



State Climate Office of North Carolina
 College of Sciences
 1005 Capability Drive
 Centennial Campus Box 7236
 Raleigh, NC 27695-7236

Phone: (919) 515-3056
 Fax: (919) 515-1441
 E-mail: sco@climate.ncsu.edu
 Web: climate.ncsu.edu
 Twitter: @NCSCO



NORTH CAROLINA CLIMATE OFFICE

2014-2015 ANNUAL REPORT

May 27, 2015 DRAFT

The State Climate Office of North Carolina (SCO) 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, the SCO focuses on service to public and private sectors of North Carolina through climate science extension, research, and education.

Dr. Ryan Boyles
 Director and State Climatologist

Mr. Ameenulla Syed
 Associate Director and ECONet Manager

Mr. Aaron Sims
 Associate State Climatologist

Ms. Ashley Hiatt
 Environmental Meteorologist

Mr. Sean Heuser
 Instrumentation Meteorologist

Mr. John McGuire
 Environmental Meteorologist & Developer

Ms. Heather Dinon Aldridge
 Applied Climatologist

Ms. Rebecca Cumbie
 Extension Climatologist

Mr. Greg Deleruyelle
 University Program Associate

Mr. Nathan Parker
 Technology Support Specialist

Mr. Corey Davis
 Applied Climatologist

Mr. Jim Epps
 Coastal Carolina University / Meso US Partner

Ms. Adrienne Wootten, Graduate Assistant
Ms. Geneva Ely, Undergraduate Assistant

Mr. Colin Loftin, Undergraduate Assistant
Ms. Melissa Mainhart, Undergraduate Assistant

Mr. Andrew Martin, Undergraduate Assistant
Ms. Jessica Miller, Undergraduate Assistant

Ms. Madeline Pope, Undergraduate Assistant
Mr. Samuel Roback, Undergraduate Assistant

Ms. Emma Scott, Undergraduate Assistant

Extension Advisory Board

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- Mr. Tommy Shingleton, Shingleton Farms*
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Staff and Students, Summer 2014



Back Row: Ashley Hiatt, Greg Deleruyelle, Andrew Martin, Heather Dinon Aldridge, Aaron Sims, Jim Epps
Middle Row: Sam Roback, Colin Loftin, John McGuire, Nathan Parker, Adrienne Wootten, Emma Scott, Jessica Miller, Ryan Boyles
Front Row: Sean Heuser, Corey Davis, Madeline Pope, Rebecca Cumbie, Geneva Ely, Ameenulla Syed
Not Pictured: Melissa Mainhart

Executive Summary

In the Academic Year 2014-2015, the State Climate Office continued its efforts to deliver climate services to the state of North Carolina through extension, research, and education programs.

Extension efforts focus on providing climate services through direct contact, online databases and analysis tools, environmental monitoring, and routine climate summaries. We partner closely with other scientists in agriculture, natural resources, public health, and water resource management to develop and deliver sector-focused climate services. We maintain an extensive Environment and Climate Observing Network (ECONet) and support regional climate services in partnership with the NOAA Southeast Regional Climate Center.

Direct requests for services have had a decrease of 19% in the past year, while online visits increased by nearly 55%, resulting in a more than doubling of web traffic in the past two years. Our climate database also continues to see heavy traffic, with 2.3TB of internal database transfers each month, over one billion data records selected, updated, or inserted each month, and more than 2.5 million queries made over the past year, an 8% increase. Maintaining and expanding the NC ECONet is an ongoing challenge, but these observations are unique and provide a highly valued service for state, local, and federal agencies. In the past year, we continued to deliver agriculture disease and forecast services, and provide service to the forestry and natural resource sectors. We have also continued to engage and serve the public health community in North Carolina.

Research efforts build on our 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 drought monitoring, weather sensor analysis, agricultural and forest sensitivities to weather, and climate model downscaling and projections. Our actionable science feeds into improved extension services and our education and outreach programs.

As North Carolina's primary statewide resource for informal climate education, outreach programming is a substantial focus for SCO staff and students with more than 6,000 direct educational outreach contact hours. In the past year SCO provided direct outreach for dozens of school and community groups; participated in large educational events, such as News14 Carolina Winter Weather roundtable; and pushed a range climate news and information to the public via our blog and social media. We also hosted student interns from Centennial Campus Magnet Middle School for a 12th year and engaged NC teachers through the CoCoRaHS grassroots rainfall network.

These activities were supported by funding from College of Sciences, the NC Agriculture Research Service, and external contracts and grants.

MISSION

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

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 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 NC climate and environment.

CLIMATE EXTENSION

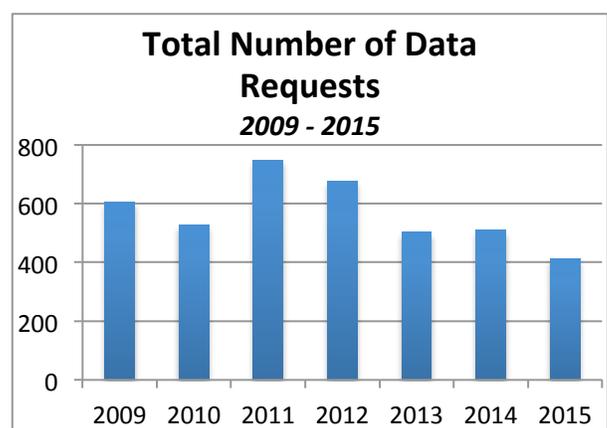
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Climate Information Services: *The State Climate Office provides many climate science services to clients and partners. Climate Services is a broad concept, but fundamentally involves interaction between a client who needs climate information and SCO 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. SCO staff and students interact directly with users to ensure responsive and reliable climate information services.*

Requests for Services: Direct requests from clients via email and phone during 2014-2015 resulted in a ~19% decrease in time spent directly responding to requests for services from clients as compared with the previous year. As with most years, a large percentage of time was devoted to supporting educational requests (60%), while remaining effort went largely to support government (18%) and private industry (16%). Formal public interest requests accounted for 6% of effort. A detailed breakdown of request-driven climate services is provided in Appendix A. While direct requests for information have decreased over the past year, usage of online climate data resources continues to grow rapidly with a **55%** increase in website visits.

Team: All staff and students



Website: The SCO website is often the first point of contact with clients who need climate information. Effort continues to focus on linking web products and tools to the climate observation database to provide products and services that are dynamically updated.

Usage: The number of website visits (sessions) increased by 55.1% (1,348,474) over the previous year (869,237). Of these visits, 80.7% of these were from new visitors (1,087,968), an increase of 59% over the previous year (684,435). Since 2009, web traffic has increased by almost 500%.



Sessions since FY2010



- Most website visits in a day: 14,087 on February 2nd, 2015
 - 88% of referrals came from Washington Post Groundhog Day Article
- US State Visits
 - 22% of all visits came from North Carolina
 - CA (9%), TX (6%), FL (6%), NY (6%) of visits
 - Only Wyoming (925) failed to have more than 1,100 visits
- Global Visits
 - 67% of all visits came from the United States
 - India (5%), Philippines (4%), Canada (4%), UK (3%)
 - 130 other countries accounted for more than 100 website visits.
- Traffic Summary
 - 81% of website visits came from a search engine (e.g. Google), an increase as compared to 64% from last year. With so much traffic coming from search engines, we will need to ensure our site is mobile-friendly as search engines are starting to promote mobile-friendly pages to the top of search results.
 - 12% of website visits came from direct sources (e.g. Bookmarks, going directly to URL), which is similar to last year
 - 0.7% of website visits came from social media, which is similar to last year
 - 6% of website visits came from non-search engine referring sites, which is a slight decrease (1%) from last year
- Content Highlights
 - 61% of all page views were on K12 Education modules

- Station Data
 - 3.1% of all page views were requests for MITC (Mount Mitchell ECONet)
 - Of all page views requesting data, top 5 viewed stations are:
 - Mount Mitchell (MITC) 30.5%
 - Grandfather Mountain (GRANDFATHR) 4.3%
 - Bearwallow Mountain (BEAR) 1.7%
 - Goldsboro (GOLD) 1.1%
 - Frying Pan Mountain (FRYI) 1.0%

Team: John McGuire, Ashley Hiatt, Aaron Sims

NC Environment and Climate Observing Network (ECONet)

The ECONet is a network of real-time research-grade monitoring stations that provide observational data on atmospheric and soil conditions. Base funding for the ECONet is provided by NC Agricultural Research Service, which supports the maintenance of sensors at Agriculture Research Stations. Additional support is provided by NC Electric Cooperatives, and individual partners. The ECONet is unique in North Carolina, and provides information that is not collected by any other sensors in the state such as solar radiation and soil conditions.

Station Maintenance: 115 site trips were made throughout the past year to perform routine or emergency maintenance covering almost 17,000 vehicle miles.

- Six wind monitors were replaced due to damages and upgrades.
- 22 integrated wind / temperature / humidity / pressure probes were repaired or replaced.
- 30 radiation sensors were recalibrated or replaced for annual maintenance.
- Five soil temperature sensors were replaced due to sensor failures.
- 14 soil moisture sensors were replaced with a newer model.
- Two stations were upgraded from traditional phone lines to internet and cell communications.
- Two telephone modems were replaced due to damage.
- 16 enhanced temperature and humidity probes were installed.
- One rain gauge was replaced due to sensor failure.
- Two leaf wetness sensors were replaced.



Staff and students at the Spindale tower installation

New Station Installations: Two new ECONet stations were installed during the past year. The first was installed on August 14, 2014 at the campus of Isothermal Community College in Spindale, NC (SPIN). This installation was a

partnership between the NOAA-CICS, Facebook, and ICC. This is our first station to use Wi-Fi communication to relay data back to our office every 5 minutes. This station will also be used for collaboration between scientists and local community college students for a sensor-training program.

The second installation was on December 18, 2014 at Sassafras Mountain (SASS) in Pickens, SC. Sassafras Mountain is the highest point in South Carolina at 3525 ft. above sea level. This station is a product of a partnership between the North Carolina Climate Office and the South Carolina Climatology Office. Data for this site is coming in every 15 minutes via cell communication.

Team: Aaron Sims, Sean Heuser, Ameenulla Syed, Jim Epps with assistance from all staff and students

Planned Installations: The North Carolina Climate Office, in partnership with the Bald Head Island Conservancy, will be installing a new station on Bald Head Island in the early summer of 2015. This will be the first ECONet station on the Outer Banks and will also help facilitate educational and outreach programs between the North Carolina Climate Office and the Bald Head Island conservancy.

Quality Assurance Quality Control (QAQC): QAQC continues to evolve improving the data quality of the network. New routines were implemented to better determine possible sensor failures. One check compares soil temperature and air temperature to determine possible soil temperature drift at our ECONet sites. A static range check for the leaf wetness sensors was also implemented to help alert technicians of damaged sensors in the field in a timely fashion.

