



NORTH CAROLINA CLIMATE OFFICE

2012-2013 ANNUAL REPORT

July 22, 2013

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.

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Staff and Students, July 2013

Back Row: Ameenulla Syed, Adrienne Wootten, Megan Hall, Heather Dinon Aldridge, Colin Loftin, Melissa Mainhart, James McClellan, Ashley Hiatt, Rebecca Cumbie, Greg Deleruyelle, Jim Epps, John McGuire

Front Row: Aaron Sims, Sean Heuser, Madeline Pope, Geneva Ely, Joe Taylor, Corey Davis, Andrew Martin, Ryan Boyles

Executive Summary

In the Academic Year 2012-2013, 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, drought 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.

While direct requests for services decreased in the past year, online visits increased by nearly 50%. Our climate database continues to see increasing traffic, with 2.5TB of internal data transfer each month, 1.25 billion data records selected, updated, or inserted each month, and more than 4.7 million queries made over the past year. Maintaining and expanding the NC ECONet is an ongoing challenge, but the observations are a unique and highly valued service for state, local, and federal agencies. In the past year, we continued to deliver agriculture disease and forecast services, and expanded our efforts to service the forestry and natural resource sectors through externally funded projects. We also began new efforts to engage and serve the public health community in North Carolina.

Research efforts in the SCO are connected to our unique data resources and established relationships with other disciplinary scientists. SCO scientists and students published scholarly manuscripts, presented at several scientific conferences, and received awards for their research. In the past year, we continued work to improve our ability to model and estimate climate conditions for times and locations where observations are not available. We also continue to develop methods for improved drought monitoring, precipitation monitoring, and climate forecasting both with partners at NCSU, through the Southeast Climate Consortium, and with research collaborators across the nation. In 2012, we began a new research project supported by US Department of Defense to explore the climate sensitivities of Marine Corps Base Camp Lejeune.

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 20,000 direct educational outreach contact hours. We provide direct outreach for dozens of school and community groups, participate in large science education events such as StormFest and NC Science Olympiad, and push a range of climate news and information to the public via our blog and social media. We also hosted our 10th class of student interns from Centennial Campus Middle School and engaged NC teachers through our online climate education material and through the CoCoRaHS grass roots rainfall network.

These activities were supported by funding from College of Physical and Mathematical 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.

Extension

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Climate Information Services

The primary service of the State Climate Office is to provide climate sciences 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 many 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.

