users all across the southeast US with funding from the USDA Southeast Regional Climate Hub. Data from 13 states from Virginia through Texas is now available in the Portal, and the tool received a back-end update to make data load more quickly and to look and function more smoothly on mobile devices.

The launch of the expanded Portal was announced via a First Friday All Climate Change Talks webinar, a presentation and demonstration at the Association for Fire Ecology's International Fire Ecology and Management Congress, and a webinar hosted by the Southern Fire Exchange and conducted by SCONC and the Montgomery Community College Prescribed Fire Training Center.

Image credit: NC Forest Service

As users across the region explored the Portal, it received an 28% increase in page views, from 33,802 last year to 43,183 this year. In the past year, this tool received a total of 6,875 unique visitors – a 14% increase from the previous year.

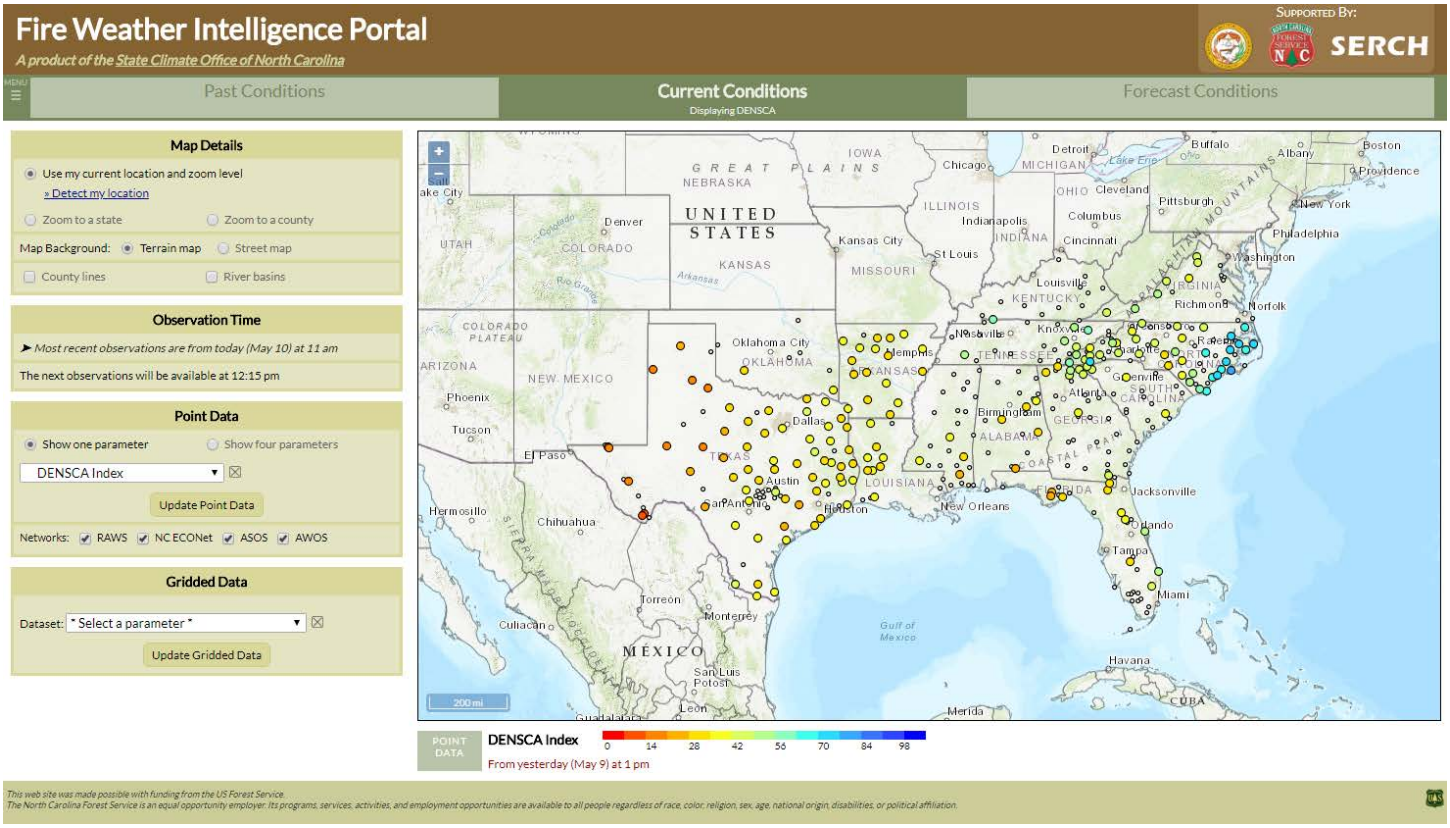
The NC Forest Service and SERCH have provided ongoing support for additional development and engagement with the Fire Weather Intelligence Portal. This has included the addition of new datasets such as US Drought Monitor boundaries and the DENSCA Index that can help inform fire monitoring and management decisions.

In addition, a SCONC undergraduate student has explored various methods of estimating solar radiation from the cloud cover observations available at airport-based weather stations due to upcoming changes to the National Fire Danger Rating System. These changes will require the availability of station-based solar radiation data to calculate fire risk parameters. Comparisons between modeled and observed solar radiation values at nearby stations in North Carolina have highlighted the strengths and limitations of the existing estimation techniques. Further comparisons have been performed for Florida and Oklahoma in order to evaluate these estimates in the broader southeast US region.

In an effort to provide better region-wide forecast guidance, SCONC has also been generating several gridded smoke and fire products based on the office's WRF model:

- Burning Category is based on ventilation rates, and many southeastern states use this index for prescribed burning guidance, with values of 1 indicating conditions are unsuitable for burning and values of 5, which includes the highest ventilation rates, often more suited for burning.
- The Pasquill-Turner stability class uses surface wind speed, solar radiation, and cloud cover to assess atmospheric turbulence and, therefore, the stability of the atmosphere. This index includes seven categories ranging from extremely unstable (A) to extremely stable (G).
- The Lavdas Atmospheric Dispersion Index, based on mixing height and the Pasquill-Turner stability class, assesses burning conditions based on how well the atmosphere will transport smoke and particles. The index ranges from 0 to 100, where midrange values indicate good smoke dispersion and the ability to control fires.
- LVORI estimates the likelihood of low visibility due to smoke and is based on relative humidity and the atmospheric dispersion index. For this index, the number 1 represents the lowest likelihood of low visibility while a 10 is the highest category.

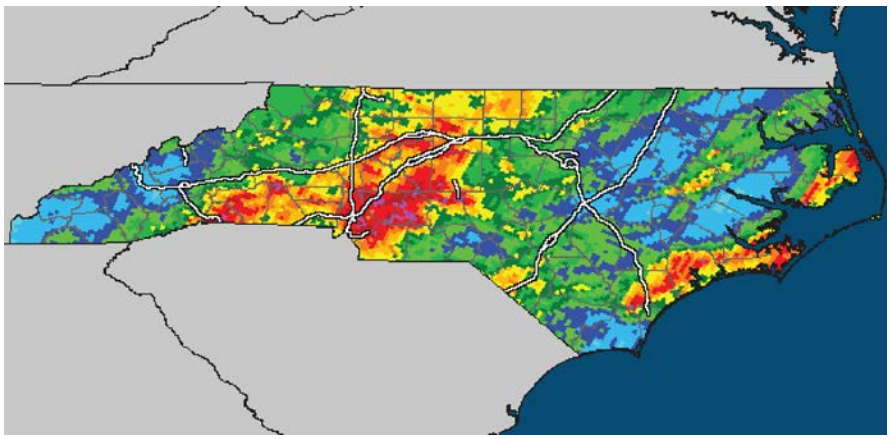
These gridded products will soon be tested and added to the Fire Weather Intelligence Portal to provide more useful tools to the southeastern fire community.



Calculated DENSCA Index – a parameter that combines several existing weather and fire danger indices to provide a single-number estimate of fire risk – for the southeast US.

PRECIPITATION MONITORING AND ALERTS

The NC Department of Transportation (NCDOT) continues to support SCONC to provide radar-based precipitation alerts and monitoring tools for storm water management. During the year, users created 669 individual alert sites and 533 projects for monitoring rainfall. Overall, there are 2,659 active alert sites for 1,901 projects as of May 15th, 2018. The NCDOT user-base continues to grow as demands for services increase. Over the past year, 185 new NCDOT user accounts were created, compared to 166 requests for new accounts in the previous year.



Gridded precipitation across North Carolina, Heavier amounts in the western piedmont and along the coast are indicated by warm colors,

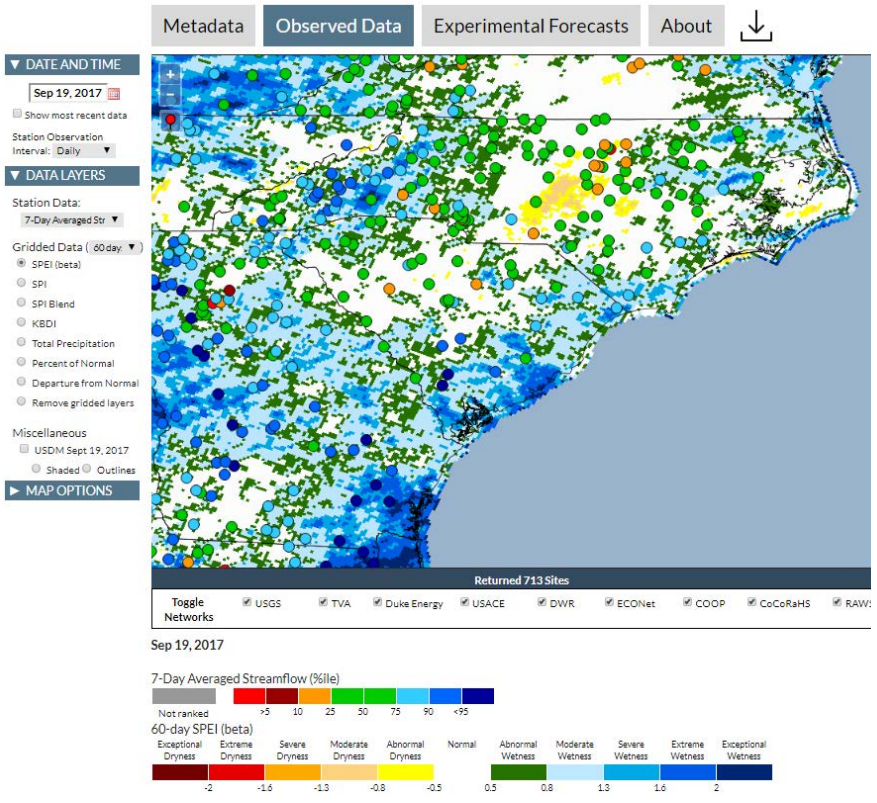
Climate Support for Water Resources

UNIFIED WATER DATA PROJECT

SCONC scientists are working with the NC Department of Environmental Quality (DEQ) Division of Water Resources (DWR) to unify data from several disparate DEQ datasets that are used to measure and determine the water quality across North Carolina. These data will be combined with SCONC-housed water quantity and weather data in a web-based application programming interface (API) service. This API will give DEQ/DWR staff and stakeholders greater accessibility to weather and water data (both quantity and quality), helping to meet regulatory, planning, and stakeholder needs. During the second year of the project, six in-person meetings were conducted to learn about various water quality datasets (such as lakes and wetlands data collected by DWR) and how they are used by basin planners and other groups within DEQ and DWR.