Additionally in 2014, a new quality control (QC) check was developed to flag summary parameters based on the number of observations input to that calculation during the requested time period. This will help users of that data understand if all data was available when calculating parameters (such as average temperature, wind speed maximum, and total precipitation).

Visualization and analysis tools remained at the forefront of QC development in 2014. New tools added during 2014 include: long term visualization charts for minute data (up to 6 months), a sensor comparison map of the multiple temperature and humidity sensors across our network, and a new station metadata page which includes sensor information, site information (such as latitude, longitude, elevation, land use, and soil type), and any outstanding ECONet trouble tickets for that station.

With the improvements to the QC routines and visualization tools, QC scores have steadily improved throughout years. In 2014, all ECONet data received a highest quality score **96.94%** of the time while only having the lowest score (failure to pass any level of quality control) **0.60%** of the time.



ECONet station on the summit of Sassafras Mountain.

Ongoing QC development is focusing on enhancing range checks and inter-sensor comparisons of precipitation and wind speed. Also, we have been developing new visualization tools to assist in the QC of Remote Automatic Weather Stations (RAWS) station data in NC.

Undergrad students continue to assist scientists with the daily examination of ECONet data using the QC interface. Improvements were made to this interface to increase speed and quality into the design. This has led to mass reduction in the time it takes to analyze and process the data.

Team: Sean Heuser with support from all staff and students

Climate Retrieval and Observations Network of the Southeast (CRONOS)

CRONOS is the name given to the SCO's climate database infrastructure, which includes data from surface observational networks, severe weather data, and almost every type of climate data available at the SCO. This database serves as the foundation for many SCO products and services.

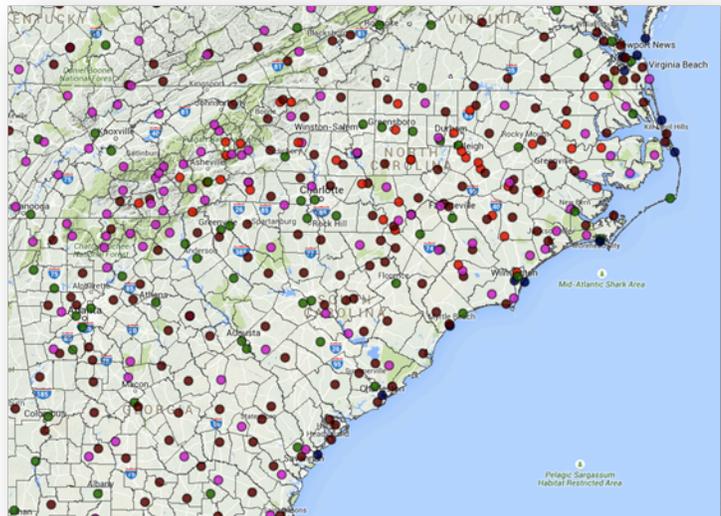
Usage: Users requested more than 2.5 million data queries through the CRONOS interface – an increase of 8% as compared to last year. With the development of more sophisticated SCO applications and products, end users now have access to more value-added information and services. In addition, the SCO is also providing terabytes of gridded data to partners and end users. Network and data support for CRONOS users involve a significant amount of internal data ingest, management, and transfer. The SCO continues to average about 2.3TB of internal climate data transfer each month with about 1.38 billion data records selected, updated, or inserted each month.

CRONOS API: An application programming interface (API) allows authorized users to access data without going to the web interface. This API facilitates the direct integration of weather and climate data into other products and services supporting automated data retrieval and machine-to-machine communication. The API will simplify internal and external data use, allowing staff, students, and collaborators access to data for research and product development without requiring SQL expertise. In the past year, there were 19.94 million API queries, which represents an increase in 574% over the previous year's value of 2.96 million queries.

A new API is being tested, incorporating many features such as data aggregation, variable calculation, and unit conversion. In the future, this will include a nearest station lookup, and ultimately include “best-estimate” data calculated from gridded data. Current work on the API is primarily back-end, linking variables to different data tables, network types, and formula calculation. The API will also incorporate variable metadata, such as units, sensor information, and date of first observation of the variable. This information will allow the API to generate a best estimate based on other parameters in the future, using surrogate data such as gridded observations or forecasts in areas where data is unavailable or missing. The API is being written to use a variety of universal output formats, such as JavaScript Object Notation (JSON), and will have the ability to be called from various programming languages such as Python and Perl.

Team: John McGuire, Ashley Hiatt, Aaron Sims

Data Management: The SCO continues to enhance its services and accessibility for weather and climate information. To keep up with increased demand, back-end infrastructure development and expansion continues to grow. Presently, we are archiving and serving up over 36TB of gridded data from various sources, which is 50% more as compared to last year. These datasets provide valuable insight to weather and climate information. Building out enterprise infrastructure offers robust and timely distribution of these datasets which ultimately improves accessibility for end users.

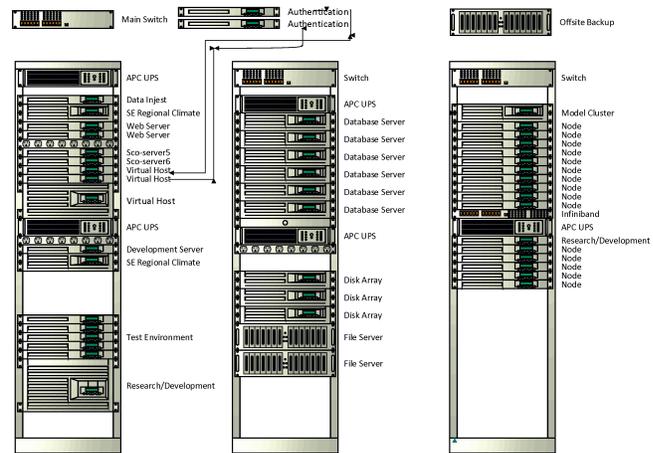


Sample map of sub-daily stations available across the southeast.

Back End Changes for Past Year

- Improved student lab environment
- Virtualized services to reduce hardware footprint
- Improved network security to protect production servers and data
- Added additional disk storage
- Added new database servers
- Added additional offsite backup storage
- Created test environment for core services upgrade testing
- Expanded shares for new partners

Team: Aaron Sims, John McGuire, Nathan Parker



Schematic of SCO computing infrastructure

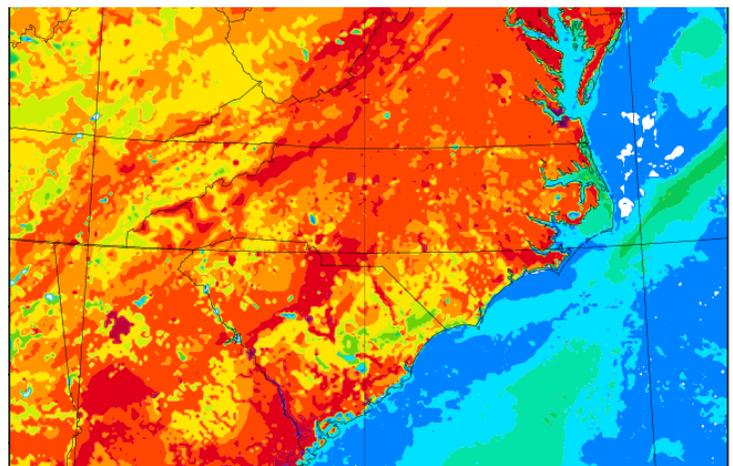
Weather Kiosk: A customizable weather display system to show current weather conditions, forecast conditions, weather graphics, and other relevant information. Displays have been tailored for our office and for groups at Jordan Hall (NC State), Isothermal Community College, and South Carolina. This tool allows for specific details on current and past weather closest to each location, as well as custom content for each site, with the goal of enabling viewers to quickly put current conditions in a historical climate context.

Team: John McGuire

National Mesonet Program: Over the course of the year, the North Carolina Climate Office in collaboration with Coastal Carolina University, continued to send ECONet observational data files to the NOAA Meteorological Assimilation Data Ingest System (MADIS) gateway for national dissemination to research groups. In addition to the ECONet stations, the files include data from three pier stations and one SODAR station based in South Carolina. During 2014, our MADIS data feed was upgraded to provide sub hourly data over the most recent hour available. As part of this program, we are also looking to upgrade ECONet stations to five minute data transmissions.

Team: Sean Heuser, Jim Epps, Aaron Sims, John McGuire, Ameenulla Syed

Environmental Modeling: The SCO continues to produce routine experimental numerical weather forecast guidance using the Weather Research & Forecasting model. Timely production of model forecasts and simulations for analysis and distribution to key partners and stakeholders requires dedicated high-performance computing with low-latency network interconnects. These simulations are available for use by the public, and are distributed to various partners. Moreover, these datasets provide inputs to a series of agricultural products, including disease forecasts for cucurbits (cucumbers, squash, melons, etc.), heat and chill forecasts for small fruits, and efforts with smoke management. The SCO is continuing to work with other scientists to implement state of the science technology to help improve the forecasts.

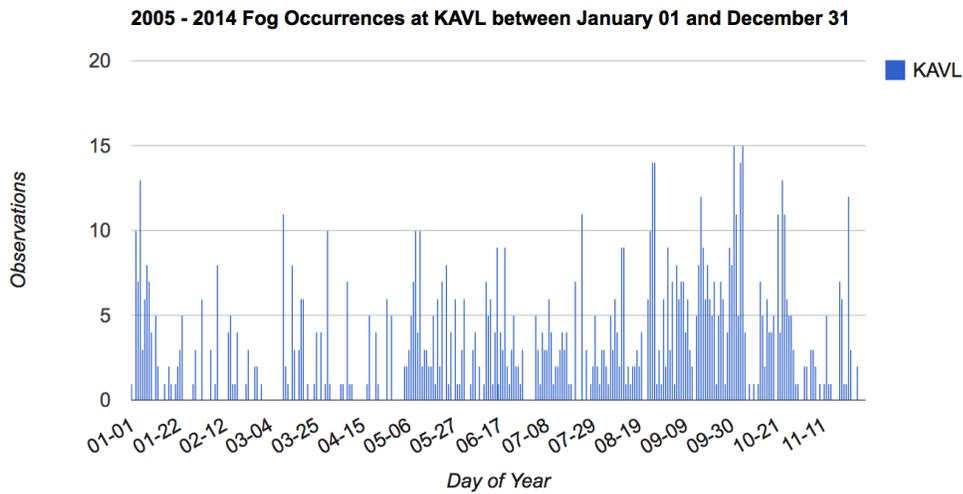


SCO model output illustrating heat exchange between the surface and air.

Team: Aaron Sims

Fog, Visibility and Present Weather Climatology: With the growth in the number of monitoring stations at both large and small airports, we now have representative statewide coverage of hourly fog, visibility, and current weather measurements. These data have been analyzed using a prototype tool to help convey the frequency suitable conditions for aviation at all airports, which is important for National Weather Service’s support services for airport weather monitoring and forecasting. This tool has been refined with input from National Weather Service (Raleigh) and is scheduled for release for public use in the summer of 2015.