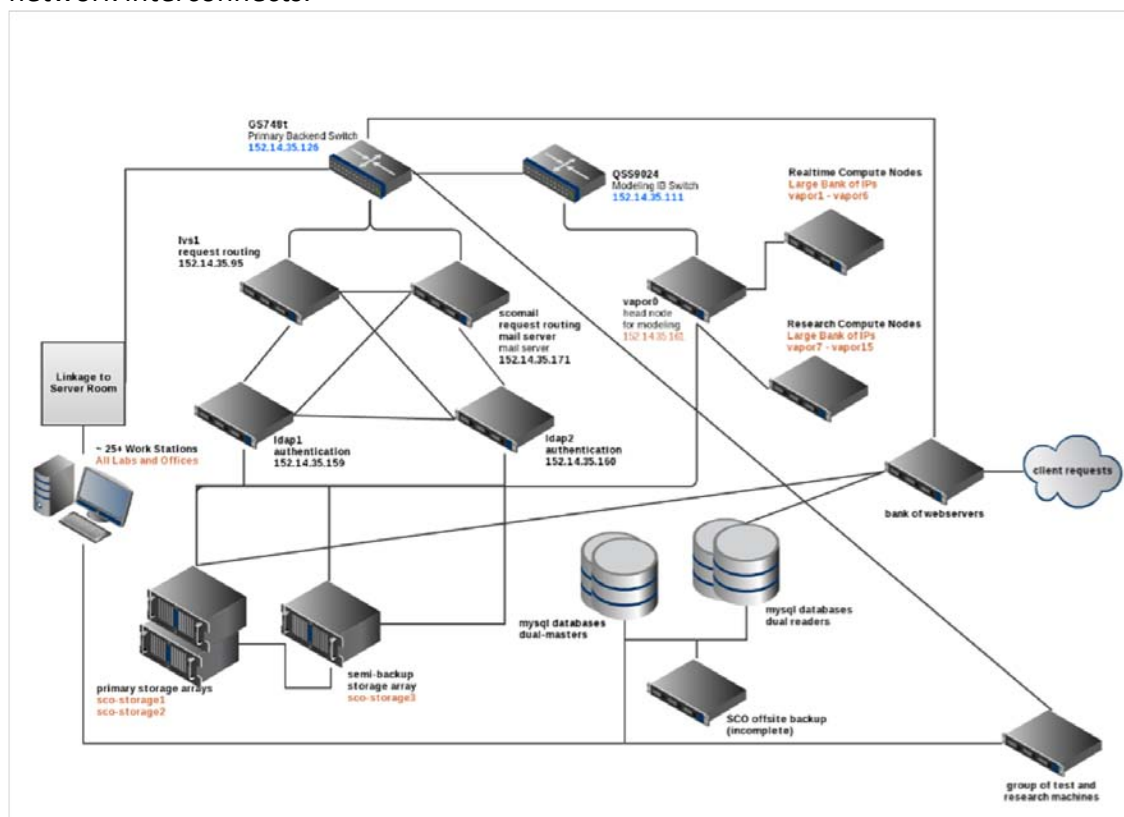
Requests for Services: Direct requests from clients via email and phone during 2012-2013 resulted in a **17% decrease** in time spent directly responding to requests for services from clients as compared with the previous year. A large percentage of time was devoted to supporting educational requests (60%), while remaining effort went largely to support government (14%) and private industry (18%). Formal public interest requests accounted for 8% of effort. A detailed breakdown of request-driven climate services is provided in Appendix A. While direct requests for information decreased over the past 2 years, usage of online climate data resources continues to grow rapidly with ~ **50% increase** in website visits. *Team: All staff and students*

Monthly climate summaries: Climate summary reports are prepared each month to review climate patterns, their causes, and impacts to agriculture and water resources in NC. These are distributed via a new blog service, reports to NOAA through the Southeast Regional Climate Center (SERCC), the Southeast Climate Consortium (SECC), and via a Twitter social media feed. Blog and Twitter announcements are distributed to 525 individuals and group listservs, with

hundreds more reached via science teacher and Cooperative extension email lists. *Team: Corey Davis, Heather Dinon Aldridge, Ashley Hiatt, Ryan Boyles.*
<http://www.nc-climate.ncsu.edu/blog/>

Drought Monitoring and Response: The SCO is a member of the NC Drought Management Advisory Committee, participating in weekly drought monitoring conference calls and providing public presentations on drought in NC. SCO has provided routine updates on drought conditions and impacts through the Drought Management Advisory Committee, monthly climate summaries and newsletters, and interviews for print and broadcast news media. Over the past year, drought was most severe in the late autumn and early winter seasons. *Team: Ryan Boyles, Rebecca Cumbie*

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 a dedicated high-performance computing cluster with low-latency network interconnects.



These simulations are available for use by the public, and are distributed to partners in DENR and National Weather Service. Moreover, these simulations provide the critical inputs to a series of agricultural projects, including routine peanut disease guidance, disease forecasts for cucurbits (cucumbers, squash, melons, etc), heat and chill forecasts for small fruits, and new efforts with smoke management.