INTEGRATED WATER PORTAL

SCONC continues to provide support for the Integrated Water Portal (IWP). This tool brings together water data from several different agencies into a map-driven data exploration and visualization tool that allows users to quickly explore regional and local water conditions. The IWP incorporates current and historical station-based water and precipitation data with high-resolution gridded products, such as precipitation estimates from the National Weather Service and drought indices produced by SCONC. In 2017-2018, the IWP was migrated to the new SCONC website and updates were made to the back end to increase longevity as well as make the page's style more consistent with SCONC's new website.



NOAA Southeast Regional Climate Center

UNC-Chapel Hill and NCSU were awarded the NOAA Southeast Regional Climate Center (SERCC) in 2007. As part of this partnership, SCONC develops and maintains the SERCC's web services and online climate tools. Additionally, SCONC supports and maintains the Applied Climate Information System (ACIS), which serves as the climate database for all six NOAA Regional Climate Centers. Collaborators at UNC-CH include Charles Konrad, William Schmitz, Jordan McLeod, and Ashley Ward.

SERCC WEB TRAFFIC

The SERCC website received 133,588 visits, a decrease of 16.8% over the previous year (160,535). The largest number of visits in a single day was 1,618 on January 7th, 2018.

- 93.6% of all visits came from the United States
- Top 10 states by visits: FL (16.3%), NC (14.6%), GA (9.8%), VA (4.6%), SC (4.4%), TX (4.2%), CA (3.8%), NY (3.5%), AL (2.6%), and PA (2.5%)

Website visits by source:

- 71.8%: Search engines (e.g., Google)
- 18.9%: Direct sources (e.g., bookmarks, direct URL)
- 7.7%: Non-search engine referral sites (e.g., articles)
- 1.5%: Social Media

CLIMATE AND PUBLIC HEALTH

Effort over the past year focused on general maintenance of the Climate-Health Toolkit, which allows researchers to explore the relationships between hospital emergency department (ED) admissions data and local climate conditions with plans to help improve early warning for public health officials. Currently, this tool allows users to search for emergency department records based on primary and secondary diagnostics codes, dates and years of interest, and locations. Users can also pull corresponding daily weather records (temperature, maximum heat index, 18 UTC/1 pm EDT heat index, wind chill, precipitation, and antecedent weather periods), and generate "reference periods" for ED admissions to help determine when excess morbidity rates occur. After initial data retrieval, the results can be aggregated over different temporal and spatial scales, and narrowed down by demographics, from which summary tables with basic counts and per capita rates can be generated.

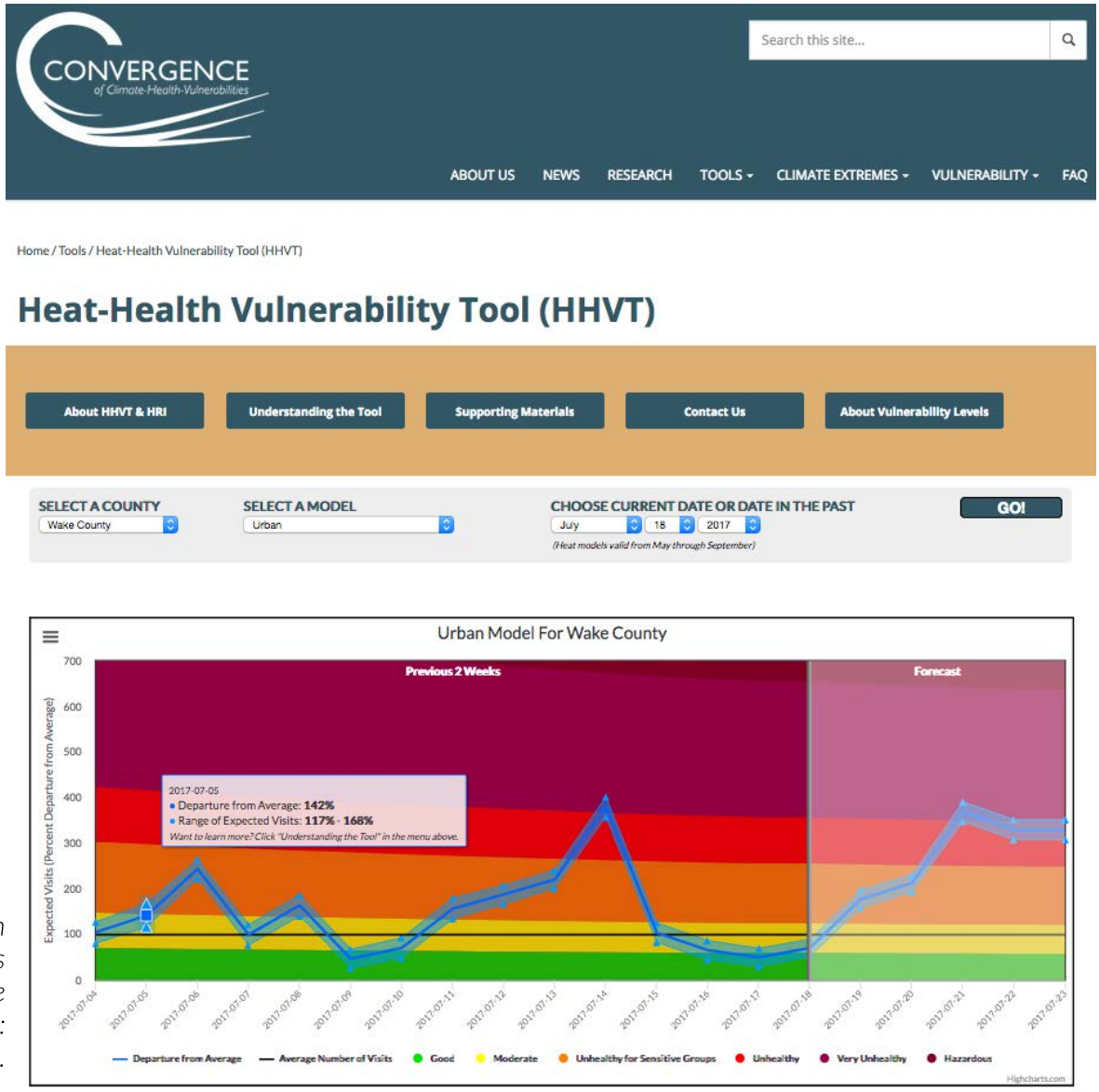
Research stemming from the Climate-Health Toolkit eventually led to the development of the Heat-Health Vulnerability Tool (HHVT). The HHVT displays the expected number of hospital ED admissions per capita per 100,000 per degree day (as a percent departure from the baseline) based on the observed and forecast heat indices, as well as on models that were derived from relationships between past admissions associated with heat illnesses across North Carolina. In addition, shaded thresholds give users a general idea of just how severe the number of heat-related hospital admissions is expected to be based on those heat indices.

While the previous year's efforts focused on embedding the HHVT within the Convergence of Climate-Health Vulnerabilities website (http://convergence.unc.edu), efforts over this past year have moved toward the development of an Early Warning System (EWS). This EWS will ultimately utilize the underlying HHVT models to send alerts via text message or email when the heat index is forecast to reach or exceed a user's specified vulnerability level.

In addition to the HHVT, a new tool is being developed for recent and forecasted wet bulb globe temperature (WBGT). WBGT is another measure of heat stress on the human body that is based on natural wet bulb temperature (evaporative potential), ambient air (dry bulb temperature), and black globe temperature (radiant heat). Unlike heat index, which only uses temperature and relative humidity to assess conditions in the shade, WBGT takes temperature, relative humidity, wind speed, and solar radiation into account in order to assess how the outdoor conditions in direct sunlight will affect the human body.

WBGT is directly applicable to numerous situations and populations, such as outdoor sporting events, yard work, those with outdoor jobs, and military personnel. This value can be measured with a black globe thermometer or calculated with climate data. For this publicly accessible tool, gridded data was used to calculate hourly WBGT across North Carolina for three days into the past and future using methodology from the NWS in Tulsa, OK. The prototype of this tool will include an hourly time series of WBGT for a user-defined location (latitude and longitude). With this information, anyone can identify their potential for heat stress when preparing for outdoor activities. Similar to the HHVT, shaded thresholds of the WBGT risk categories will be shown on the time series. Furthermore, the tool will display the WBGT in the sun and shade.

The next steps of this tool include an expansion to the southeast US and a spatial component in which maps of WBGT across the southeast will be available to view. In addition, the WBGT values will be validated with black globe thermometer measurements from ECONet sites across North Carolina in order to assess the validity of the gridded WBGT computations.



The Heat-Health Vulnerability Tool is accessible from the Convergence website: convergence.unc.edu.

CLIMATE PERSPECTIVES

The Climate Perspectives tool accounts for 10.5% of all web traffic on the SERCC website., including nearly 62% of traffic on the most visited day. Weekly US Drought Monitor authors and contributors from across the country routinely use Climate Perspectives in drought assessments. Nationally, local National Weather Service offices and other groups such as the Capital Weather Gang and The Weather Channel use Climate Perspectives for communicating recent weather to a public audience. Additionally, state offices such as SCONC often cite the Climate Perspectives tool in monthly or seasonal climate summaries such as those in the Climate Blog.

Over the past year, a new feature was developed called “Similar Day of Year”. This gives the user a seasonal perspective for a given location, comparing the recent temperatures of a given period to that location’s 30-year normal temperature throughout the entire year.

Past 2 Weeks 04/18/18 - 05/01/18 View History	**100%** 14 Daily	Value	**71.9 °F**	**45.2 °F**	**58.6 °F**	**1.05 in**
		DFN	*-2.7 °F*	*-5.1 °F*	*-3.9 °F*	*-0.2 in*
		Ranking	*T-18th coldest*	*T-7th coldest*	*10th coldest*	*37th wettest*
		Similar DOY	Apr 7-Apr 20	Mar 30-Apr 12	Apr 3-Apr 16	-

Screen capture showing Climate Perspective's Similar Day of Year (DOY) feature.

Climate Support for Cooperative Extension

EXTENSION ADVISORY COMMITTEE

SCONC established a formal collaboration with the North Carolina Cooperative Extension Service (NCCES) over the past two years. As part of this engagement effort, an advisory committee was established to help steer interactions and priorities between SCONC and NCCES. In spring 2017, a web-based survey was filled out by 137 extension agents. This served as a needs assessment that identified two key priorities:

While roughly half of respondents indicated that they had used the SCONC website, many suggested that it was difficult to locate weather data and tools on the site. This feedback informed key layout changes to the new NCSCO website design in which current observations were placed on the homepage and links to data retrieval resources were displayed more prominently.

Only about one-third of respondents said they had received any weather and climate training, so they requested instruction on basic topics such as soil moisture and monitoring. Short videos were generally preferred as a communication medium, so SCONC produced three videos about Soil Physical Characteristics, Soil Moisture in North Carolina, and and Soil Moisture Measurements and Monitoring. These videos were shared with the NCCES advisory committee to receive feedback and will be finalized, published, and shared publicly and with extension agents in 2018.

ONGOING AND NEW PARTNERSHIPS

In 2017-18, SCONC continued to provide several ongoing services as part of engagement activities with NCCES:

An RSS feed of recent posts from NCSCO's Climate Blog was developed in April 2014 and continues to be shared on NCCES's Extension Integrated Pest Management website alongside other external blog posts and CES news articles.