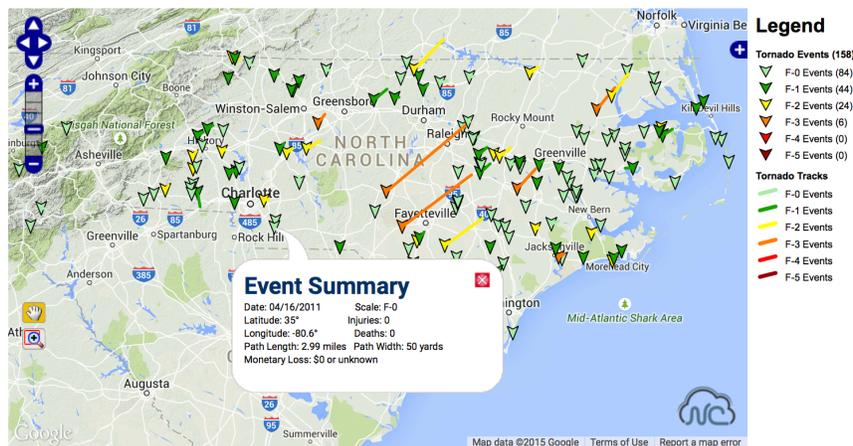
Team: Andrew Martin, Corey Davis, Heather Aldridge



Total reports of fog at Asheville Airport by calendar day. Fog reports are less common in the late winter and spring at this valley location.

Severe Weather Updates: Last fall, our information pages on thunderstorms and associated severe weather were updated. New mapping tools were added to complement the charts and graphs developed in FY2014. Released in the fall of 2014, the new maps provide individual and summary statistics for all verified storms in the southeastern US. The same tool also displays bar chart of storms by month, pie chart showing the frequency of storm severity, and tables of monthly storm summaries. (<http://climate.ncsu.edu/spc/map.php>).

Team: Colin Loftin, Corey Davis, Heather Dinon Aldridge



Tornado origins and tracks for the period 2009-2013 using new mapping tool

Climate Support for Agriculture

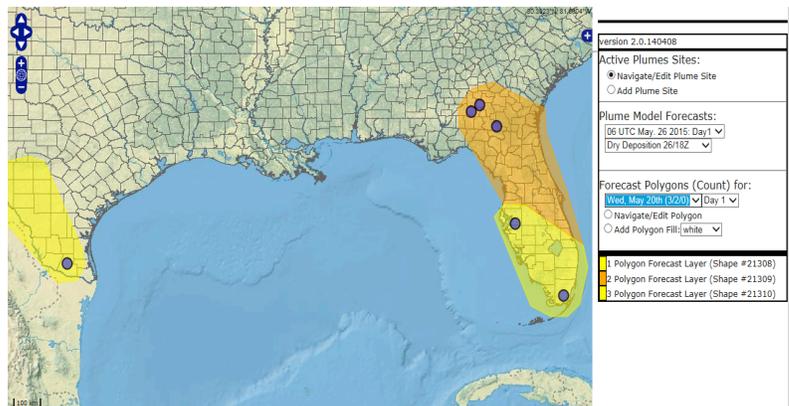
Peanut Disease Advisories: 2014 brought the 11th year of our continuing partnership with Dr. Barbara Shew in NCSU Plant Pathology to provide routine advisories for two peanut foliar diseases: peanut leaf spot and peanut sclerotinia. Daily email alerts are sent from June- September for review by Dr. Shew, who then passes along guidance to her constituents across eastern NC and southeastern VA. Analysis from past years suggests these advisories can save 2-3 fungicide applications a year, with a value to growers of at least \$1-\$3 million a year.

Team: Aaron Sims, Ashley Hiatt, Ryan Boyles

Late Blight for Potatoes and Tomatoes: In collaboration with Dr. Jean Ristaino (NCSU Plant Pathology), the SCO continues to provide technology support and website administration for monitoring and alerts of Late Blight affecting tomatoes and potatoes. This year, new backend improvements include enhancements to security and login functions. Planned effort with this project will incorporate the new ECONet leaf wetness sensors to improve estimates of high humidity environments. During the past year, there were 235 confirmed lateblight cases across the United States and Canada, 5% less than last year (248). As part of the monitoring effort, there were 364 alert sites setup by 336 active users.

Team: John McGuire, Ryan Boyles, Sean Heuser, Ameenulla Syed, Aaron Sims.

Cucurbit Downy Mildew Forecasts: SCO continues ongoing collaboration with Dr. Peter Ojiambo, Mr. Thomas Keever, and Ms. Wendy Britton (NCSU Plant Pathology) to provide national operational integrated pest management (IPM) forecasts for Downy Mildew affecting cucurbits (cucumbers, melons, squash). The SCO provides weather information, technology support, and dispersion forecast guidance. We continue to work with our partners in NCSU Plant Pathology to maintain the website (<http://cdm.ipmpipe.org>) and forecasting tools. Over the past year, this included upgrading the meteorological model and output graphics as well as refining the new forecasting interface.



Cucurbit Downy Mildew Risk Maps are prepared with daily SCO dispersion forecasts.

During the 2014 growing season (April – October), the website averaged 200 - 934 unique visitors each month, with 4,070 unique users between May 2014 and April 2015, representing a decrease of 39.4% compared to the same period last year (9,981). There were 151 confirmed reports of cucurbit downy mildew this year, a 48% drop compared to last year (293).

Team: John McGuire, Aaron Sims, Ryan Boyles

Climate Support for Forest and Natural Resource Management

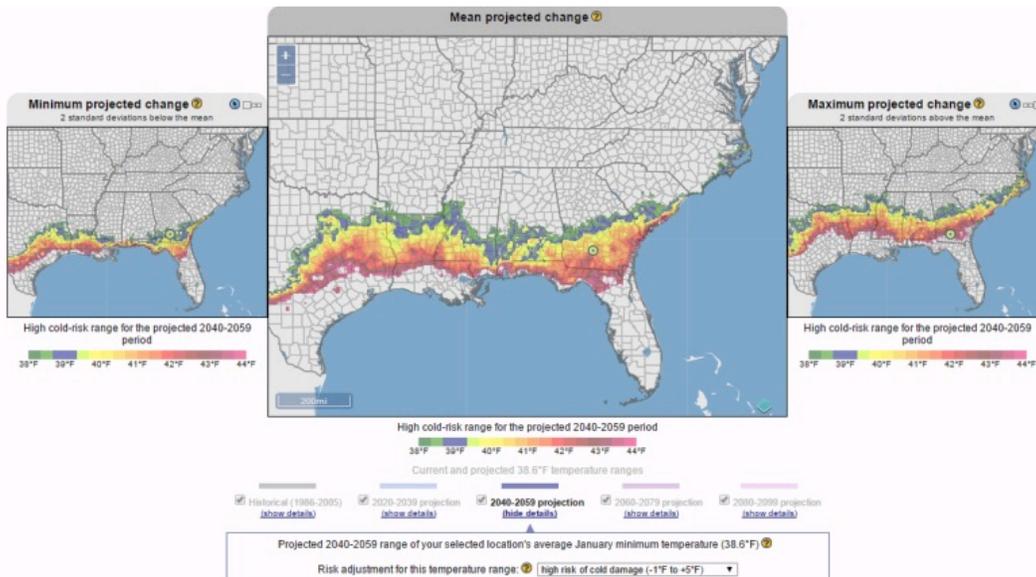
PINEMAP: Climate Support for Southern Conifer Management: In collaboration with 42 other investigators from across NC State University and the southern US, the SCO successfully proposed a 5-year project to USDA in 2010 for research, extension, and educational activities to improve the management of pine trees in the southern US. The SCO will specifically serve as the conduit to the other State Climatologists, developers of a decision support



system based on AgroClimate.org, and the climate extension resource for all partners.

Effort in the past year includes:

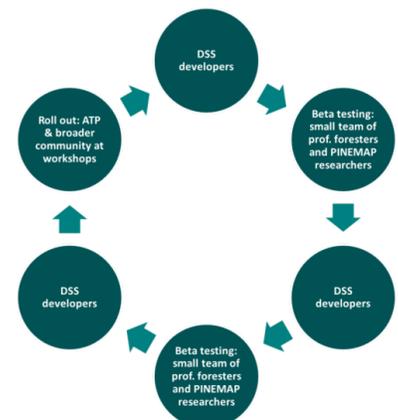
- Connecting forestry extension partners with southern State Climatologists who have served as presenters at regional workshops for natural resource professionals.
- Extending climate expertise as part of the PINEMAP outreach including:
 - Assistance with several PINEMAP webinars (for internal and external users) to promote understanding of climate science and collaboration among the interdisciplinary PINEMAP team.
 - Reviewed materials (factsheets, PPTs, websites, etc.) for PINEMAP audiences such as private landowners, limited resource landowners, industry/corporate landowners, and state forest agencies.
 - Provide guidance to the research sub-groups as to which climate datasets (historical data and future projections) are the most useful for PINEMAP.



High-resolution estimates of drought severity produced by SCO are now routinely used for statewide & national drought monitoring

Providing 19 invited presentations about climate and climate change related to forestry.

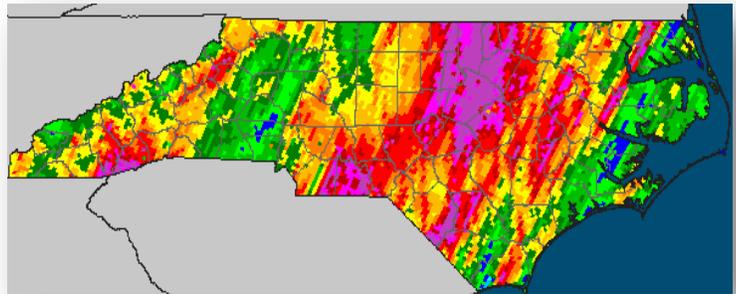
- Hosting the PINEMAP gridded datasets (~6 Terabytes) on THREDDS data server, which allows for automated requests and machine-to-machine data manipulation.
- Manipulating MACA climate model data by averaging over HUC12 regions with output available for three ecological models (~300GB):
- Performing and storing daily extractions at ~850 PINEMAP sites for six standard MACA outputs: min/max temperature, precipitation, wind speed, specific humidity, and solar radiation (~550GB).
- Completing about ten PINEMAP data requests for point or gridded datasets aggregated spatially and/or temporally to meet the needs of PINEMAP researchers.
- Developing on a beta version of the DSS website, which is available at: http://climate.ncsu.edu/pinemap_dss.
- Initial tools created include:
 - Temperature
 - Projected change in annual number of days <32F.
 - Projected change in growing season length.
 - Precipitation



- Projected change in summer precipitation.
 - Seedling Deployment (based on historical average extreme minimum temperatures)
 - **Seedling Markets:** View ranges where seedlings from a selected location could be moved in the future; ideal for nurseries.
 - **Seedling Sources:** View ranges where seedlings could be pulled from for future planting at a given location; ideal for landowners.
- Identifying and engaging with a DSS beta tester team for the seedling deployment tools. This team includes a few industry professionals, a consultant, a TIMO/REIT representative, and several PINEMAP scientists.
- Completing beta testing for the seedling deployment tools, including an independent exploration period and small group discussions.
- Partnering with an NCSU technical communications student on a project that evaluated how information is presented within the DSS and offered solutions to make the DSS more intuitive to our target audience.