We are currently producing 66 GB of raw model data a day. Additional data processing and incorporation into applications and tools generates an additional 10 GB of data per day. Presently, we are archiving and serving up over 8.5TB of gridded data. Data storage capacity is

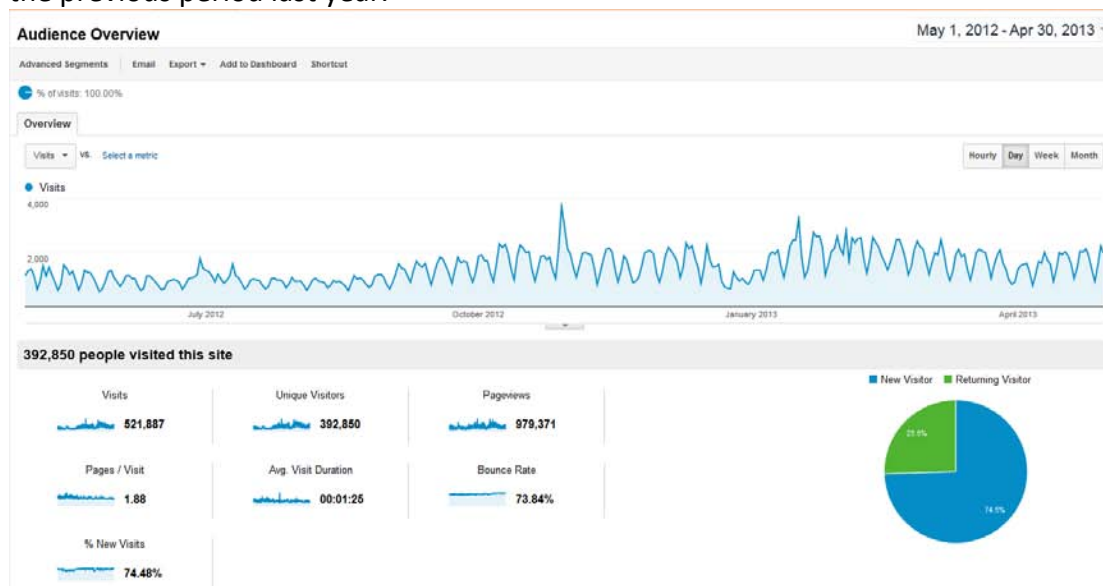
key to retaining valuable model datasets. Proper data management is critical to maximize dataset availability and effectively managing and maintaining available resources.

Team: Aaron Sims, John McGuire

Website

The SCO website is often the first point of contact with clients who need climate information. Effort over the past several years has been focused on linking web products and tools to the climate observation database to provide products and services that are dynamically updated.

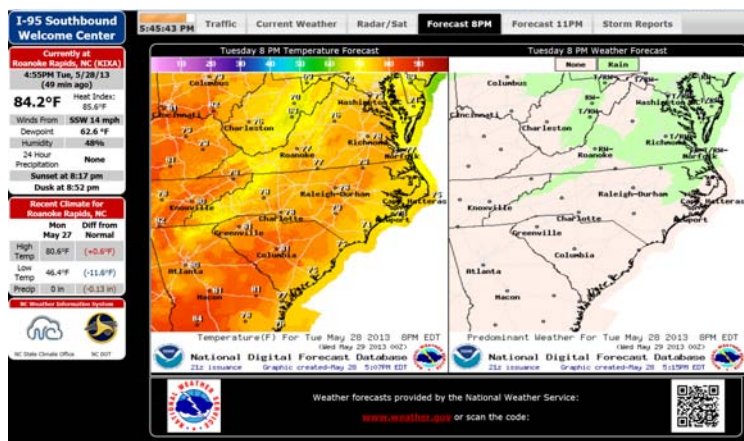
Usage: The volume of unique visitors **increased by 49.4%** (392,850) over the previous year. Overall, the SCO website has received over half a million visits (521,887), **an increase of 39.2%** from the previous period last year.