In January 2017, SCONC was invited by NCCES to participate in the Bertie County Partnership Discussion in Greenville, NC. This meeting brought together scientists from NCSU and East Carolina University, extension agents from NCCES and USDA, and participants from the Town of Windsor to discuss recurring flooding in the town since Hurricane Floyd in 1999. SCONC provided background on these heavy rain events and historical frequency, and a key action item that emerged was creating a more dense network of precipitation observations in Bertie County. This led SCONC to connect NCCES with the RAIN Across the River program, funded by the Burroughs Wellcome Fund, to recruit student CoCoRaHS observers in the county.

SCONC also continued to engage with NCSU researchers and extension faculty on projects with implications for NCCES and growers across the state. These include providing weather inputs and an online framework for peanut disease advisories, which have been offered for the past 14 years. SCONC has also partnered with Dr. Gina Fernandez (NCSU Horticulture) on projects to explore improved

blackberry harvest predictions and night harvesting impacts. SCONC has also developed several tools, some of which are frequently cited in extension publications, for improved planting and disease protection guidance. These include the Cotton Thrips Infestation Predictor, Tobacco Tomato Spotted Wilt Virus Risk Prediction Tool, and a Farm Water Needs tool. SCONC is also working with the USDA Southeast Regional Climate Hub to host a webinar for extension agents and foresters to provide feedback on the PINEMAP DSS and inform the development of a new springtime dry days tool.

OUTREACH AND ENGAGEMENT

As part of SCONC's routine engagement and outreach efforts, staff and students participated in multiple conferences and events organized or attended by NCCES.

SCONC participated in the Farm Animal Days event at the Lake Wheeler Road Field Laboratory in Raleigh in March 2018, which provides a hands-on environment for children to learn about agriculture

SCONC also brought students to an ECONet station for a field trip with Tommy Corbett, the station superintendent at the Lewiston, NC Agricultural Research Station.

Several talks were given by SCONC scientists, including a talk reviewing North Carolina's weather in 2017 and previewing conditions in 2018 at the Crop Protection School in Raleigh in December 2017, a talk about seasonal outlooks and climate change impacts to agriculture at a Women in Agriculture meeting in Franklin County in December 2017, and a talk discussing ENSO, seasonal forecasting, and atmospheric inversions for a pesticide training workshop in Onslow County in March 2018.

SCONC tools and products were featured, or SCONC wrote, reviewed, collaborated with NCCES on several publications. These include multiple features of the CottonTIP tool in extension articles for the NCCES website about thrips risk to cotton. SCONC helped author the NC State Extension publication titled "Understanding Climate, Planning, and Response Terms within the Forestry Context" as well as writing an article about CoCoRaHS Match Madness for the Orange County Master Gardener blog. SCONC scientists also provided feedback about climate change guidelines.

FUTURE DIRECTIONS

While the formal funded partnership with NCCES has ended, in the coming year, SCONC expects to continue providing value for NCCES and its agents and their constituents across the state by participating in similar talks and events, continuing existing partnerships on tools and services, and providing training about weather- and climate-related topics.

Applied Research

Research efforts build on SCONC's large climate data resources and strengths in connecting climate data and climate science to the decision needs of resource managers. This past year's efforts focused on soil moisture and temperature monitoring and analyses, heat stress, climate information for pest management, and improvements to short-term weather forecasting. SCONC's actionable science feeds into improved extension services and education and outreach programs.

Contents

APPLIED RESEARCH HIGHLIGHTS

6 manuscripts were accepted in peer-reviewed journals

7 manuscripts are in development or currently in submission

27 presentations were given at meetings and scientific conferences

18 staff and students attended **33 scientific meetings and conferences**

15 funded collaborative research and applied projects

6 peer-reviewed publications authored by staff scientists and students

Submitted 8 proposals for contracts and grants with **6 funded** (2 pending)

SCONC scientists **completed climate projections downscaling research** as part of the Department of Defense-funded Defense Coastal/Estuarine Research Program

Scientists from SCONC continued research in multiple sector areas, including **environmental monitoring**, **health**, **heavy precipitation**, **climate and weather modeling**, **pest management**, and **drought monitoring**.

Research to Support Decision Making

ASSESSING CITIZEN SCIENTIST'S CONDITIONS REPORTS

SCONC contributed to engagement activities of the Carolinas Integrated Sciences and Assessments (CISA), a NOAA Research Integrated Sciences and Assessments. CISA recently piloted a project to collect narrative reports describing on-the-ground conditions for use in drought monitoring and assessment. This project was part of the NIDIS (National Integrated Drought Information System) Coastal Carolinas Drought Early Warning System (DEWS). Volunteers are part of the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS), a citizen science project that SCONC is actively involved with.

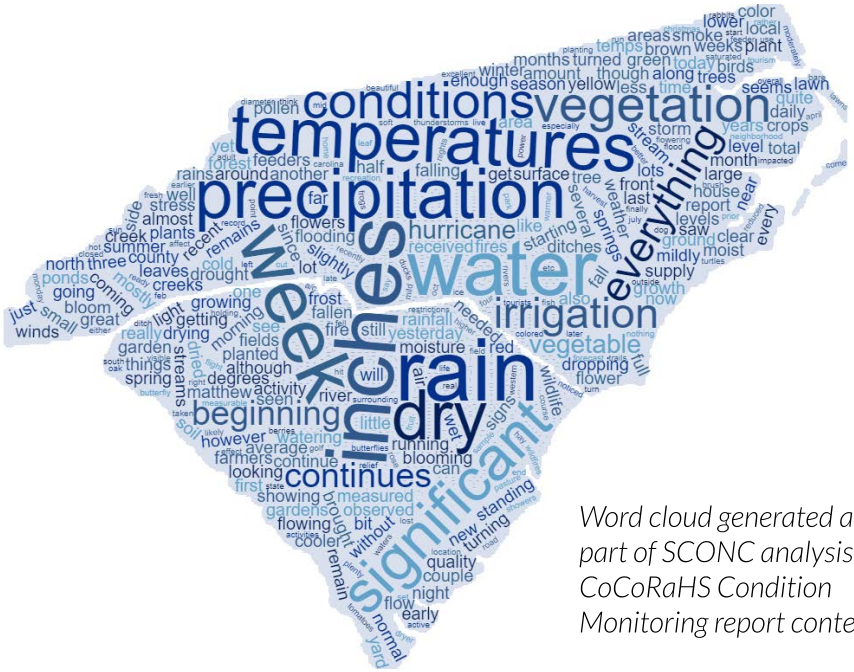
Since 2015, SCONC has been using the CoCoRaHS Condition Monitoring reports as part of its weekly assessment process with the NC Drought Management Advisory Council (NC DMAC) and has relayed information between the NC DMAC and CISA on improvements to the visualization of the reports and types of information collected. SCONC partnered with CISA to analyze citizen scientists' narrative reports and quantitative scale bar

A CoCoRaHS rain gauge showing a day's precipitation.

selections to objective drought indices developed by SCONC.

Results indicate these reports have significant drought early warning potential and provide information beyond what is available through conventional drought indices. Additionally, condition monitoring reports also frequently provide non-drought information, such as impacts from weather events such as freezes or hurricanes. Future work by SCONC and CISA may be to explore the value of this additional information for event assessments.

SCONC also collaborated in CISA's effort to develop a series of story maps describing various aspects of drought in Coastal Carolinas. SCONC's efforts were primarily concentrated in creating a video to provide an overview of Coastal Carolinas drought, providing content and images for a story map detailing fire risk in coastal areas, and providing edits and suggestions to overall structure and content of other maps within the series.



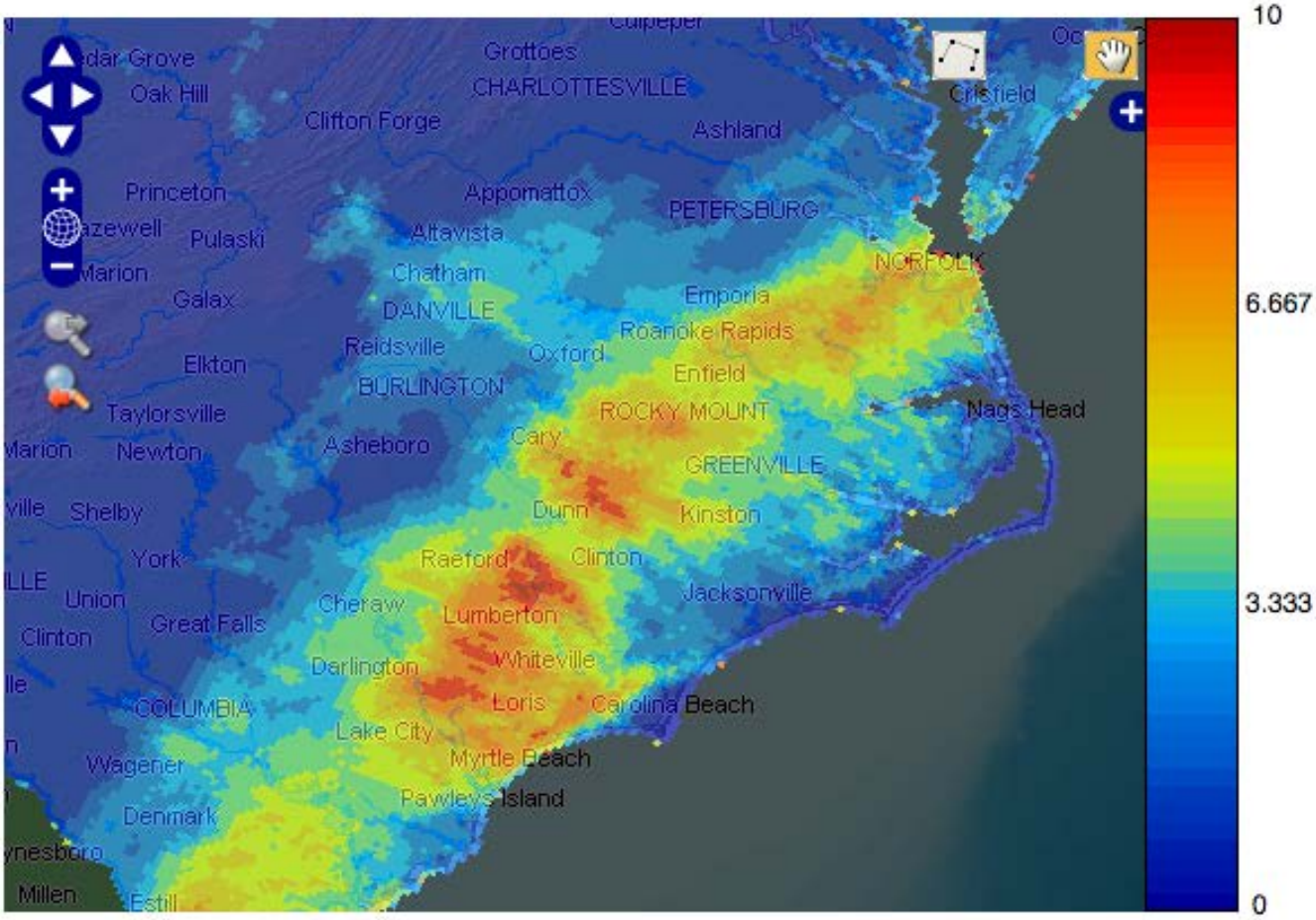
Word cloud generated as part of SCONC analysis of CoCoRaHS Condition Monitoring report content.