Team: Heather Dinon Aldridge, Corey Davis, Ryan Boyles

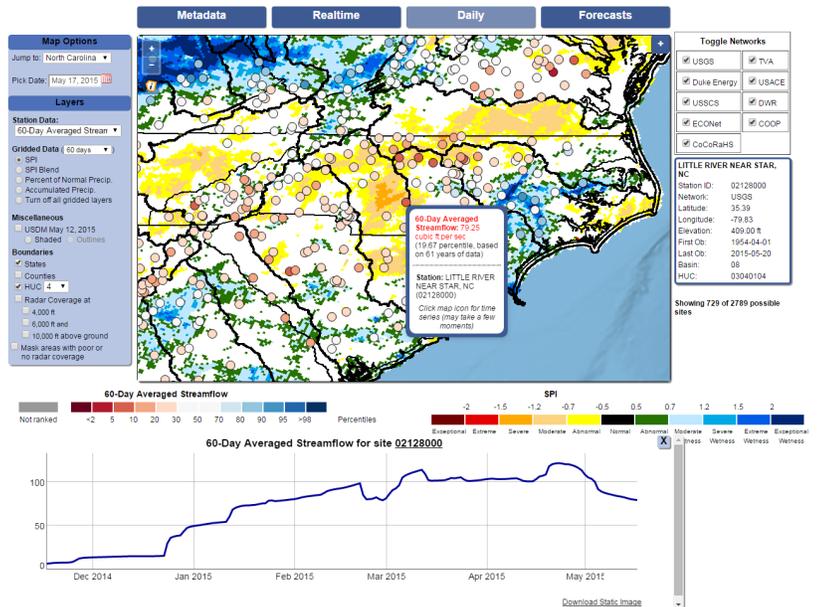
Precipitation Monitoring and Alerts for Storm Water Management: NC DOT continues to support the SCO to provide radar-based precipitation alerts and monitoring tools. There are currently 1,233 active user accounts for this product with 1,741 active sites monitored. Of those sites, 496 were added in the past year. This partnership with NC DOT has received three state and national awards. Improvements to the DOT page include development of a new map interface that will allow for faster rendering and processing.



Estimated rainfall amounts across the state from NC DOT Precipitation Alert Tool

Team: John McGuire, Aaron Sims, Ashley Hiatt, Ryan Boyles

Integrated Water Portal: SCO is developing an integrated portal that will bring together water data from several different agencies into a map-driven data exploration and visualization tool. This tool allows users to quickly explore regional and local water conditions, focused mainly on surface and near surface supplies. This portal incorporates current and historical station-based water and precipitation data with high-resolution gridded products, such as precipitation estimates from the National Weather Service that incorporate radar-estimates of precipitation and drought indices produced by the SCO. In addition to this, point-based streamflow and reservoir forecasts have been added to the portal. In the future, gridded output from NASA Land Information System (LIS) will be added supply gridded forecast information as well as streamflow and reservoir forecasts for more sites.



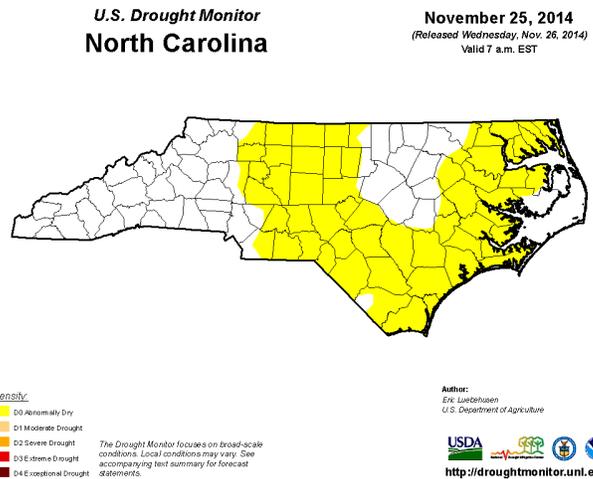
Streamflow and gridded drought severity (SPI) in the new Integrated Water Portal. The integrated water portal is especially designed to support

drought monitoring and forecasting needs and is targeted toward an audience of water supply and natural resource managers at municipal, state, basin, and ecosystem scales. The portal was presented at the 2015 WRRRI Annual Conference. Support for this project was provided by WRRRI, NC Urban Water Consortium, Tennessee Valley Water Partnership, and DENR Water Resources. Gridded drought products were developed with support from USDA NIFA, NOAA CPO, and NIDIS. <http://www.nc-climate.ncsu.edu/water/map> Collaborators: Sankar Arumugam.

Team: Rebecca Cumbie, Ryan Boyles, Ashley Hiatt, Aaron Sims, John McGuire

Drought Monitoring and Response: The SCO is a member of the NC Drought Management Advisory Council, participating in weekly drought monitoring conference calls and providing public presentations on drought in NC. During the weekly calls, the SCO regularly delivers information on recent precipitation placed in historical context as well as the current level of dryness indicated by custom maps of drought indices calculated by the SCO. The SCO has provided routine updates on drought conditions and impacts through the Drought Management Advisory Council, monthly climate summaries and blog posts, and interviews for print and broadcast news media. Over the past year, NC has been spared from drought, though abnormal dryness has been present in some part of the state nearly every week.

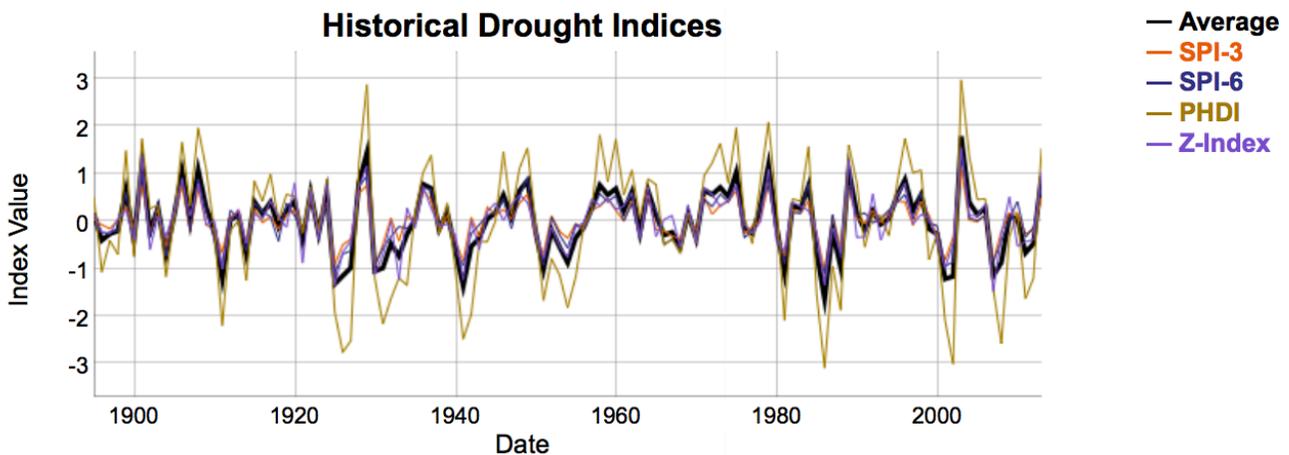
Team: Rebecca Cumbie, Ryan Boyles



Example of US Drought Monitor for NC, created with weekly input from SCO staff and drought tools.

New Drought Information and Drought History Tool: Drought has been one of the most commonly requested topics for invited presentations since 2002. This past year, we renovated the drought information section on our website to provide improved material on how drought is defined, monitored, and predicted. The highlight of the new drought section is dynamic charts that allow users to explore the historical frequency and severity of drought across climate divisions and statewide. <http://nc-climate.ncsu.edu/climate/drought>

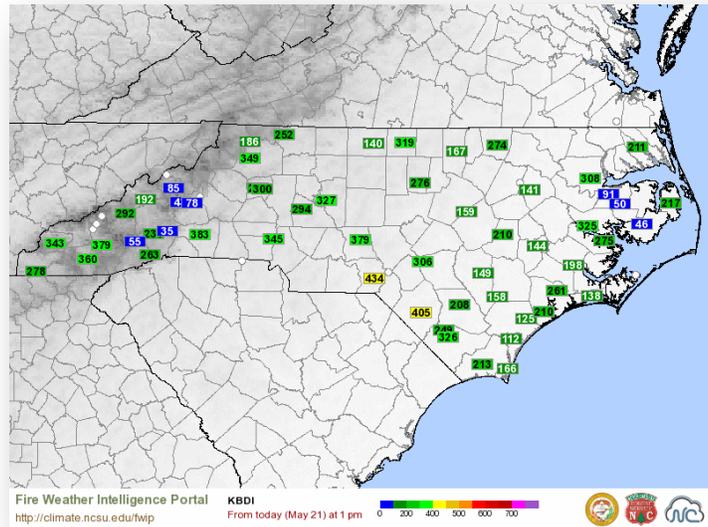
Team: Emma Scott, Ashley Hiatt, Rebecca Cumbie



Annual average statewide drought severity for NC as measured by 4 different drought indices. User-selected regional and statewide drought histories are a new feature of the Drought section of the SCO website.

Fire Weather and Smoke Guidance: In its second full year of availability, the Fire Weather Intelligence Portal remained a useful tool for NC Forest Service operations officers, foresters, landowners, forecasters, and others to monitor past, current, and forecasted weather and fire risk conditions across the state. In the past 12 months, the Portal received 22,140 page views from 2,976 unique visitors. Both are slight decreases from the previous year in which the Portal was first released. The Portal is regularly updated with new stations and parameters. Another recent addition is a set of static image maps for certain fire danger parameters, which can be used for local and regional condition monitoring by groups like the Southern Area Coordination Center and the Drought Management Advisory Council. (<http://nc-climate.ncsu.edu/fwip/>)

Team: Corey Davis, Ryan Boyles



KBDI Product from Fire Weather Intelligence Portal used daily by NC Forest Service

NOAA Southeast Regional Climate Center

UNC-Chapel Hill and NCSU were awarded the NOAA Southeast Regional Climate Center (SERCC) in 2007. As part of that award, the SCO supports and maintains the Applied Climate Information System (ACIS), which serves as the climate database for all six NOAA Regional Climate Centers. Additionally, the SCO is responsible for developing and maintaining the SERCC web services and online climate tools (<http://www.sercc.com/>). Partners at UNC-CH include Chip Konrad, William Schmitz, Jordan McLeod, and Maggie Kovach.