- Three in four visitors from the website provided new visits (392,850), with the remaining 25% being a return visit (133,021).
- October 29th, 2012 brought the most visitors in a single day (3,720).
- 34% of all unique visits came from North Carolina (136,791)
- Traffic also comes from outside NC, with visits from each of the 50 states and over 50 counties
- 61% of web traffic came from search results (e.g. Google), an increase of 5% from last year.
- 18% of web traffic came from direct sources (e.g. bookmarks, going directly to the URL).
- 20% of traffic comes from non-search engine referring sites
- *Team: John McGuire, Ashley Hiatt, Aaron Sims*

Wind Rose Tool: Based on input from users at National Weather Service and DENR Division of Air Quality, we renovated the Wind Rose tool to include improved graphics and to allow for customized seasonal climatologies. *Team: Bradley McLamb, Corey Davis, Megan Hall, Ashley Hiatt, Adrienne Wootten.*

Climate Kiosk: Working with partners in NC DOT, we developed a prototype website to display current weather, road conditions, and educational material for use at highway rest areas and other locations. This tool allows for location specific details on current and past weather, with the goal of enabling viewers to quickly put current conditions in a historical climate context. *Team: John McGuire, Aaron Sims, Melissa Mainhart*

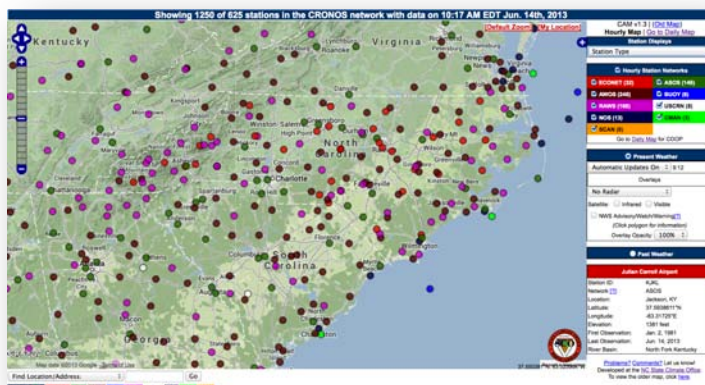


1981-2010 Climate Normals: Generated by the National Climatic Data Center, climate normals serve as one of the many datasets people can use to understand the typical climate conditions for locations all across the country. The 1981-2010 Climate Normals contain calculated statistics of not only temperature and precipitation for the previous 30-year period, but for other weather parameters such as wind, pressure, and cloudiness as well. These normals are given on an hourly, daily, monthly, seasonal and annual basis, and will be available through the SCO website later this summer. In addition, several SCO products and tools dependent upon normals calculations are currently being modified to use the data from the 1981-2010 period versus the previous 30-year values from 1971-2000. *Team: Ashley Hiatt, John McGuire, Aaron Sims.*

Climate Retrieval and Observations Network of the Southeast (CRONOS)

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

Usage: Users requested more than 4.7 million data queries through the CRONOS interface – an increase of 600,000 over the previous year. With over 46,000 stations in the CRONOS database, we are currently archiving and providing access to over 210 billion observations. Network and data support for CRONOS users involve a



significant amount of internal data ingest, management, and transfer. We are averaging about 2.5TB of internal climate data transfer each month with 1.25 billion data records selected, updated, or inserted each month.

CRONOS API: An application programming interface (API) continues to be developed to allow authorized users to access CRONOS data without going through the web interface. This tool allows for development of web services that will facilitate 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 over 3 million API queries, which represents an increase of 1.4 million over the previous year. *Team: John McGuire, Ashley Hiatt, Heather Dinon Aldridge, Aaron Sims*

New CRONOS Variables: Daily and monthly summaries for heat index and wind chill were added. Hourly output for these variables were previously available, but user requests for daily and monthly output drove efforts to implement new software for the CRONOS interface. New calculations for reference evapotranspiration were implemented to support cool and warm season turf grass. *Team: Ashley Hiatt, Corey Davis, Heather Dinon Aldridge Bradley McLamb, 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 DENR Air Quality, 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.

Station Maintenance: 64 site trips were made over the past year to perform routine or emergency maintenance covering nearly 15,000 vehicle miles.

- Five wind monitors were replaced due to damages and more than 20 serviced with new parts.
- 13 integrated wind/temperature/humidity/pressure probes were repaired or replaced.
- 42 radiation sensors were recalibrated or replaced for annual maintenance.
- 9 soil temperature sensors were replaced due to sensor failures.
- One multilevel soil moisture sensor was replaced due to failure.
- One telephone modem was replaced due to damage.
- 33 precipitation gauges were upgraded.
- 10 enhanced temperature and humidity probes were installed for sensor inter-comparison.