IDENTIFYING HIGH-RISK AREAS DURING PRECIPITATION EVENTS

Over the past year, SCONC has been developing an alert system to allow near real-time precipitation events to be placed into a historical perspective. Using the Precipitation Frequency Estimates generated by the NOAA Hydrometeorological Design Studies Center — widely known as NOAA Atlas 14 — these efforts have taken both storm duration and recurrence intervals into account to identify significant rainfall events that exceed certain historical precipitation amounts for any given location across the state. The results of this research will be incorporated into the existing monitoring and alert system, enhancing NCDOT's ability to efficiently manage construction and stormwater projects in accordance with water quality permits during extreme rainfall events. Given that such events can pose a high risk for flooding and storm water runoff, this project is also expected to reduce NCDOT's response time to these events as they unfold.

PREDICTING BLACKBERRY HARVEST DATE

A SCONC graduate student is working with Dr. Gina Fernandez from NCSU Horticultural Science to develop a product to predict the date of blackberry harvest in North Carolina and the greater Southeast. Historical harvest date data provided from several local blackberry growers will be compared to growing degree day and chill unit accumulations. If a relationship between harvest date and meteorologically-based data is determined, these will inform the development of an online tool that will allow growers to enter their location and receive a projection of when their blackberries may be ready for harvest. This tool will allow growers to better coordinate for harvesting and delivery of blackberries.



Example map showing precipitation recurrence intervals exceeded during Hurricane Matthew in 2016. A value of 10 corresponds to exceeding a 1,000 year event while a 1 corresponds to a 1 year event.

Environmental Monitoring

ORGANIC SOIL MOISTURE MONITORING

The peat soils found in parts of the North Carolina Coastal Plain are a challenge to monitor for fire and smoldering risk. These complex organic soils don't often reflect the risk shown by traditional fire danger estimates, and fires can burn deep into these soils, which can make planning for and managing them even more difficult.

In order to provide better monitoring information and high-quality data that will be used in a later analysis to identify proxies for soil moisture and fire risk, SCONC is deploying four organic soil moisture monitoring stations in eastern North Carolina.

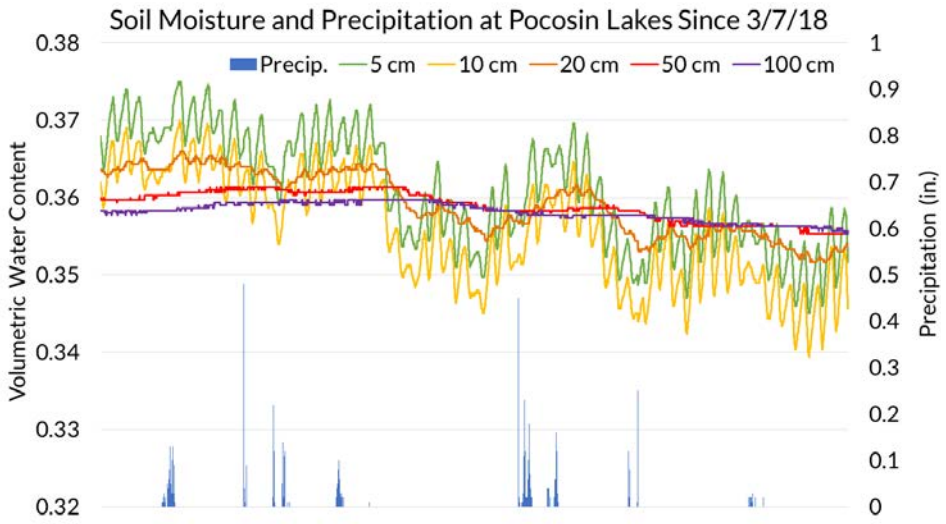
Each station includes basic above-ground instrumentation to measure air temperature, relative humidity, and precipitation. Beneath the ground in the organic soils, three columns of sensors track soil temperature and soil moisture at depths of 5 cm, 10 cm, 20 cm, 50 cm, and 100 cm, in order to provide a complete picture of conditions beneath the surface.

The first station, funded by CISA, was installed in Hyde County at the Pocosin Lakes National Wildlife Refuge in March 2018. This site is located near a canal on a block of land with a well-managed and a typically high water table. Preliminary data from this station reflects these conditions, as deeper levels have remained consistently wet while shallower levels typically see soil moisture values spike in response to rainfall but quickly drop on hot days and during week-long dry spells.

Three additional station installations are planned for the spring and summer of 2018. These include two other CISA-funded stations in Brunswick County at the Green Swamp, which is managed by The Nature Conservancy, and in Camden County at the Dismal Swamp, which is managed by the North Carolina State Parks Service.

A second station at Pocosin Lakes NWR is also planned, and will be funded by the US Fish and Wildlife Service through a contract with The Nature Conservancy. This site will be located on a drained block roughly 2 miles south-southeast of the existing Pocosin Lakes station. Measuring soil moisture conditions in both a drier and a wetter area on the refuge will help better inform

The organic soil moisture monitoring station at Pocosin Lakes NWR.



Soil moisture and precipitation data, Pocosin Lakes station, March 7 - May 1, 2018.

management decisions by showing the range of conditions present.

Data from these stations will be incorporated into the Fire Weather Intelligence Portal to provide real-time information access for that tool's users and SCONC's partners that manage the lands where stations are located.

LAND COVER EFFECTS ON SOIL MOISTURE & TEMPERATURE

ECONet stations are sited on many different types of land cover across the state, from cropland, to bare soil, to densely vegetated grassland. The type of land cover plays a significant role in the properties of the underlying soil. A prior SCONC study on land cover indicated that soil moisture sensor performance was highly dependent on soil type. In the past year, SCONC continued this research to isolate land cover's influence on soils with the same physical characteristics. Beginning in the summer of 2017 and continuing through spring 2018, SCONC conducted a field experiment at the ECONet site in Clayton, NC, to measure differences in soil moisture and soil temperature between two different land covers: bare soil and grassy vegetation.

Results of analyses suggest that soil moisture and soil temperature have great variability and are more likely to reach extreme values under bare land cover, compared to dense vegetation. Additionally, soil moisture values, on average, were higher for a vegetative cover compared to bare soil (by 7%). Land cover was found to strongly dictate soil drying trends and water movement.

Experimental station in Clayton, NC.

Future research in summer 2018 will compare this experimental data with modeled data. Findings will also be applied to other soil types to improve SCONC soil moisture data quality control processes.

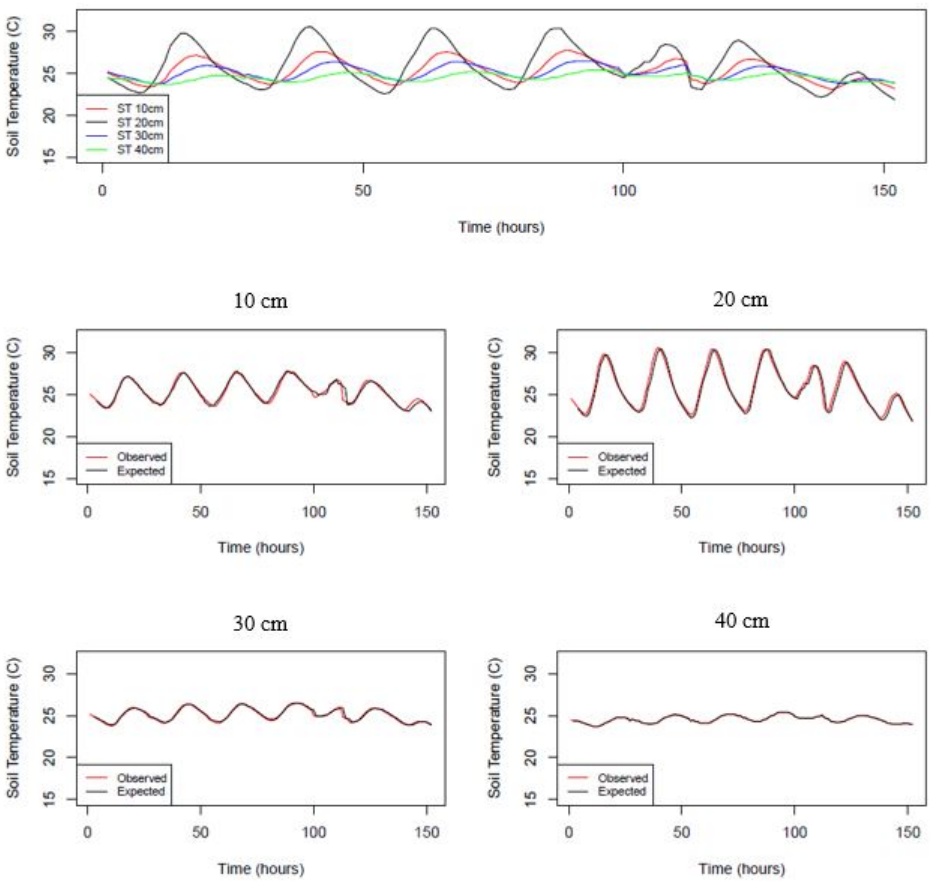
SOIL MOISTURE QUALITY CONTROL

Quality control of soil moisture is a difficult process. While SCONC currently has basic automated routines that perform QC checks on soil moisture, these checks are only adequate for catching major problems with the measurements. In an effort to capture subtle problems in soil moisture measurements, SCONC staff and students explored multiple approaches, including regression analysis, neural networks, and using at-station atmospheric parameters as surrogate predictors. Some preliminary success was achieved with modeled soil moisture closely predicting observed soil moisture, though North Carolina's heterogeneous soils continue to make broad, statewide applicability a challenge. Continued research and analysis will help improve dynamic QC routines for better understanding and predictability of soil moisture variability.

SOIL TEMPERATURE QUALITY CONTROL

Past quality control routines for the soil temperature sensors CS 109-L (10 cm depth) and SCO-ST (10, 20, 30, and 40 cm depths) used station specific linear relationships. However, this method was unable to always appropriately flag the data during rapid changes in soil temperature.

A modified version of an empirical model has now been deployed for every ECONet station with soil temperature sensors. This model predicts soil temperatures at different depths using observed air and soil temperatures. The model has been adjusted for individual ECONet stations using coefficients that are specific to station soil type. Overall, the model has a mean absolute error of 0.04°C, which is within the error range of the CS 109-L (±0.40°C).



Hourly observed and expected soil temperature over one-week period from June 1 - 7, 2017. Data was measured using the SCO-ST sensor at the Lake Wheeler Field Laboratory and compared to modified-model output.

WIND SPEED SENSOR COMPARISON

The NC ECONet measures wind speed at three levels: 2, 6, and 10 meters above the surface. While the same sensor is used to measure wind speed at 6 and 10 meters (RM Young 05103 propeller anemometer), the sensor used at 2 meters is different (Vaisala WXT520 sonic anemometer). A study was conducted using data from 2015 to 2017 to compare wind speeds between these two sensors at the same height.

Preliminary results show that the wind speeds from the WXT520 are 0.24 m/s greater than the RM Young 05103, on average. As part of future research efforts, the SCONC plans to develop log wind profiles to help quantify differences in wind speeds for use in quality control efforts or to provide estimates when the sensor reports are unavailable.

Anemometers at 6m and 10m record different wind directions.