SERCC Web Traffic

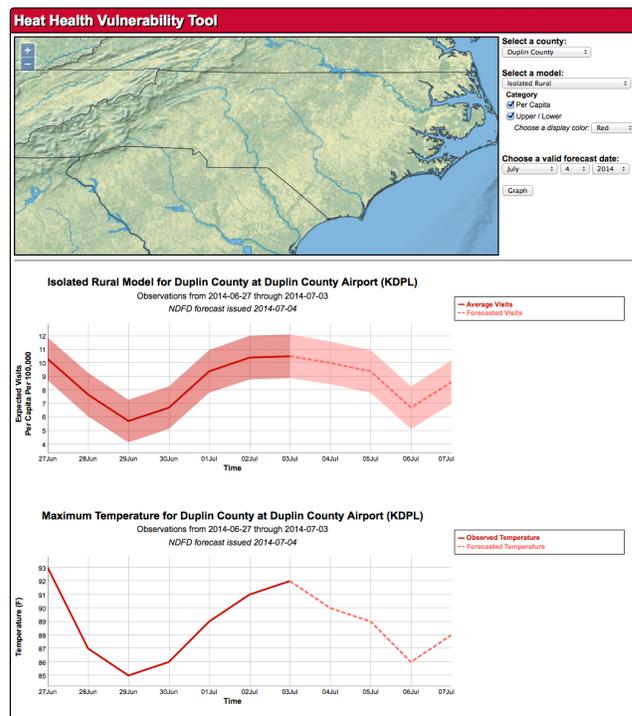
Usage: The number of website visits (sessions) was 134,998, a decrease of 28% over the previous year (188,739). The largest number of visits on a single day was 1,850 visits on February 19th, 2015.

- 92.3% of all visits came from the United States.
- Among US States, the most visits came from FL (14.6% of total visits), NC (13.6%), GA (9%), VA (6.5%), CA (4.4%), SC (4.4%), TX (3.9%), NY (3.6%), and AL (2.9%).
- 76.3% of website visits came from search engines (e.g. Google), a decrease of 8.8% over last year.
- 14.2% of website visits came from direct sources (e.g. Bookmarks, typing in address into URL), a decrease of 20.1% over last year.
- 9% of website visits came from non-search engine referral sites, a decrease of 14% over the previous year.

Climate and Public Health: In 2014, we continued to focus effort on additions to a prototype tool that allows researchers to explore the relationships between hospital emergency department (ED) admissions data and local climate conditions. The hope is that these relationships, if robust, will enable 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, heat index, wind chill, precipitation), 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.

New features added to the tool over the past year include antecedent weather conditions – namely, sums of precipitation and temperature departures from normal over various time frames leading up to the hospital emergency department admission. Such antecedent conditions often play a role in the development of water borne diseases that can have an influence on human health. UNC researchers will study relationships between the antecedent weather and subsequent emergency department admissions in the upcoming year. In addition, initial research results from this tool have been used over the past year to develop a Heat Health Vulnerability Tool (HHVT) geared toward public health officials, NWS personnel, the state emergency response team, and others who could potentially target messaging of heat warnings to particular groups or areas. A backend console was developed to make it possible for researchers to upload their location-specific climate-health models directly to the database, which are then made available through the HHVT. The HHVT allows users to view all models applicable to their location of interest, and graphically displays the model based on observed and forecasted temperatures for a nearby weather station over their selected time period.

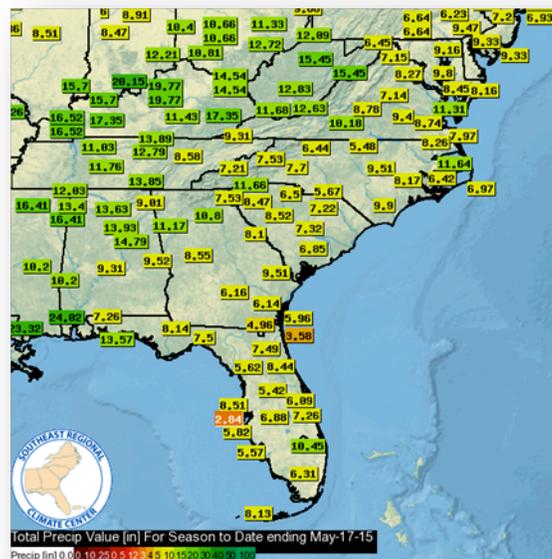
Team: John McGuire, Ashley Hiatt, Aaron Sims, Ryan Boyles



Example of Heat-Health Vulnerability Tool showing predicted temperatures and heat-related emergency department admissions for Duplin County in July 2014.

Climate Perspective Updates: Updates and enhancements were made to the regional climate information tool known as Climate Perspectives. Static images are now being generated for display on the future homepage. Upcoming updates will also enhance the existing Climate Perspectives Map that matches the display output of the static images, bringing speed and performance improvements for station rendering.

Team: John McGuire



Updated Climate Perspectives Tool for SERCC

APPLIED RESEARCH

Research efforts build on our 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 drought monitoring, weather sensor analysis, agricultural and forest sensitivities to weather, and climate model downscaling and projections. Our actionable science feeds into improved extension services and our education and outreach programs.

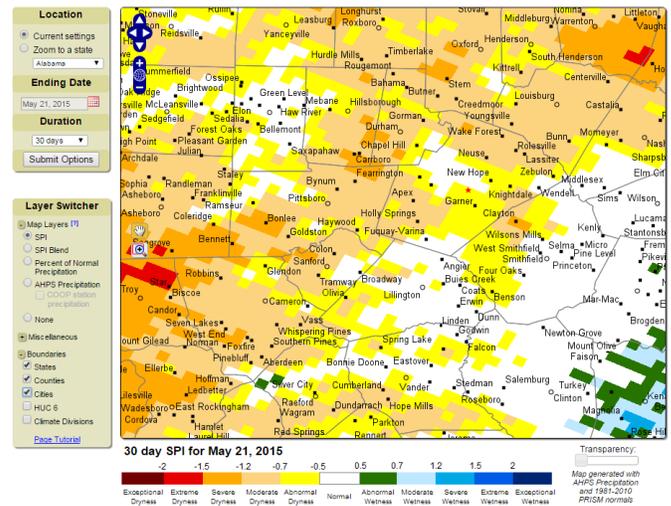
Presentations and Publications

- 4 manuscripts were successfully published in peer-reviewed journals or reports
- 5 manuscripts are in development or currently in submission
- 18 presentations were given at 10 scientific conferences
- 5 staff and students attended 12 scientific meetings and conferences

Evaluation of Multi-Sensor Precipitation Estimates (MPE): The SCO uses MPE products provided by NWS River Forecast Centers and the National Center for Environmental Prediction (NCEP) in several products and tools used by DOT, DWR, TVA, and others. As part of the ongoing use of the data, SCO has completed an evaluation of the NCEP Mosaic of MPE across the eastern United States (2002-2012). The evaluation excepted for publication has been published in the Journal of Applied Meteorology and Climatology (doi: <http://dx.doi.org/10.1175/JAMC-D-14-0034.1>). Similar analysis is also being run for Puerto Rico.

Team: Adrienne Wootten, Ryan Boyles

High-Resolution Drought Indices: A Standardized Precipitation Index (SPI) algorithm that is calculated using high-resolution grids that incorporate gauge-calibrated radar-estimates of precipitation, known as Multi-sensor Precipitation Estimates (MPE), was developed by Texas A&M University (TAMU). The resolution the SPI is approximately 5km, and has the ability to capture high spatial variation in drought severity. SCO was awarded a project with partners at TAMU and Purdue University to produce a routine SPI product based on these high-resolution precipitation grids. The product has been made publicly available through a website where users can view, query, and interact with the data. Currently it is being widely used and evaluated by experts across the nation as supplemental guidance for creating the weekly US Drought Monitor. Research was conducted in summer and fall 2014 to evaluate the high-resolution SPI's performance over droughts in the Central Great Plains in 2012 and the Carolinas in 2007-2008. Both analyses showed the high-resolution SPI performed well at depicting localized drought variation and severity. Three additional drought indices, the Keetch-Byram Drought Index (KBDI), the Palmer Drought Indices (PDI), and the Standardized Precipitation Evapotranspiration Index (SPEI) are undergoing development. These will be evaluated in summer 2015 and

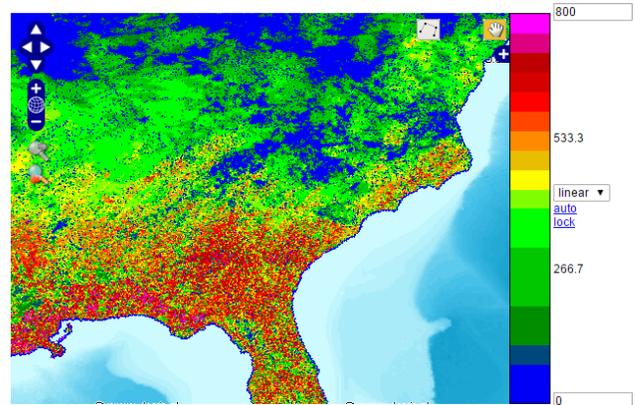


High-resolution estimates of drought severity produced by SCO are now routinely used for statewide & national drought monitoring efforts.

added to the website in summer or fall 2015. The PDI are based on a simple climate balance and are commonly used in drought monitoring. The SPEI has an algorithm that is computationally similar to SPI, but is based on the balance between precipitation and potential evapotranspiration rather than only precipitation. The KBDI is commonly used by the US Forest Service to estimate the dryness in soil and is related to fire potential. The SPI and its associated webpage were presented at the 2014 AASC Annual Meeting, while a presentation detailing the methodology and need for the SPI, SPEI, PDI, and KBDI was given at the 2015 WRRRI Annual Conference. Collaborators are John Nielsen-Gammon (TAMU) and Dev Niyogi (Purdue). www.nc-climate.ncsu.edu/drought

Team: Rebecca Cumbie, Jessica Miller, Melissa Mainhart, Corey Davis, John McGuire, Aaron Sims, Ryan Boyles

Coastal Drought: As part of a project with NIDIS to investigate measures of drought and fire risk in organic soils, we are creating a gridded Keetch-Byram Drought Index (KBDI) dataset using National Weather Service radar-based precipitation estimates and PRISM daily temperature data. KBDI is often used to monitor soil dryness, but engagement with partners suggests the tendency of organic soils to burn or smolder is not well captured by KBDI. After evaluating the gridded KBDI data against existing point-based observations, KBDI and several other drought indices will be compared with Estimated Smoldering Potential data taken from several organic soil sites in eastern North Carolina. These drought indices may also be compared with salinity or dissolved oxygen data from coastal estuaries to evaluate their potential usefulness as indicators of water and habitat quality where observations are otherwise unavailable. Collaborators include NC Forest Service and The Nature Conservancy.