- The station located at Mt. Mitchell continues to be our most challenging site, with complete tower collapses two years in a row.

Station Improvements: Wind sensors at 6-meter heights were added across the network to assist DENR Forest Resources in meeting their data needs for the National Fire Danger Rating System. New, more robust precipitation gauges were also installed across the network in the past year. These new precipitation sensors are substantially more expensive to purchase, but have proven to be more reliable and less likely to clog, which should reduce personnel time for maintenance. In addition, leaf wetness sensors have also been installed at 18 locations with additional deployments in the summer of 2013. Leaf wetness probes are of critical importance to plant disease researchers and extension agents. Multi-depth soil temperature and soil moisture probes were installed at 12 locations. The soil temperature probes were developed in-house, as no commercial version of this sensor currently exists. If these prove robust, additional sensors will be installed in later years.

Station Communication: Development of radio-based communications using the State Highway Patrol is ongoing. One station currently has a direct connection, and we continue to work with State Highway Patrol to enable data relay through their network interface in Garner, NC. If successful, this would enable broader deployment of low power radio transmitters that will provide robust data communication with minimal long-term ongoing costs. A second method using cellular data modems has been tested and implemented at 2 sites. While the initial costs and setup for cellular data relay is much lower, ongoing monthly charges make this choice less cost effective as compared to using State Highway Patrol infrastructure over the long term. Most ECONet stations continue to use direct phone line connections to field sensors, which requires very little power but are not always reliable and can be expensive.

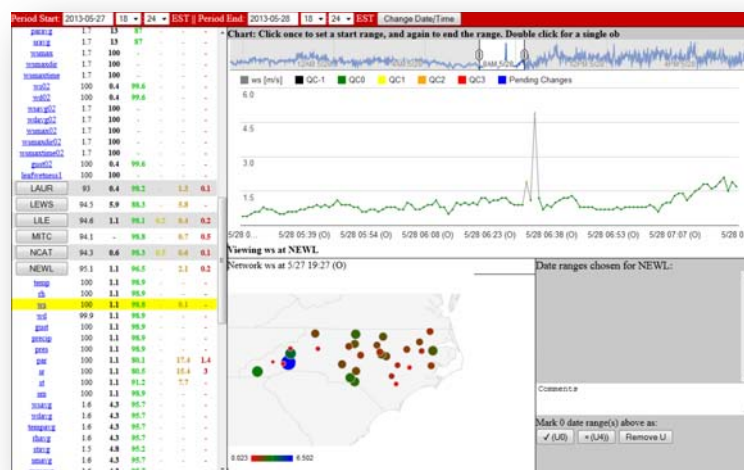


Experimental Station Installation: An experimental station was installed on the roof of Jordan Hall on NC State's main campus. The station (ID: CAMP) has all sensors of a typical ECONet station with the exception of soil parameters. Data are displayed in real-time in the Jordan Hall lobby outside the Natural Resources Library, where most MEAS students gather during the day. Like all ECONet data, observations from this campus station are also readily available for use by students and faculty for teaching and research.

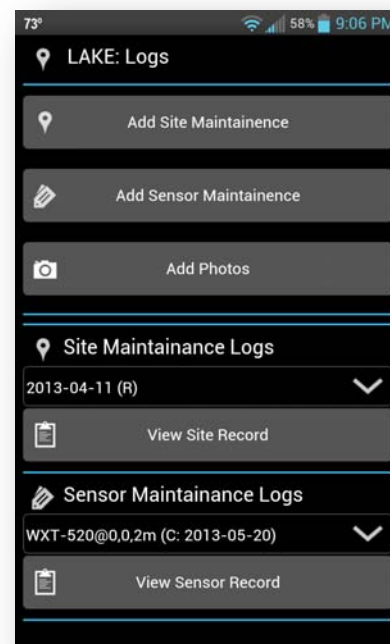
New Station Installation: As part of an agreement with the Unimin Crystal Plant in Spruce Pine, NC, the State Climate Office installed a new ECONet tower on February 6, 2013. With a station ID of SPRU, this tower has all updated equipment to help the plant monitor the atmosphere and communicates the data every 5 minutes.