Heat and Health

COMPARISON OF MODELED AND OBSERVED HEAT INDEX

Extreme heat exposure is the most common cause of weather-related fatalities in the United States. The SERCC and SCONC have partnered to improve early warning of heat-related ilnesses. To support the SERCC's efforts in using forecasted heat index, a comparison of observed and model heat indices were performed for six heat waves from 2013 to 2016. Determining the most accurate lead time forecasts will help local officials better prepare for upcoming heat waves, and more timely and effective public communication regarding the dangers of prolonged heat exposure. Heat indices were calculated based on observations across regions of Virginia, Georgia, and the Carolinas. These heat indices were then compared to data from the National Weather Service's National Digital Forecast Database (NDFD). Based on this heat wave analysis, correlations were highest in North Carolina. However, forecas errors were smaller in Georgia and South Carolina. 48-hour forecasts were the least accurate, particularly in the mountain and coastal areas of each state.

RMSE

	00 hour lead time	06 hour lead time	12 hour lead time	24 hour lead time	48 hour lead time
GA	2.57	2.60	2.83	2.78	2.77
NC	2.80	3.01	3.00	3.34	3.56
SC	2.97	3.14	3.14	2.88	3.27
VA	4.31	4.03	4.04	4.22	4.96

Correlation

	00 hour lead time	06 hour lead time	12 hour lead time	24 hour lead time	48 hour lead time
GA	0.750	0.735	0.678	0.700	0.691
NC	0.901	0.897	0.899	0.883	0.883
SC	0.710	0.6871	0.681	0.720	0.678
VA	0.804	0.848	0.840	0.828	0.710

State-by-state comparisons between observed and modeled heat index.

NIGHTTIME BLACKBERRY HARVEST

In an effort to help categorize the quality of blackberries harvested during nighttime, the SCONC partnered with Dr. Gina Fernandez in Horticultural Science at NCSU to monitor atmospheric and moisture parameters during a two week period in June of 2017. During this period, air temperature, dew point, and leaf wetness were recorded at 15 minute intervals. These environmental data were paired with data on the quality of harvested blackberries to investigate the best time to harvest blackberries for fruit longevity and health. This project also helped verify metrics for determining when leaf wetness sensors recorded wet conditions as compared to actual conditions observed on blackberry bushes during the harvest periods.

One of the remote monitoring sites placed among a blackberry rows to record leaf wetness, air temperature, and relative humidity.

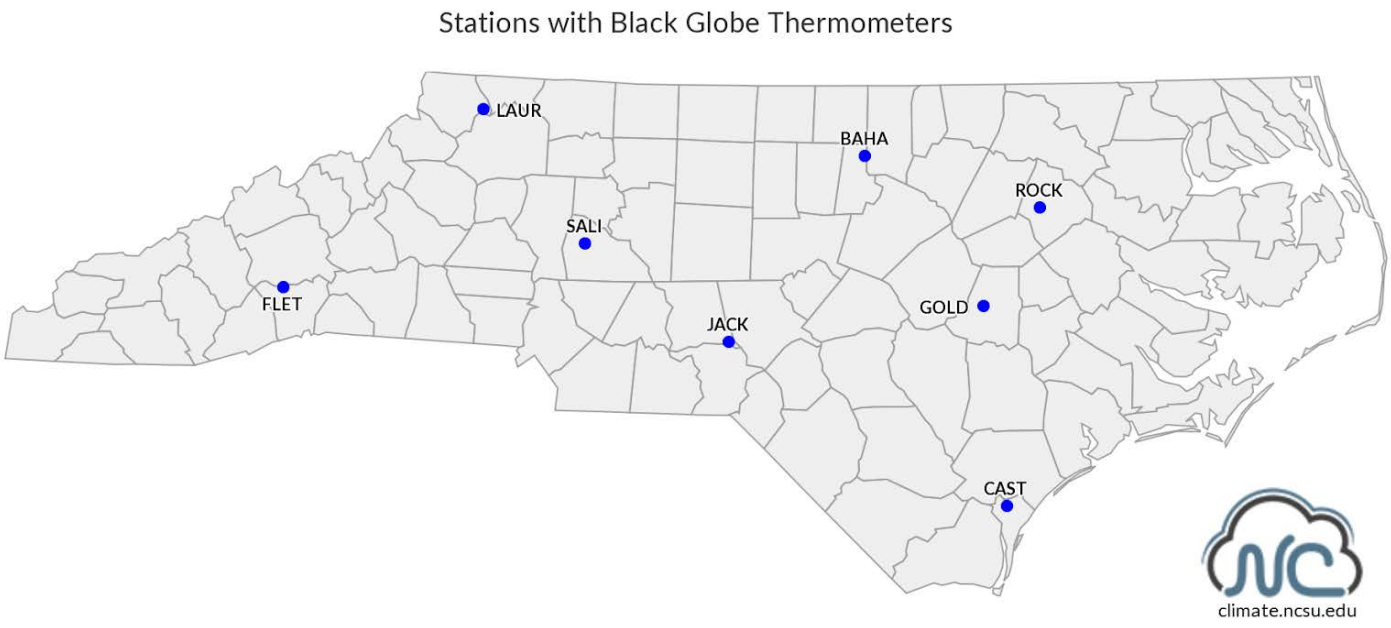
BLACK GLOBE TEMPERATURE

Heat index is a way to measure how a person feels given current air temperature and relative humidity values. While useful, it may not be the best metric to calculate heat stress . The US military uses Wet Bulb Globe Temperature (WBGT) to determine heat stress in direct sunlight. This metric uses three parameters: wet bulb temperature, dry bulb temperature, and black globe temperature.

Black globe thermometers are relatively expensive, however, an algorithm developed by the National Weather Service in Tulsa, OK has been tested to calculate globe temperature using common meteorological parameters. Over the past year, SCONC deployed 8 black globe thermometers across the state, with 1 in each climate division.

Currently, SCONC is evaluating the sensors and comparing their values to other sensor measurements and methods for estimating black globe thermometers. In the next year, SCONC hopes to deploy more of these sensors and make the available data public for all end users who are impacted by heat stress.

Black globe thermometers (right) have been installed at 8 ECONet site s across the state(below).



Modeling and Predictions

SPATIAL ANALYTIC FRAMEWORK FOR ADVANCED RISK INFORMATION SYSTEMS PROJECT

SCONC scientists serve as the climate focal point on the SAFARIS project – a collaboration between the Center for Integrated Pest Management (CIPM) at NC State University and the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). The goal of SAFARIS is to contribute forecasts of the behavior of potentially harmful pests to APHIS' Plant Protection and Quarantine (PPQ) program. These pest forecasts inform risk assessment and management for the United States and the entire globe.

Effort over the past year has built on previous work that determined the accuracy of two global climate datasets: NCEP Climate Forecast System Reanalysis (CFSR) and Climate Forecast System Version 2 (CFSv2). Two additional global climate datasets – ERA-Interim and Climatic Research Unit Time-Series version 4.01 – have been evaluated to determine the level of accuracy as compared with an independent, land-based weather station dataset called International Surface Temperature Initiative's Global Land Surface Temperature Databank. Monthly and annual quantitative statistics – including the coefficient of determination (R-squared), root mean square error, and bias values – were computed for maximum and minimum temperature at each grid-point – weather-station pair across the globe. Preliminary work has begun on an evaluation of ERA5, which is an updated version of ERA-Interim.

These global evaluation results were presented at the American Meteorological Society's 23rd Conference on Applied Climatology in June 2017 and the 9th International IPM Symposium in March 2018. In addition, a similar presentation was given at a USDA PPQ Quantitative/Economic Analysis Coordination Meeting in April 2018. A publication highlighting two evaluations performed to date – CFSR and CFSv2 global results and an analysis of PRISM and METDATA in the US – is in preparation for submission to the Journal of Applied Meteorology and Climatology.

In addition, SCONC researchers have begun to calculate CONUS grids of 19 bioclimatic predictors, which are derived from monthly temperature and precipitation data. Representing broader trends (e.g., annual, seasonal) as well as conditions that may be limiting factors (e.g., temperature of the coldest and warmest month), these bioclimatic predictors are often used in modeling species distributions and for other ecological applications.

To examine possible future changes in these variables, the 19 bioclimatic predictors are being computed for four future time periods (2020-2039, 2040-2059, 2060-2079, and 2080-2099) and two future emissions pathways (RCP4.5 and RCP8.5) using the statistically downscaled climate projection dataset called Multivariate Adaptive Constructed Analogs (MACA). Project collaborators include: Yu Takeuchi and Ann Joseph, NCSU's Center for Integrated Pest Management; and Glenn Fowler, USDA APHIS.

DEFENSE COASTAL/ESTUARINE RESEARCH PROGRAM

In summer 2012, SCONC joined a team of scientists headed by RTI International in the second phase of the Defense Coastal/Estuarine Research Program. Formal research connected with DCERP began in spring 2015 and concluded in fall 2017. SCONC completed an assessment of the climate sensitivities of the ecosystem models and the climate needs of the research teams. Using this information, SCONC assessed the usefulness of different historical and future projection datasets for the DCERP ecosystem

modules. SCONC also created an ensemble of climate projection information for Marine Corp Base Camp Lejeune and evaluated these data at multiple thresholds deemed important by base management operators. More information about the project and partners is available at http://dcerp.rti.org.

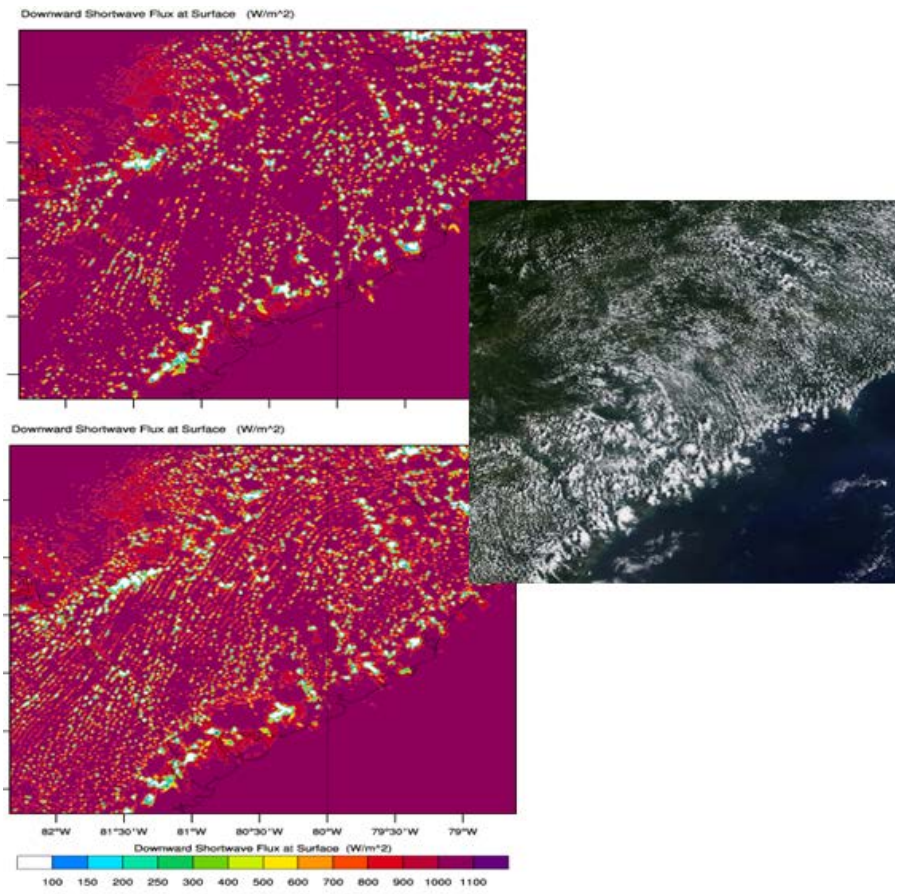
SUMMERTIME MESOSCALE CIRCULATIONS

Sensitivities of Summertime Mesoscale Circulations in the Coastal Carolinas to Modifications of the Kain–Fritsch Cumulus Parameterization

The convection and precipitation associated with the interaction between the Sandhills convection and the sea-breeze front was simulated using high resolution numerical weather prediction models. Accurate representation of these processes at high resolutions are difficult as models are known to have problems predicting the timing, location, and amounts of convective precipitation.