KBDI calculated for the coastal drought analysis

Team: Rebecca Cumbie, Corey Davis

Comparison of Relative Humidity Sensors: Peanut disease modeling is critical to peanut farmers across our state. Based on feedback from partner Dr. Barbara Shew (NCSU plant pathology), we have explored the sensitivity of the humidity sensors used across the ECONet. As part of this research, 20 experimental sensors were deployed across the ECONet. In comparing high humidity conditions (RH>90%), we found the experimental sensors to be 5%-6% higher than our current standard WXT-520 probe. Based on these findings, we are implementing the transition of older operational sensors to these new experimental sensors. Partner: Dr. Barbara Shew (NCSU Plant Pathology)

Team: Sean Heuser, Madeline Pope, Ameenulla Syed, Ryan Boyles



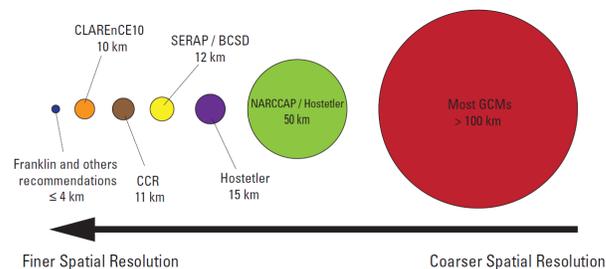
RH probes (in Gill shields) used in comparison study

Leaf Wetness: Leaf wetness sensors are being used to help estimate when a leaf is wet, which is critical for estimating risk for agricultural and horticultural pests. In 2013, we deployed 20 leaf wetness sensors across the agriculture production regions of NC to explore sensor sensitivities. Previous work from FY2014 defined the sensor's capabilities to estimate wetness onset and dryoff, and allowed us to define a sensor threshold. These data are an important component of the new Strawberry Disease Alert Tool, and will feed the development of additional extension tools and research studies. A planned field test in Mills River, NC should help refine the sensor's output to replicate samples taken on tomato leaves in the field. Partner: Dr. Jean Ristaino (NCSU Plant Pathology)

Team: Sean Heuser, Madeline Pope

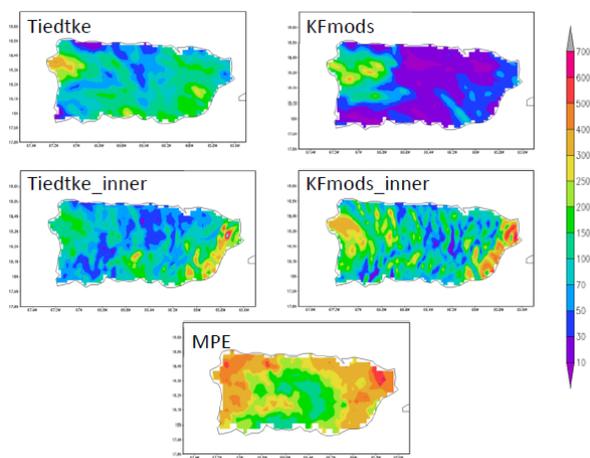
Evaluation of Downscaled Climate Projections: Local level projections (or downscaled climate projections) of climate change are being used more commonly in ecosystem modeling and conservation planning related to climate change. The proliferation of downscaled climate projections often leaves users questioning which dataset is appropriate for their application. The goal of this project was to synthesize the information available from these local level projections, evaluate several sets of projections with regards to ecological modeling in the Southeast U.S., and provide guidance for the ecological modeling community on how to choose a downscaled climate projection for their application. The USGS Open File Report (<http://pubs.usgs.gov/of/2014/1190/>) was published in September 2014, and highlights the challenges of modeling climate in the complex topography of the Southern Appalachians and under the influence of hurricanes. In addition, the report emphasizes the need for further engagement between climate modelers and the ecological community. Collaborators: Adam Terando (Southeast Climate Science Center), Kara Smith and Frederick Semazzi (NCSU), Lydia Stefanova and Vasu Misra (Florida State University), Tom Smith (USGS Southeast Ecological Science Center), and David Blodgett (USGS Center for Integrated Data Analytics).

Team: Adrienne Wootten, Ryan Boyles



Comparison of spatial resolution in climate projections, from USGS Open File Report by Wootten and team.

High Resolution Projections of Climate Change in Puerto Rico: Ecosystem scientists are working to understand how climate can impact species distribution and habitat. In Puerto Rico, there is also a need for climate



Comparison of convective parameterization schemes used for climate model downscaling over Puerto Rico.

projections at a sufficient spatial resolution to assess ecosystem vulnerability. Working with USGS and the Department of Interior Southeast Climate Science Center, SCO is producing high-resolution projections for Puerto Rico with an emphasis on the needs of ecosystems scientists in the region. Production simulations began in early 2015 after an analysis of model sensitivities and accuracy based on the sensitivity of the ecosystems in Puerto Rico. For instance, the rainfall pattern on the island is very complex, with dramatic differences over short distances due to the mountains in eastern Puerto Rico. This variation drives changes in the ecology across the island, from rainforest to dry forest. Our projections will help natural scientists understand how precipitation may change in the region and how these ecosystems may react to such changes. Two manuscripts related to the work in

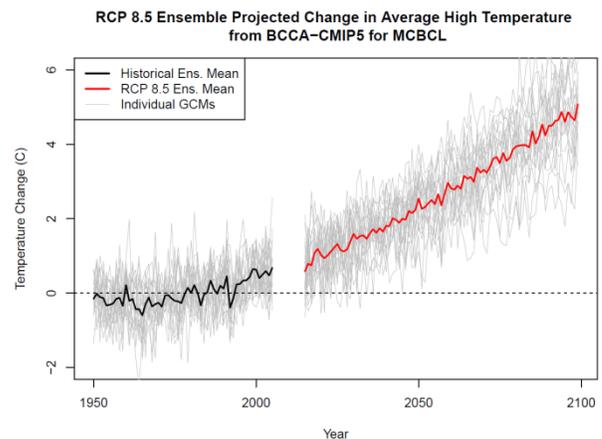
Puerto Rico are currently being prepared for submission for journal publication in early Fall 2015.

Collaborators: Adam Terando (USGS SECSC), Jared Bowden (UNC-CH), Lydia Stefanova and Vasu Misra (Florida State University).

Team: Adrienne Wootten, Ryan Boyles

Defense Coastal / Estuarine Research Program (DCERP): In summer 2012, the SCO joined a team of scientists headed by RTI International in the second phase of the Defense Coastal / Estuarine Research Program. As DCERP enters its third year, the SCO has completed an assessment of the needs of the ecosystem models and modules. The four ecosystem modules have some common requirements for their individual models. For instance, the LANDIS model being used by the Terrestrial module requires temperature, precipitation, and photosynthetically active radiation on a monthly timescale at approximately 10km spatial resolution. Using the information gleaned from all modules, the SCO is beginning research to assess the usefulness of different historical and future projection datasets for the DCERP ecosystem modules. Specifically, the SCO has the following research objectives for DCERP:

- Evaluate the historical climate datasets
- Evaluate climate projections for accuracy and characterize the uncertainty
- Identify the point at which adding more projections no longer influences the uncertainty
- Identify the point at which increasing spatial resolution no longer influences ecosystem model results.



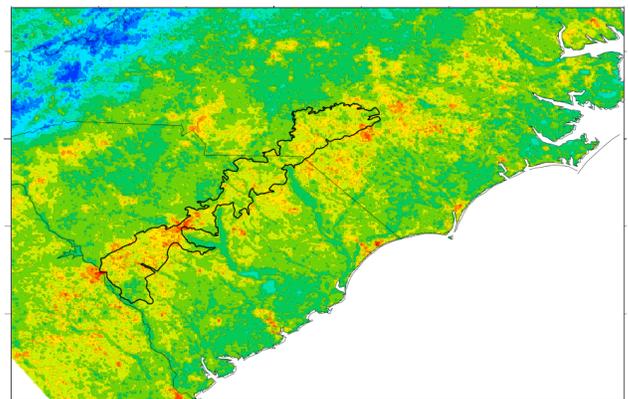
Projected annual average maximum temperature from a single model for Marine Corps Base Camp Lejeune.

While the SCO proceeds on this research, engagement with the ecosystem module and Camp Lejeune base management will continue to assure the results meet the needs of both groups. For the final objective above, the SCO will be working with the ecologists focusing on red-cockaded woodpecker assessment. The SCO will provide information at several spatial resolutions for these ecologists to assess how spatial resolution of the climate data influences the projected change in red-cockaded woodpecker productivity. Products from this work will include an assessment of gridded historical observations, an ensemble of future projections, and decision support tools for base management in Eastern, NC. Formal research connected with DCERP began in Spring 2015 and continues through Fall 2017. More information and partners is available at <http://dcerp.rti.org>.

Team: Adrienne Wootten, Ryan Boyles, Geneva Ely

Interaction between the Sandhills and sea breeze circulations: The Coastal Carolinas is a region consisting of an intricate coastline and highly variable soil types and land use. This region is bordered by the Sandhills to the west. Differential heating along the land and sea often generate sea breezes in the summer that can be quite strong. Additionally, similar circulations can form due to the different heating rates of land types inland along the Sandhills. These circulations can contribute to the development of locally driven convective precipitation. Outflow from convective storms can converge with the sea breeze, enhancing precipitation in this region. Ongoing research focusing on these interactions will help to improve our understanding of intense convection in Coastal Carolinas during the summer.

Team: Aaron Sims



Surface heating differences as shown by the Satellite derived land surface temperatures.

Educational Outreach

As North Carolina's primary statewide resource for informal climate education, outreach programming is a substantial focus for SCO staff and students with more than 6,500 direct educational outreach contact hours. We provide direct outreach for dozens of school and community groups; participate in large educational events, such as News14 Carolina Winter Wx roundtable; and push a range climate news and information to the public via our blog and social media. We also hosted our 12th year with student interns from Centennial Campus Magnet Middle School and engaged NC teachers through the CoCoRaHS grassroots rainfall network.



Undergraduate & Graduate Student Training

- SCO supported seven undergraduate and two graduate students over the past year
- Ms. Rebecca Cumbie received her Master of Science degree from the Department of Marine, Earth, and Atmospheric Sciences
- Four SCO undergraduate students completed their degrees, and all were successfully placed in jobs or graduate programs
- Ms. Geneva Ely was awarded an Outstanding Laboratory Teaching award for Spring/Fall 2014 by the University Graduate Student Association's Teaching Effectiveness Committee

Undergraduate Student Assistant Training: Over the past year, SCO scientists worked with one of our graduate students, who won the University Graduate Student Association's Outstanding Laboratory Teaching award, to develop SCO's first formal training program for new undergraduate student assistants. SCO alumni gain technical and professional skills that make them competitive applicants for graduate school and industry positions. In order to efficiently introduce students to these skills, the SCO staff and graduate students created a rigorous training program to jumpstart their progress and skill set development. Students were trained on how to do common office activities, such as client data requests, ECONet station maintenance and data quality control, outreach tour leadership skills, and scientific blog post writing and video making. Students were also introduced to several technical skills and computer languages. These skills included browser and server-side web development, MySQL database query structure and best practices, and statistical analysis on climate data.