Planned Installations: A new station is planned for installation during summer 2013 on the peak of Mount Jefferson in Ashe County. This site is supported by DENR Air Quality, who is particularly interested in high-elevation monitoring.

Data Quality Control: Quality control of the ECONet data advanced in 2012 with the implementation of multiple new quality control checks. A minimum variability check for air temperature, pressure, wind speeds (at 2, 6, and 10 meters), relative humidity, and soil temperature has been implemented. Maximum variability tests for these same parameters are also now in use. Intersensor comparison with wind speeds at 2 meters, 6 meters, and 10 meters are now being used as well as intersensor comparisons between soil temperature sensors that are co-located. With all of the checks being run (currently 4-5 per sensor), a QC Score was improved upon for grading accuracy and quality of data. The score runs from 0 to 3 with 0 being the best score and 3 being the worst. For the calendar year of 2012, 93.23% of all ECONet data scored a QC 0, while only 3.36% of all ECONet data scored a QC 3. A new quality control webpage has been developed to better flag suspicious data and alert ECONet technicians of a possible faulty sensor. This webpage will be available for daily monitoring starting in summer 2013. We are incorporating undergraduate students into the QC monitoring process. This is a great educational opportunity to help them gain exposure to working with the data and understanding the complexities of sensors.



Enhancing Observations through Metadata: As part of the NOAA effort to establish linkages with all local mesonets, the SCO was included in a proposal with Coastal Carolina University and GST, Inc to establish MesoUS in support of the National Mesonet. As part of the MesoUS effort, we provide all routine observations to NOAA using a gateway called MADIS. MADIS serves as a national resource for all National Weather Service offices, and serves as the primary starting dataset for most numerical weather forecasts. In addition, we are working toward an in-the-field metadata management system that will enable technicians to digitally update metadata, take photos, and log station visit activities using mobile devices. Metadata is data about data, including information about sensor types and accuracies, station maintenance and repair visits, changes in the station environments, and related details. Accurate and extensive metadata is required to understand the accuracy and value of environmental observations. In collaboration with the MesoUS consortium, we have created a new standard format for recording metadata and observations. As



of early March 2013, the SCO has uploaded these newly formatted files for metadata and observations to MADIS. These files will be continuously updated as new metadata are recorded.

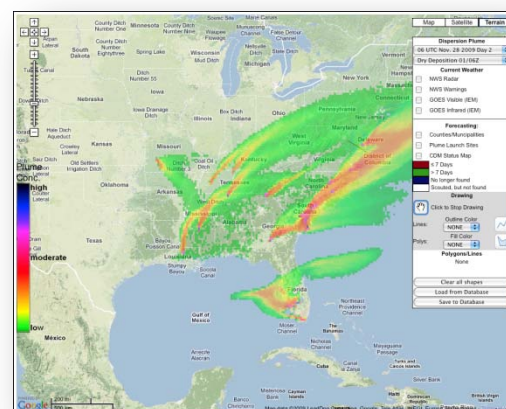
Team: Ameenulla Syed, Sean Heuser, Jim Epps, Aaron Sims, John McGuire, Heather Dinon Aldridge, Ryan Boyles with support for data quality control and field work from all staff and students.