For this research, modifications were made to the cumulus cloud physics scheme in the model. These changes include modifications to the small-scale cloud formulations, the time it takes for the model to produce deep convective clouds, and the rates at which cloudy and non-cloudy air are added to or lost from a cloud.

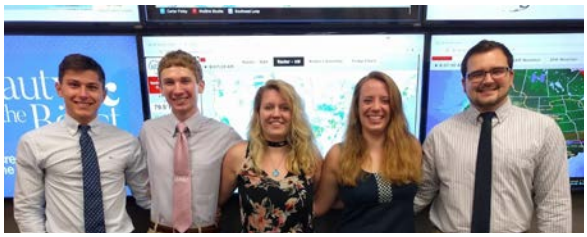
Results from this research indicate that the timing of convection and precipitation are improved in the simulations using modified schemes. Other results indicate that simulated air temperatures near deep clouds are reduced due to the model having direct links from the deep convective cloud physics to the incoming solar radiation. The strength of the convection is also increased in these simulations.

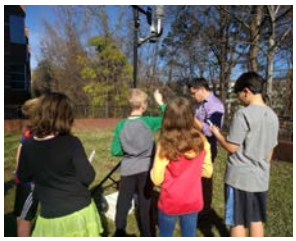


Comparison of two different model simulations of solar radiation values with observed cloud cover.

Education, Outreach, and Engagement

Outreach programming is an important mission area for the SCONC. Scientists and students provide direct outreach for dozens of school and community groups and contribute to large educational events. These contributions amount to thousands of direct educational outreach contact hours each year. SCONC's scientists additionally supply a range climate news and information to the public using social media, SCONC's Climate Blog, and through media interviews. For over ten years, SCONC has also been actively engaged with a citizen science weather observing network (CoCoRaHS) through volunteer recruitment, coordination, and training.





Contents

OUTREACH & ENGAGEMENT HIGHLIGHTS

Trained and financially supported **6 student research assistants**

Hosted 2 students from the Climate Change and Society Professional Master's Program. SCONC scientists mentored these students on their Applied Climate Experience capstone summer projects.

Logged **81, 328** educational outreach contact hours

10 school and community groups were hosted by SCONC for outreach events. SCONC also participated in **4 large community events** including Farm Animal Days and NCSU's Solar Eclipse Day

SCONC staff gave **15 invited presentations** to professional or community groups,.

15 conferences and workshops,were attended by SCONC scientists, who gave **presentations at 7** of these

25 NC Climate Blog posts were published, earning **40,740 views**

1,042 Twitter followers (a 12% increase) with **3,864 engagements**

12 interviews to print or broadcast media were given by SCONC scientists in the past year about weather or climate events in North Carolina.

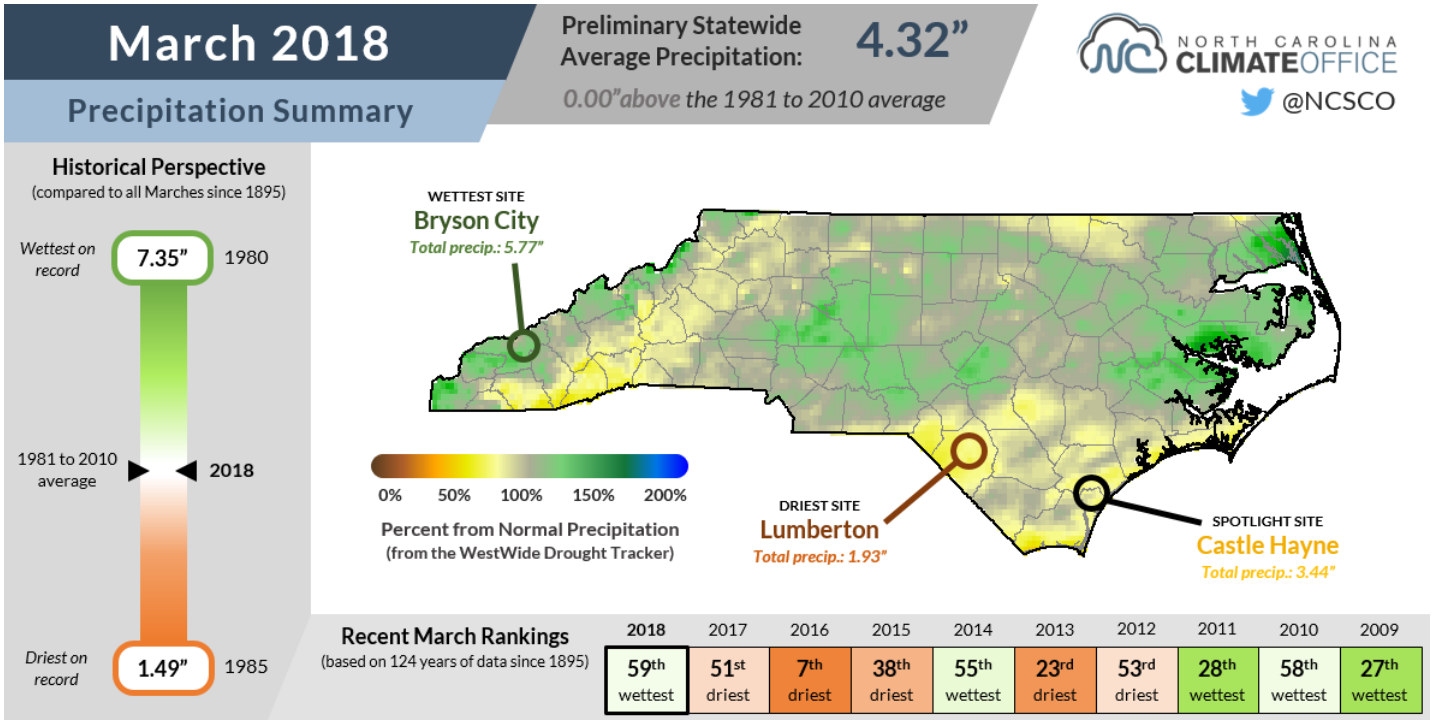
Public Science Communication

SOCIAL MEDIA

SCONC participates in public science communication through social media platforms such as Twitter and its own NC Climate Blog. SCONC uses Twitter to post weekly content, including blog post announcements, science videos, information about recent weather events, and updates from outreach events and environmental monitoring station (ECONet) visits. Since December 2012, SCONC's Climate Blog has provided timely and user-friendly summaries of events, monthly and seasonal conditions and outlooks, student-written posts about projects, and behind-the-scenes insight about monitoring and tracking North Carolina's weather and climate conditions. These communication activities translate weather and climate science into useable information for the North Carolina citizens. In the past year, SCONC's Twitter account (@NCSCO) had 1,042 followers, a 12% increase in from the previous year.

To coincide with the launch of the new SCONC website, in early 2018, the monthly climate summary posts were revamped to provide more detailed infographics of monthly temperatures and precipitation, better highlight ECONet updates such as new station and sensor installations, and prioritize impactful news such as changes in North Carolina's drought classification.

From May 2017 through April 2018, 25 blog posts were published that received 40,740 total views, or an average of 1,629 views each. Although the number of posts decreased from the previous year, the number of views per post increased by 58%. A total of 664 individuals and group listservs receive email notifications when new blog posts are released, which is an increase of 3.3% from the previous 12-month period. Blog posts are also shared on Twitter and via an RSS feed.



The monthly temperature summary infographic for March 2018

NEWS MEDIA

SCONC is a trusted source for weather and climate information for news media and staff scientists and SCONC tools and products are often cited in news stories, such as pieces on the Great American Eclipse in NCSU's Technician and UNC-CH's The Daily Tar Heel. In the past year, SCONC scientists provided interviews to news media, including nine radio interviews on the Southern Farm Network a syndicated radio program in eastern North Carolina, South Carolina, and Virginia.

ABC11 also interviewed a SCONC scientist about the 2017-2018 winter outlook and climate change impacts on NC winter weather.

Interview with ABC11 about winter outlook and climate change impacts on NC winter weather.

INVITED PRESENTATIONS & CONFERENCES

In the past year, SCONC scientists were invited to give 12 presentations to professional groups and 3 presentations to community groups. These presentations covered a range of topics, from drought, to climate change, to an overview of SCONC tools and products.

SCONC staff and students also participate in numerous knowledge-sharing meetings with other groups on campus to discuss potential research collaborations or provide climate expertise. Finally, SCONC scientists attended 15 conferences and workshops in the past year, and gave presentations at 7 of these. Many of these meetings were located in other states, increasing SCONC's reach to broader geographic audiences.

Each year, SCONC scientists give a presentation at the annual, in-person Drought Management Advisory Council meeting, held on the North Carolina State Fairgrounds.

Educational Outreach Programs

Above: SCONC staff and students held a booth at the NCSU COS Solar Eclipse Day on the campus Brickyard. (upper let). For this event, SCONC's mini tower was deployed to record weather parameters during the event (upper right). The mini tower is used in educational activities at the SCONC, such as having students compare hand-held thermometer recordings to research-grade thermometer measurements (lower right). Another popular outreach activity, the CoCoRaHS Rain Game (lower left), involves teaching students how to record precipitation using CoCoRaHS rain gauges.

EDUCATIONAL PROGRAMMING

SCONC continues to provide regular outreach programming to K-12 and public audiences. School and community groups visit the SCONC's office in Raleigh for tours, educational activities, and trips to the nearby Lake Wheeler ECONet station to learn about instrumentation and weather monitoring. SCONC scientists and students also travel to external locations, such as schools or community buildings, to provide educational programming for groups with limited travel capabilities. In the past year, SCONC scientists and students held 10 educational outreach events for school and community groups.

SCONC continued to focus on developing and improving office

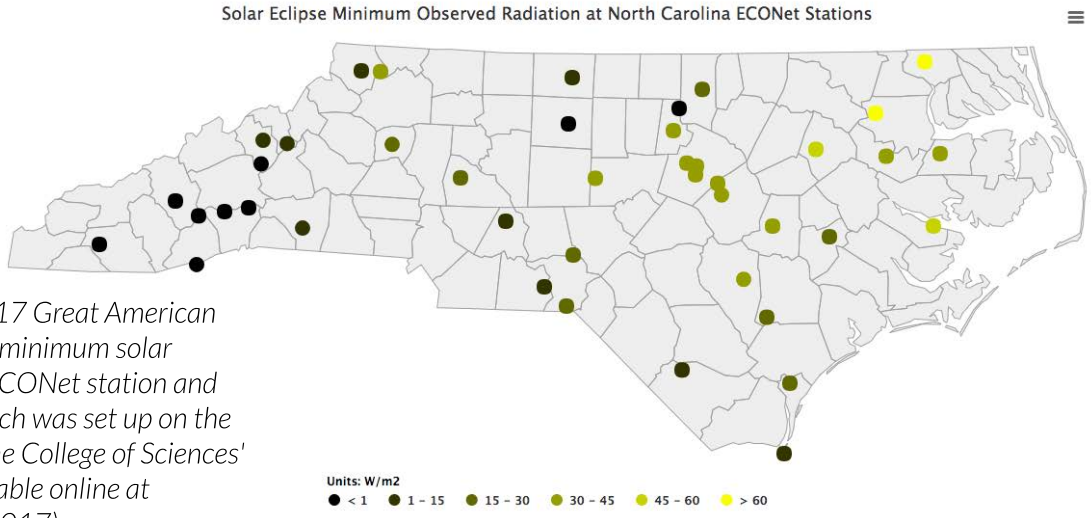
Below: Educational outreach numbers for the past year compared to previous years reflect SCONC's continued focus on providing informal education while increasing its reach through public events.