Student Rated
4.4 out of 5

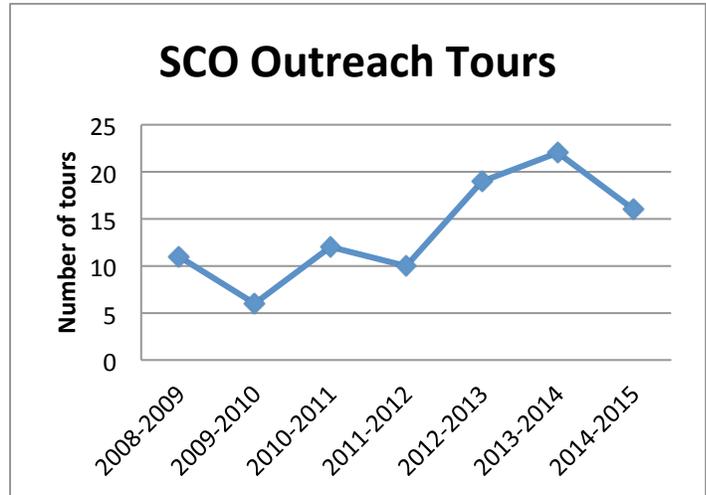
At the end of the training period, students were asked to rate each training module on a scale from 1 to 5 with a score of 1 meaning the training was ineffective, and a score of 5 representing a very effective training module. The average score for the entire two weeks of training was a 4.4 out of 5. Students responded positively to their training and are excited to start building on the

skills learned during the training program. One student writes in their review "Getting to try our hand at writing a blog post and making videos were fun ways to help us gain valuable experience with writing and outreach aspects of working at the SCO." Based on the response from the students, this training program will likely be an annual activity for all new students starting their summer work at the SCO.

Team: Geneva Ely, Ryan Boyles, Aaron Sims, Nathan Parker, Greg Deleruyelle, Ashley Hiatt, Rebecca Cumbie, Adrienne Wootten, Corey Davis, Heather Dinon Aldridge, John McGuire, Sean Heuser

Invited Presentations and Visitor Programs

- Total direct educational outreach contact hours: 6,861
- SCO staff provided 40 presentations by invitation
- SCO provided tours and programs for 16 visitor groups, which is slightly above the 6-year average (2008-2009 through 2013-2014) of 13 total
- Kylie McCorquodale from Sampson Early College High School visited SCO in March 2015 to job shadow scientists and learn more about careers in the atmospheric sciences
- SCO presented at several large group events, including Southern Region Extension Climate Academy conference, News14 Carolina Winter Wx roundtable, Multi-State Society of American Foresters meeting, Crop Advisors training, and Conference on Farming Strategies for Climate



During May 2014 through April 2015, SCO scientists engaged with several different sectors by co-hosting and/or presenting at various workshops, conferences, meetings, and symposium, including:

- Wrote guest articles for Midwestern Regional Climate Center's *The Climate Observer* and for Orange County Master Gardeners' Newsletter
- Invited back again to lead the S-290 training on basic weather processes for NC Forest Service
- Presented on climate change and hazards during Weather Ready Nation meeting hosted by the State Emergency Operations Center
- Gave three presentations at 2015 Water Resources Research Institute annual conference, which highlighted the water portal, Drought Management Advisory Council, and hi-resolution drought indices
- Hosted a SCO booth and gave a talk during the Kudzu's Kousins session, which was organized by the Chowan Edenton Environmental Group



Adrienne Wootten and Madeline Pope at an outreach event in Edenton, NC



CCMMS Interns: Zach Flatt, Savannah Mosley, and Ribhi Triesh

Centennial Campus Magnet Middle School Internship: For the 12th consecutive year, the SCO hosted 8th graders from Centennial Campus Magnet Middle School for an internship on weather and climate. Due to building renovations, the SCO only hosted students from September- December of 2014. This year, the students looked at weather as it related to pumpkin growth. The first part of the project looked at thresholds of air and soil temperature at a few of our ECONet stations and determined possible plant dates for pumpkins based on the thresholds. The second part of the project looked at disease monitoring based on growing degree days and when you should start looking for the squash vine borer in your

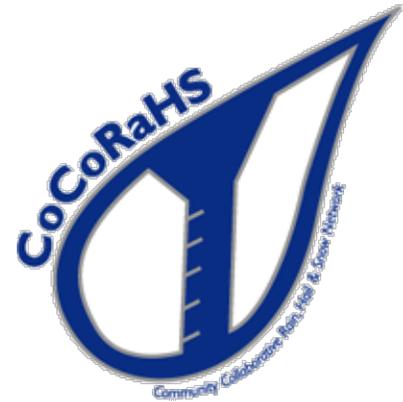
pumpkins. A blog post was written up about their internship: <http://nc-climate.ncsu.edu/climateblog?id=110>

Team: Rebecca Cumbie, Sean Heuser, Heather Dinon Aldridge, Corey Davis, John McGuire, Ashley Hiatt.

Community Collaborative Rain, Hail & Snow Network (CoCoRaHS):

Through 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. We led the establishment of CoCoRaHS in North Carolina in 2007 and over the past year, we have worked to recruit new volunteers for the program, especially encouraging participation from local schools and areas with data gaps. Our recruiting efforts include:

- an introduction to CoCoRaHS during our invited presentations and visitor programs;
- an agreement with more than five local NC schools to provide a rain gauge in exchange for their observational commitment of at least one year, reporting as often as possible;
- an engagement with many new County Coordinators and other volunteers interested in the program;
- an interview (published in the CoCoRaHS condition monitoring newsletter) with scientists leading the project on CoCoRaHS condition monitoring, with the purpose of highlighting usefulness/value of CoCoRaHS data;
- an engagement with Orange County Master Gardeners during CoCoRaHS March Madness; and
- a blog post series on CoCoRaHS during March Madness: <http://nc-climate.ncsu.edu/climateblog?id=124>, <http://nc-climate.ncsu.edu/climateblog?id=126>, and <http://nc-climate.ncsu.edu/climateblog?id=128>.



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 the days of March. North Carolina has **won the contest in three of the last four years**, taking home the CoCoRaHS Cup! During this past year, North Carolina was once again the “Traditional Count” winner of the contest, recruiting an impressive 151 new volunteers during the month of March! Over 750 new observers signed up across the nation during this event.



Thanks in part to our SCO recruiting efforts and the efforts of many others across the state, North Carolina has the second highest number of schools signed up as CoCoRaHS observers – the highest number is Colorado, the birthplace of the CoCoRaHS program.

Team: Heather Dinon Aldridge with contributions from all SCO staff

Environmental Statistics Practicum Course – Mentoring Undergraduate Students in Analysis / Applications of Climate Data: Environmental Statistics Practicum Course in the NCSU Department of Statistics offers an opportunity to train interdisciplinary undergraduate students to analyze environmental data. Students answer real world questions and gain professional presentation skills. Each student team works with a client to gather the data and answer questions posed by the clients. Since the 2013-2014 academic year, the SCO has been serving as one of the clients for this course. The course, which is taught twice per year, has up to 12 students split between 2-3 clients. For those students working with the SCO, the students receive guidance about the data itself, but perform their analysis independently. The course offers the opportunity for the students to work through the entire process of analysis, from gathering data to presenting the results for a general audience. The

presentations themselves are given to the SCO, which offers a medium to provide constructive feedback for the students, and at the undergraduate research symposia in North Carolina. This SCO partnership with the instructor, Dr. Brian Eder, allows students the opportunity to work on real world analysis and learn how weather and climate impact multiple sectors in North Carolina. Student projects for 2014-2015 academic year include the following:

- Spring 2015
 - Trends of North Carolina Record Maximum and Minimum Temperatures
 - Quantifying the Impact of El Nino / La Nina on North Carolina's Climate
 - Soil Temperature Estimation Across North Carolina
 - Cluster Analysis of Soil Moisture in North Carolina
- Fall 2014
 - What is the relationship between Atlantic Basin Hurricanes and Those that Impact North Carolina?
 - Analysis the Change of El Nino's Impact on North Carolina's Climate
 - Changes in the Agricultural Growing Season Length in North Carolina

As part of our partnership and participation in the course, the SCO has served as the client and provided guidance for 19 students split between the seven projects above.

Team: Adrienne Wootten, Geneva Ely, with contributions from all SCO staff

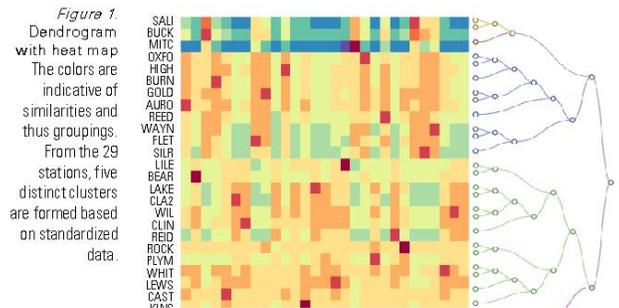
Climate Science Communication

SCO Climate Blog: The State Climate Office entered the third year of routinely disseminating news and scientific content via the Climate Blog (<http://climate.ncsu.edu/climateblog>). The blog continues to feature monthly climate summaries, seasonal climate summaries and outlooks, recent event recaps, and SCO research and student projects. In addition, new content has been added during the past year, including:

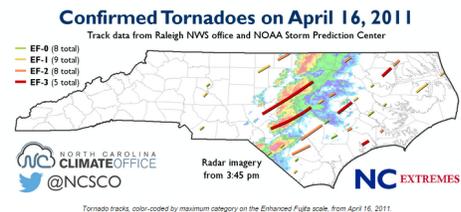
- Recaps of North Carolina's historical extreme weather events
- Seasonal climatologies covering summertime temperature lag, high heat index occurrence, and first and last frost and freeze dates
- Guest blog posts by professional scientists at the NC Division of Air Quality, the NC Forest Service, and other organizations
- Infographics for many posts

The 56 posts published from May 2014 to April 2015 received more than 56,000 views, averaging about 1,012 views each. A total of 539 individuals and group listservs are subscribed to receive notifications about new blog posts via email. That number is essentially unchanged from last year. Blog posts are also shared via Twitter and an RSS feed, allowing other groups such as the NC Cooperative Extension Service to share our content.

VISUALIZATIONS



Undergraduate students in Statistics explore spatial relationships in soil moisture observations.