Climate Support for Agriculture

Peanut Disease Advisories: 2012 brought the 9th year for our ongoing partnership with Dr. Barbara Shew in NCSU Plant Pathology to provide routine advisories for two peanut foliar diseases: peanut leaf spot and peanut sclerotinia. Monitoring and forecasts for these, and other fungal diseases will benefit from the introduction of new leaf wetness probes as part of ECONet enhancements. *Team: Aaron Sims, Ashley Hiatt, Ryan Boyles*

Climate Information for Thrips Risk Assessment: In collaboration with Drs. George Kennedy, Hannah Burrack, and Thomas Chappell (NCSU Entomology), SCO has developed a web-based advisory system to evaluate the risk of thrips in tobacco. Tobacco thrips are vectors of Tomato Spotted Wilt Virus (TSWV) that causes heavy tobacco crop losses in NC. The website uses a combination of past weather data, climate data, and forecasted temperatures and precipitation to predict thrips flight dates and relative numbers of dispersing thrips for a user's location. Additions to the website in 2012-2013 include a seasonal TSWV outlook and graphical displays of current-year predictions for thrips flights, TSWV incidence, and the window of maximum TSWV susceptibility. These additions will be tested in a beta-version of the website during the 2013 growing season with plans for implementation to the main website in fall and winter of 2013. *Team: Geneva Ely, Rebecca Cumbie*

Cucurbit Downy Mildew Forecasts: In 2012, we continued our 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 that affects cucurbits (cucumbers, melons, squash). As part of this project (known as ipmPIPE), SCO is responsible for providing weather information, technology support, and dispersion forecast guidance. During the 2012 growing season, the ipmPIPE website (cdm.ipmpipe.org) averaged 850 site visits per month, which represents an increase of 14% from the previous year. There were 275 confirmed reports of cucurbit downy mildew in 2012. While the formal USDA project has ended, SCO continues to work with partners in NCSU Plant Pathology to maintain the cdm.ipmpipe.org site and forecasting tools. *Team: Aaron Sims, John McGuire, Ryan Boyles*



Late Blight for Potatoes and Tomatoes: In collaboration with Dr. Jean Ristaino (NCSU Plant Pathology), NCSU joined a team of plant pathologists in 2010 to successfully propose development

of a national monitoring and alert tool for Late Blight that affects tomatoes and potatoes. In 2012, we implemented new enhancements to the national Late Blight website (usablight.org) to allow for disease alerts and tracking of sample leaf specimens sent for lab analysis. Planned effort with this project will incorporate the new leaf wetness sensors to improve estimates of high humidity environments. *Team: John McGuire, Ryan Boyles, Sean Heuser, Ameenulla Syed, Aaron Sims.*

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, 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. SCO will specifically serve as the conduit to the other State Climatologists, developers for a decision support system based on AgroClimate.org, and the climate extension resource for all partners. Effort in the past year includes:



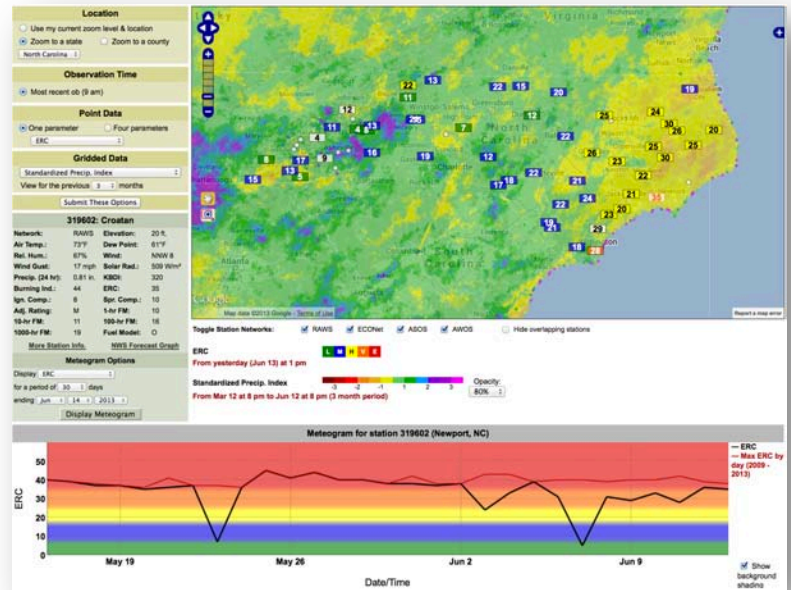
- Introduction of forestry extension partners to southern State Climatologists through a national conference and a series of phone conferences
- Working with partners in the multi-state Southeast Climate Consortium and other PINEMAP colleagues to plan the Decision Support System (DSS). A prototype DSS website has been implemented into the pinemap.org main website's content management system and is available at:
 - <http://www.pinemap.org/extension/pinemap-decision-support-system-dss>
- Development of 5 fact sheets that translate PINEMAP research topics to landowners:
 - *Glossary of Climate Terms*
 - *Southern Forests and Drought (in final review)*
 - *Climate Oscillations: Impacts to Forestry*
 - *Introduction to Weather and Climate*
 - *What's Under the Umbrella that is Climate?*
- Provide climate expertise as part of the PINEMAP outreach including:
 - Revision of online climate education materials for forestry sector
 - Assistance with a PINEMAP webinar series to promote understanding of climate science and collaboration and knowledge sharing among the interdisciplinary PINEMAP team.
 - Coordinate webinars for the PINEMAP distance education graduate course
 - Reviewed materials (factsheets, PPTs, websites, etc.) for PINEMAP audiences including private landowners, limited resource landowners, industrial/corporate landowners, state forest agencies
 - Reviewed a Project Learning Tree module activity called "Climate and Forests" for the education subgroup in PINEMAP