Reporting Year (May - April)	Total Number of Events	Number Public Events	Visitors to SCONC*	Public Event Attendances	Total Contact Hours
2017-2018	14	4	172	26,102	81,328
2016-2017	22	5	197	83,240	38,460
2015-2016	24	6	278	73,888	32,307
2014-2015	16	0	387	N/A	6,861
2013-2014	26	4	497	4,400	42,044
2012-2013	22	2	877	2,690	18,220

**Only counts those who visited as part of an educational outreach event.*

educational outreach through large engagement events, building partnerships with Raleigh institutions such as the NC Museum of Natural Sciences, and increasing its virtual offerings. With each collaboration, SCONC attempts to bring its expertise in climate and climate monitoring. An example of this occurred during the Solar Eclipse Day, held by NCSU's College of Sciences. SCONC hosted a table at this event to discuss the influence of solar eclipses on local weather and setup a mini tower on the brickyard to record air temperature and solar radiation measurements every 30 seconds. Data from this site was combined with data from SCONC's ECONet network of weather monitoring stations across the state to create an online map and time series tool to show the eclipse's influence on temperature and solar radiation across the entire state of North Carolina.

In addition to the NCSU Eclipse Day, SCONC participated in 3 other large community events that each drew thousands of visitors: NCSU College of Agriculture and Life Sciences' Farm Animal Days; the NC Museum of Natural Sciences' Reptile and Amphibian Day; and the NOAA-NWS Hurricane Awareness Tour.



Map created after the 2017 Great American Solar Eclipse showing the minimum solar radiation recorded each ECONet station and SCONC's mini-tower, which was set up on the NCSU Brickyard during the College of Sciences' Solar Eclipse event. (Available online at climate.ncsu.edu/eclipse2017).

BUILDING CAPACITY

In the past year, SCONC developed or adapted new educational activities to expand its educational offerings:

- Tree Cookies: adapted from a Project Learning Tree activity, students learn how to read tree rings and relate these to climate events, such as droughts, wet spells, and fire activity.
- Storm Surge: adapted from a NOAA lesson plan, SCONC teaches students about hurricane safety and storm surge using an hands-on activity in which students use play-doh to build coastlines and make predictions about storm surge damage.
- Climate Regions: SCONC has developed a game that gets participants to apply their knowledge of North Carolina climate patterns and geographic regions. This game is adaptable to be played in a field, such as during school field days, or on a table top at public events.

While the number of educational outreach events SCONC participated in during the 2017-2018 year represented a decrease from prior years, four of these were large, public events with high attendance. Additionally, SCONC's staff and scientists were at full capacity for fulfilling outreach event requests and had to turn away eight school and community groups in the past year.

To assist with meeting the demand for educational outreach to fulfill its outreach mission, SCONC has partnered with external entities across the state. SCONC is working with local conservancy educators to implement the Bald Head Island Educational Program, a weather program designed for younger children as they visit the Bald Head Island Conservancy. SCONC constructed a mobile sensor platform that they can use for experiments around the island and compare with the permanent ECONet station. Climate Tower Hikes are another way SCONC's outreach capacity has been increased by partnerships. The hikes are led by Mt. Jefferson State Park rangers and include discussions of the climate and weather experienced on the mountain and feature SCONC's Mt. Jefferson ECONet tower (JEFF).

RAIN ACROSS THE RIVER PROGRAM

SCONC completed the first year of the three-year RAIN (Raising Achievement through Inquiry and Networking) Across the River program project funded by the Burroughs Wellcome Fund as a Student STEM Enrichment Program grant. Through this program, SCONC hosts a STEM program for rising 7th graders in Bertie and Chowan Counties, an area in rural northeastern NC that historically has few STEM opportunities. Students are introduced to weather and science concepts through SCONC-developed curriculum and precipitation data collection as part of the CoCoRaHS citizen science program.

With an emphasis on inquiry-based, experiential learning, this year-round program consists of after school meetings, Saturday field trips, a week-long summer academy, and a field trip to Raleigh, NC,to explore STEM careers and visit science museums. Furthermore, by connecting with a well-known national volunteer network of precipitation observers, students and the broader community are engaged, providing positive societal impacts.

As part of its efforts on this program in the past year, SCONC conducted a CoCoRaHS training with parents and students in July 2017. SCONC also held two, 2017 Summer Academies (one per county) for students and held a total of 39, 1-2 hour long after-school meetings with students. Students were taken on two field trips: one to Raleigh and one to the Peanut Research Station in Lewston, NC, for a tour of a ECONet weather tower. A webpage was created on SCONC's website to provide program information for recruitment. SCONC staff traveled to four conferences to speak about the program and exchange ideas with professionals coordinating similar programs.

SCIENCE VIDEOS

In the past year, SCONC continued to expand its educational reach through science videos. Three videos were developed about soil characteristics using North Carolina as a context through a project with North Carolina Cooperative Extension. A video describing a SCONC summer mountain ECONet maintenance trip was also developed and included in the NC Climate Blog's June 2017 climate summary. These videos join others by SCONC that describe educational activities, NC ECONet towers, and other office activities. In the next year, additional videos will be made in partnership with NC Cooperative Extension and for educational outreach.

RAIN students present the results of their student projects at an end-of-year poster symposium..

Citizen Science

CoCoRaHS

Through the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS), thousands of volunteers, young and old, document the size, intensity, duration, and patterns of rain, hail and snow by taking simple measurements in their own backyards. These reports help supplement existing observations from local weather stations and fill in gaps where there are no nearby stations. SCONC led the establishment of CoCoRaHS in North Carolina in 2007 and over the past year has continued to recruit new volunteers for the program, especially encouraging participation from local schools and areas with data gaps. SCONC frequently engages with volunteer participants in the program and provides training. In recent years, SCONC has also helped promote the CoCoRaHS Condition Monitoring program, an effort spearheaded by the Carolinas Integrated Sciences and Assessments (CISA) to collect drought impacts information from CoCoRaHS volunteers.

During May 2017 through April 2018, 252 total volunteers signed up to participate in the CoCoRaHS program. To help with recruitment, SCONC wrote a blog post for the Orange County Master Gardener website and incorporated CoCoRaHS into educational outreach events and invited presentations. Additionally, SCONC held a CoCoRaHS Gauge Contest at the 2018 Reptile and Amphibian Day. Every year, a friendly recruiting contest called "CoCoRaHS March Madness" takes place between all 50 states to see who can recruit the most new volunteers during March. North Carolina has won the contest in four of the past eight years (2011, 2012, 2014, and 2015), taking home the CoCoRaHS Cup. In 2018, North Carolina placed fourth in the competition by recruiting 81 new observers.

EXPANDING EFFORTS

Over the past year, SCONC increased its contribution to other citizen science efforts within the state. As part of the eMammal project coordinated by the NC Museum of Natural Sciences, SCONC placed a wildlife camera on its Clayton, NC, ECONet tower for three weeks in summer 2017. Data collected from this camera was submitted to the eMammal database, contributing to efforts to measure wildlife activity across North Carolina. SCONC also participated in a mini-citizen science expo as part of the NC Museum of Natural Science's 2018 Reptile and Amphibian Day with a booth on CoCoRaHS. Finally, SCONC has participated in several meetings of the NCSU Public Science Cluster on creating a Citizen Science Campus.

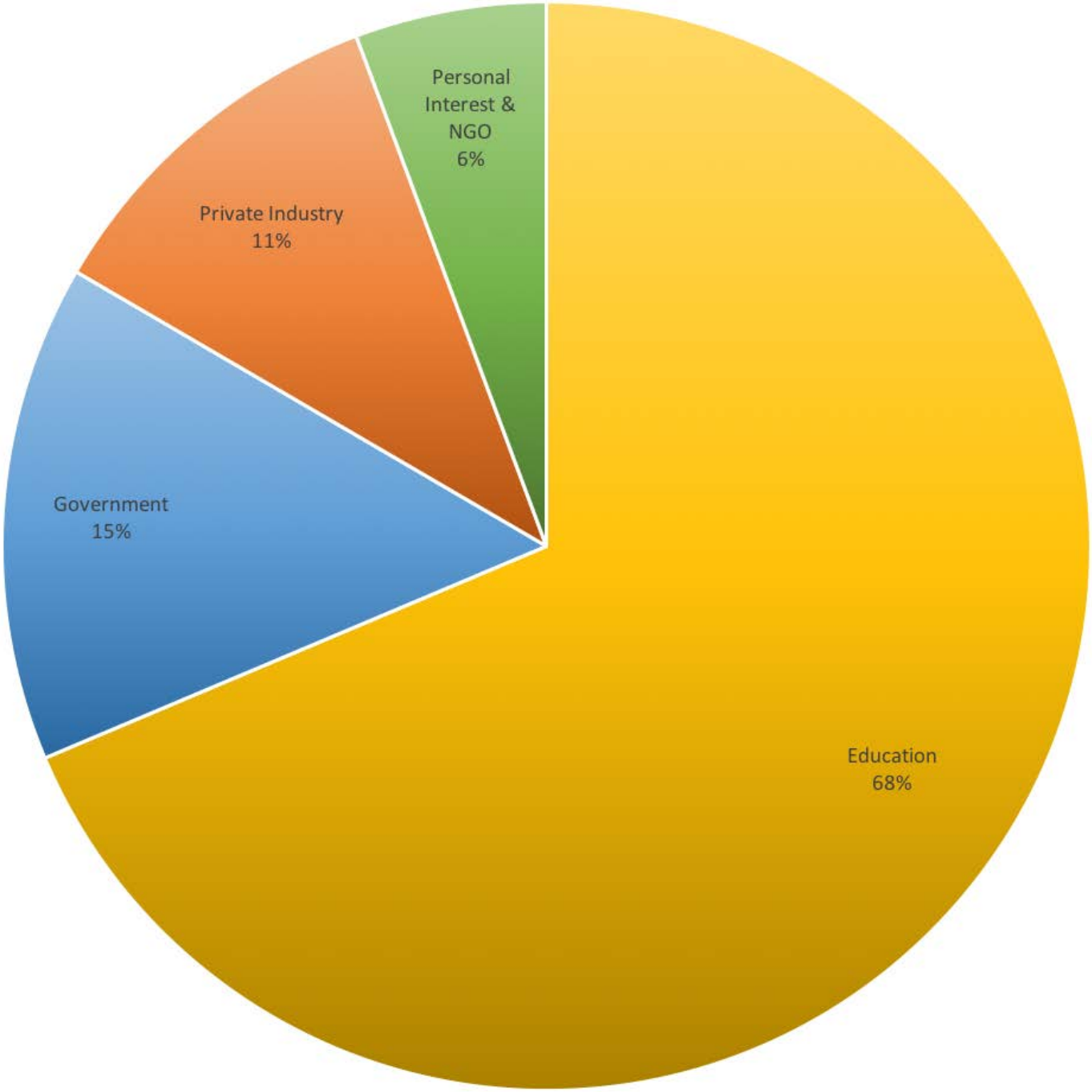
This white tailed deer was captured walking by SCONC's Clayton, NC, ECONet tower in July 2017.