The Damage Done

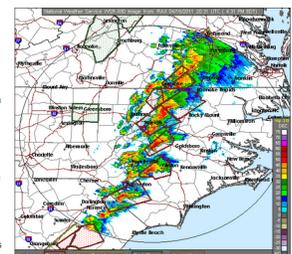
All told, **30 tornadoes** were confirmed across the state that day, breaking the old record of 20 tornadoes from April 7, 1998. These tornadoes weren't the strongest on record – there were four F-4 tornadoes across the coast on March 28, 1984, when 14 tornadoes responsible for 41 fatalities occurred – but the April 16, 2011, event was the most numerous and possibly most widespread tornado outbreak for the state.

The total property damage was estimated at just over \$326 million, about 88% of that coming from the the Sanford-Raleigh and Fayetteville-Smithfields tornadoes. In total, 304 injuries and 24 deaths were reported.

Although damage from these strong tornadoes was inescapable, it was clear in the days and hours before the event that there was a strong potential for this sort of severe weather – a testament to the improvements in our forecasting and monitoring abilities.

The Raleigh National Weather Service office reports that the average lead time for tornado warnings in their forecast area was 26 minutes, and the average lead time for warnings where fatalities occurred was 28 minutes. Both are above the national average lead time of about 13 minutes, and that's still an improvement since the 1980s, when lead times for tornadoes were generally five minutes or less.

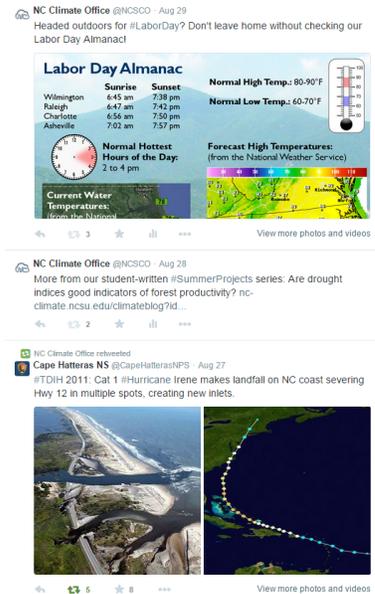
While the April 16, 2011, tornado outbreak was the most numerous for North Carolina, those advancements certainly prevented it from collecting any records for more grim statistics.



SCO Twitter Account: In the past year, we increased our Twitter presence by more regularly posting content, including new blog posts, timely weather-related facts, and live updates at events such as weather station installations. Not counting any retweets to share content from other groups, we posted 115 original tweets from May 2014 through April 2015. That is a **51%** increase from the 76 tweets posted during the previous 12-month period.

Our tweets during the past year received 150,006 views, 2,388 engagements (which includes replies, retweets, and mentions by other accounts), and 138 “favorites”. Several statistics tweeted prior to Hurricane Arthur’s landfall last July were widely shared by national broadcast media and meteorologists.

Those tweets also brought many new followers for our account, @NCSCO. All told, our following on Twitter more than doubled in the past year, from 256 followers one year ago to 516 as of April 30, 2015.



Southern Farm Network: Since February 2015, SCO blog posts and expertise have been featured on the Southern Farm Network (<http://www.sfnoday.com/>) radio broadcasts across eastern North Carolina, South Carolina, and Virginia. The three to five minute interviews and web content have covered the NC Extremes blog post series and updates on global conditions such as El Niño, with an emphasis on impacts to the mid-Atlantic region.

Teacher Engagement: Last fall, the SCO was involved in teaching a group of North Carolina educators about weather and climate science. This included highlighting tools available on the SCO website. This was done during Fall 2014 in partnership with Kathryn Stevenson (Fisheries, Wildlife & Conservation Biology, NCSU).

Training Videos: In an effort to enrich the multimedia content on our website, the State Climate Office has begun a push to create new professional-quality videos to explain weather basics and other scientific content. Four staff members attended the Southeast Climate Science Center’s Science Video Making Workshop in October 2014 to learn more about designing, filming, and editing these videos.

One product of that workshop was a new video explaining a “Cloud in a Bottle” experiment. That video is now embedded on our educational Experiments page. Videos currently in progress include an update to our ECONet tower tour highlighting the sensors, measurements, and utility of our weather stations.

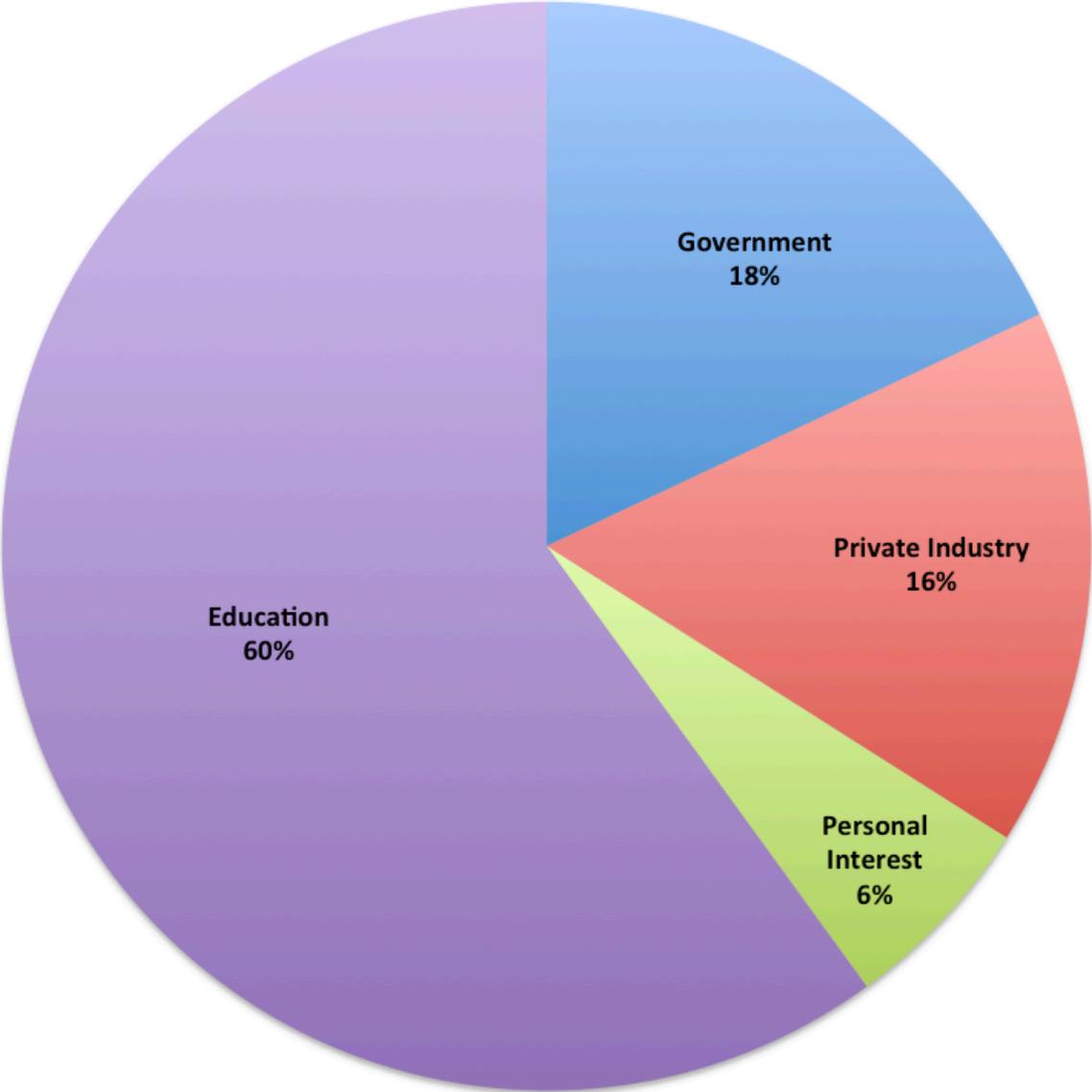


Team: Corey Davis, Rebecca Cumbie, Ryan Boyles, Ashley Hiatt, John McGuire, Sean Heuser, Heather Dinon Aldridge, Geneva Ely, Adrienne Wootten, and all SCO undergraduates

Appendix A: Climate Services by Client Sector

Climate Information Services Effort by Client Sector

May 1, 2014 through April 30, 2015



Climate Information Services by Client Sector - Details

May 1, 2014 through April 30, 2015

Classification	Number of Requests	Hours Worked
Government: Federal-Agriculture	7	7
Government: Federal-Education: college, university	12	12
Government: Federal-Engineering	2	3
Government: Federal-Other	1	1
Government: Local-Agriculture	1	1
Government: Local-Economic development	8	8
Government: Local-Education: college, university	3	3
Government: Local-Education: K-12	8	8
Government: Local-Energy	2	2
Government: Local-Engineering	237	244
Government: Local-Health	1	1
Government: Local-Library	2	2
Government: Local-Other	20	20
Government: Local-Water	7	8
Government: multijurisdictional-Economic development	2	2
Government: State-Agriculture	1	1
Government: State-Construction	9	21
Government: State-Education: college, university	4	4
Government: State-Education: K-12	8	8
Government: State-Energy	1	1
Government: State-Health	18	18
Government: State-Legal/insurance	6	6
Government: State-Other	1	1
Government: State-Water	5	5
NGO-Tourism/recreation	11	11
Private entity-Agriculture	25	25
Private entity-Construction	11	11
Private entity-Education: college, university	7	7
Private entity-Education: K-12	12	12
Private entity-Energy	2	3
Private entity-Engineering	1	1
Private entity-Legal/insurance	1	1
Private entity-Manufacturing	8	8
Private entity-Media	3	3
Private entity-Other	8	8
Private entity-Personal interest	2	2
Private entity-Water	237	244
Totals	413	434
Percent Change from Previous Year	-18.9%	-19.3%

Appendix B: Impact Statement

State Climate Office of North Carolina

NC State University

The Need

Climate affects many aspects of our daily lives - agriculture, environment, transportation, tourism, and natural disasters to name a few. Nearly 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 (SCO) is a public-service center for climate-environment interactions in North Carolina. The SCO is housed at NC State University in the College of Physical and Mathematical Sciences with support from the NC Agricultural Research Service. The SCO 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:

- Operate and collect high-resolution weather data from a growing network of 38 research quality weather stations called the Environment and Climate Observing Network (ECONet).
- Disseminate climate information to the citizens and businesses of North Carolina through the CRONOS database, an intuitive website making climate data available from over 20,000 surface weather and water resource stations in and around North Carolina.
- Assist state government agencies in climate adaptation activities that reduce costs and conserve resources.
- Collaborate with extension scientists to provide agricultural guidance to growers for disease management and irrigation, which lead to crop loss mitigation and better production decisions. Drought monitoring and management at community, statewide, and national scales.
- Study climate variations and impacts on North Carolina, including sensor and model evaluation, severe weather patterns, drought and water resource management, and economic impacts.
- Numerous community presentations, science fairs, and other interactions with K-12, college students and teachers.

Impact beyond North Carolina

Undergraduate and graduate students working at the SCO gain a genuinely multi-disciplinary experience that contributes to career growth and lifelong learning. Many successes of the SCO are often heralded as a model for other states' climate offices.