Appendix A: Climate Services

Climate Information Services

Effort by Client Sector

May 1, 2017 through April 30, 2018



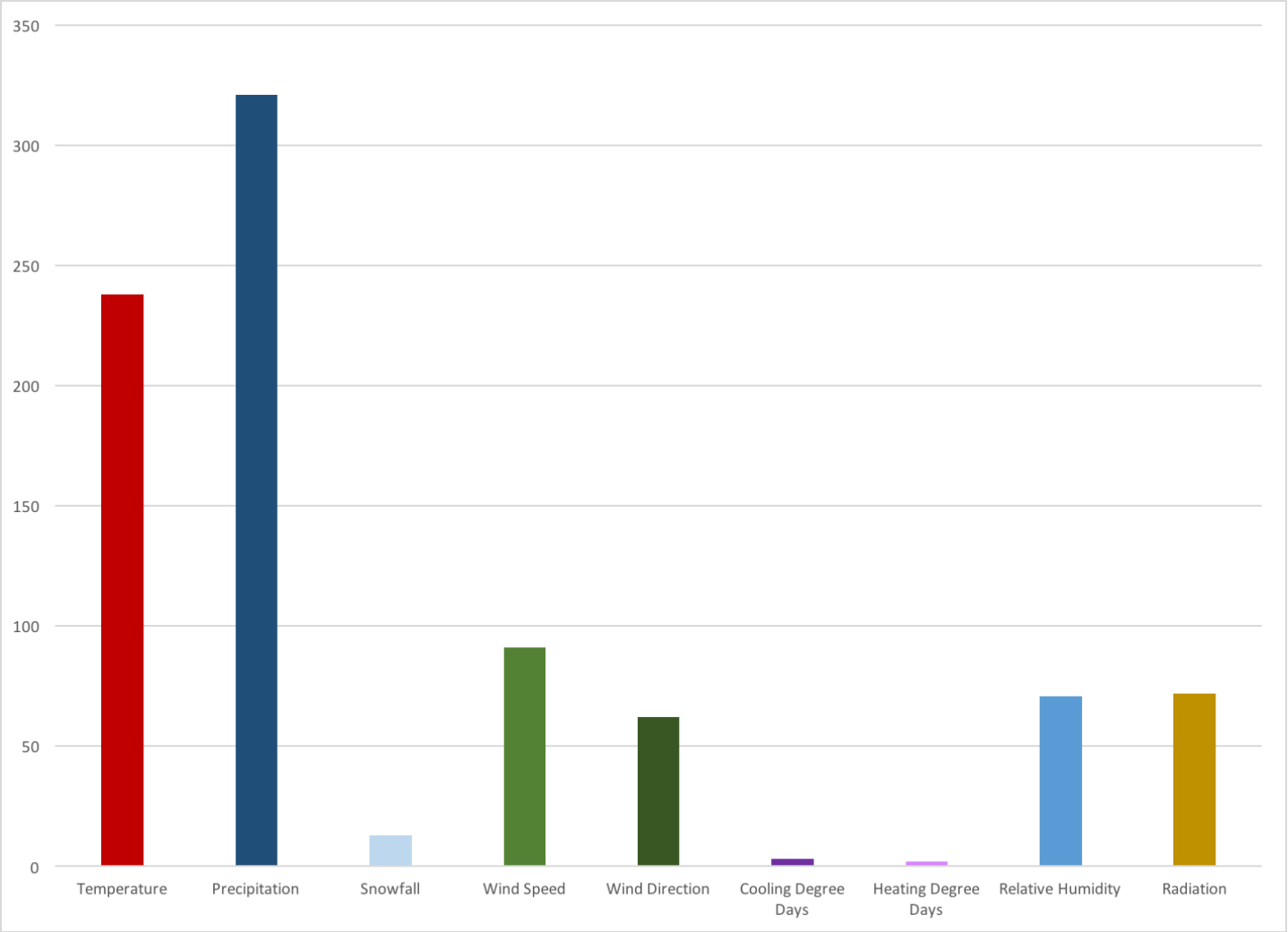
Climate Information Services by Client Sector – Details

May 1, 2017 through April 30, 2018

Classification	Number of Requests	Hours Worked
Government: Federal-Agriculture	12	12
Government: Federal-Engineering	2	3
Government: Federal-Other	11	13
Government: Local-Education: college, university	1	1
Government: Local-Other	9	9
Government: Local-Water	2	2
Government: State-Agriculture	2	2
Government: State-Construction	2	2
Government: State-Education: college, university	275	285
Government: State-Engineering	1	1
Government: State-Health	3	3
Government: State-Legal/insurance	1	1
Government: State-Other	16	18
Government: State-Tourism/recreation	1	1
Government: State-Water	3	3
NGO-Other	2	2
Private entity-Agriculture	8	10
Private entity-Construction	2	2
Private entity-Economic development	1	1
Private entity-Education: college, university	25	25
Private entity-Education: K-12	1	1
Private entity-Energy	2	2
Private entity-Engineering	20	20
Private entity-Legal/insurance	2	2
Private entity-Media	3	3
Private entity-Other	10	10
Private entity-Personal interest	23	24
Totals	***440***	***458***
Percent Change from Previous Year	***19.2%***	***10.4%***

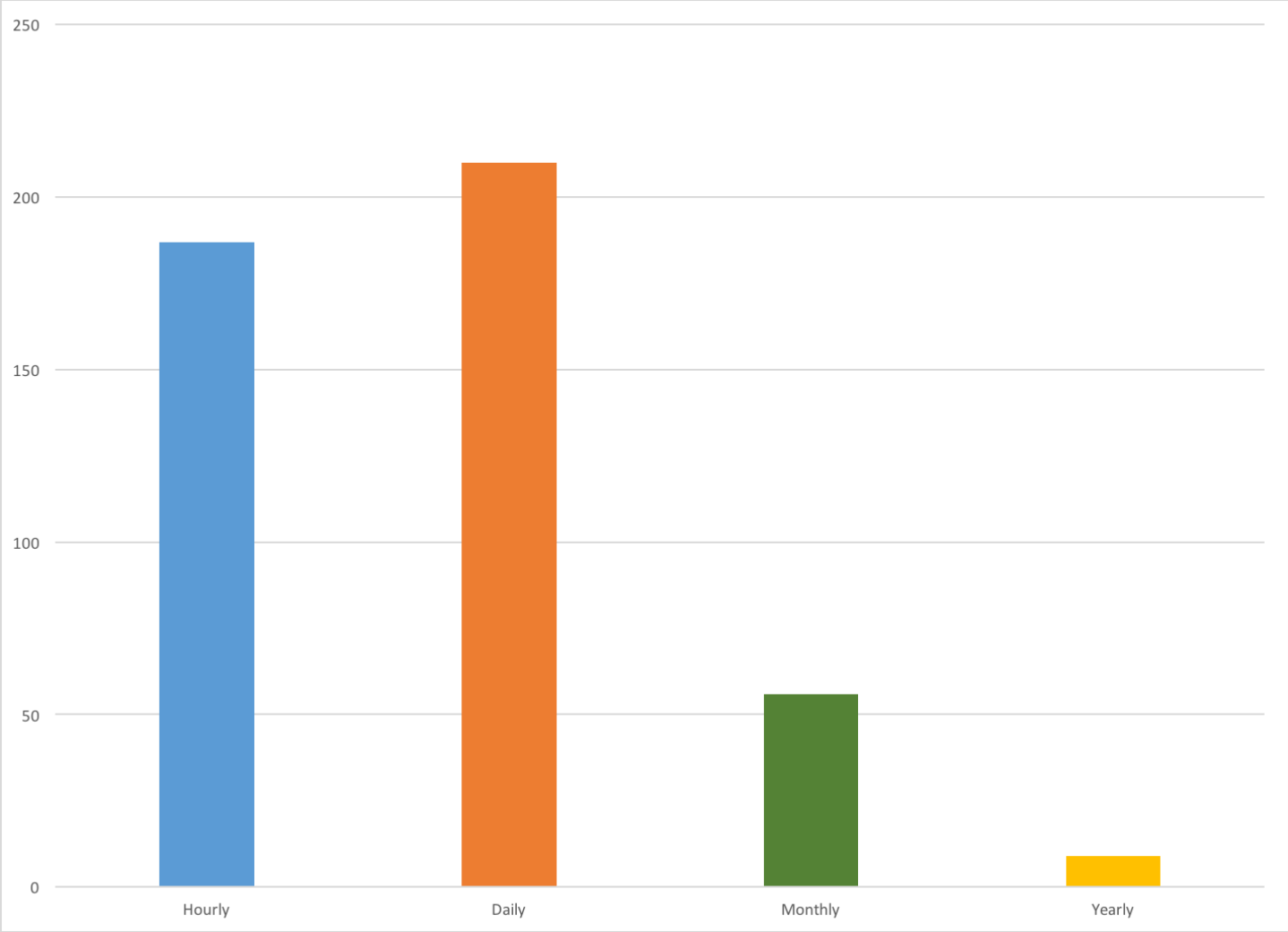
Climate Information Services by Parameter – Details

May 1, 2017 through April 30, 2018



Climate Information Services by Temporal Scale – Details

May 1, 2017 through April 30, 2018



Appendix B: Impact Statement

State Climate Office of North Carolina

NC State University

THE NEED

Weather and climate affects many aspects of our daily lives - a few examples include agriculture, environment, transportation, tourism, and natural disasters. Roughly one-third of our nation's economic activity is estimated to be sensitive to weather and climate. Scientific discovery and understanding of weather and climate begins with environmental data collection, research and education.

SERVING THE NEED

The State Climate Office of North Carolina (SCONC) is a public-service center for climate-environment interactions in North Carolina. SCONC is housed at NC State University in the College of Sciences with support from the NC Agricultural Research Service. SCONC is the primary source for North Carolina weather and climate information and is involved in all aspects of climate research, education, and extension services. Activities include:

- Operating and collecting high-resolution weather data from a growing network of 41 research quality weather stations called the Environment and Climate Observing Network (ECONet).
- Disseminating climate information to the citizens, businesses, and agencies of North Carolina through the web, social media, meetings, email, phone calls, and one-on-one conversations - all supported by the SCONC environmental database infrastructure. Online data are accessible through an intuitive interface making climate data available from over 20,000 surface weather and water resource stations in and around North Carolina.
- Assisting state government agencies in activities influenced by weather and climate, reducing costs and conserving resources.
- Collaborating with extension scientists to provide agricultural guidance to growers for disease management and irrigation, which lead to mitigation of crop loss and better production decisions. Staying involved with drought monitoring and management at community, statewide, and national scales.
- Studying climate variations and impacts on North Carolina, including sensor and model evaluation, severe weather patterns, drought and water resource management, and economic impacts.
- Providing numerous community presentations, participating in science fairs, and other interactions with K-12, college students, and teachers.

IMPACT BEYOND NORTH CAROLINA

SCONC is involved in regional and national partnerships to facilitate the understanding of climate science and the development of climate science applications. Undergraduate and graduate students working at SCONC gain a genuinely multi-disciplinary experience that contributes to career growth and lifelong learning. Many successes of SCONC are often heralded as a model for other states' climate offices.