- Provide guidance to the research sub-groups as to which climate datasets (historical data and future projections) are the most useful for PINEMAP
- Multiple invited presentations about basics of climate change and how it relates to forestry
- Established new partnerships with US Forest Service Southern Research Station and the Association of Natural Resources Extension Professionals (ANREP) Climate Science Initiative
- *Team: Heather Dinon Aldridge, Ryan Boyles, Megan Hall*



Fire Weather and Smoke Guidance: With support from NC Forest Service, SCO has developed a Fire

Weather Intelligence Portal that includes map-based web tools to visualize fire risk using the National Fire Danger Rating System and inputs from all CRONOS observations. In addition, SCO has tested a preliminary tool to provide improved smoke dispersion guidance based on previous research and effort on the ipmPIPE for Cucurbits. This tool was released in June 2013 for broad fire community testing and use. *Team: Corey Davis, Aaron Sims, John McGuire, Ryan Boyles*



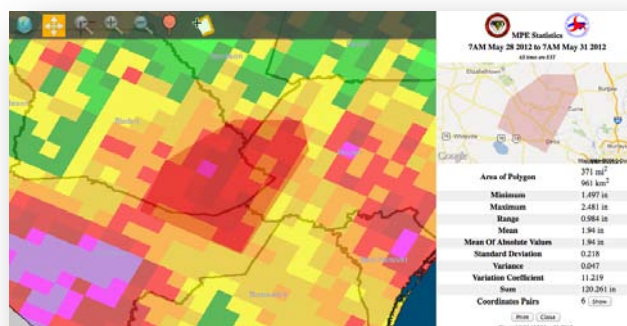
DOI Climate Science Center: NCSU hosts the US Department of Interior’s SE Climate Science Center.

Establishment of this new center provides a range of new opportunities for collaboration with university, government, and non-profit agencies to research and manage the impacts of climate on wildlife resources in the southeastern US. SCO scientists and graduate students participate in both research and training programs. In 2012, we began work on a report to summarize the utility of downscaled climate change projections with emphasis on the needs of ecological applications in the southeastern US. This project focuses on compiling information available for several publicly available downscaled climate change datasets with a secondary goal of beginning engagement between the climatologists and ecologists throughout the Southeast. Currently, this project has produced a literature review of downscaling techniques used and comparative meta-analysis of these datasets. This initial report, created with the input of ecologists across the Southeast, led to a workshop hosted in May 2013. The Regional Climate Variations and Change for Terrestrial Ecosystems Workshop, organized jointly with the UNC Institute for the Environment and the US Environmental Protection Agency, brought together climate scientists and ecologists to discuss the challenges of using downscaled

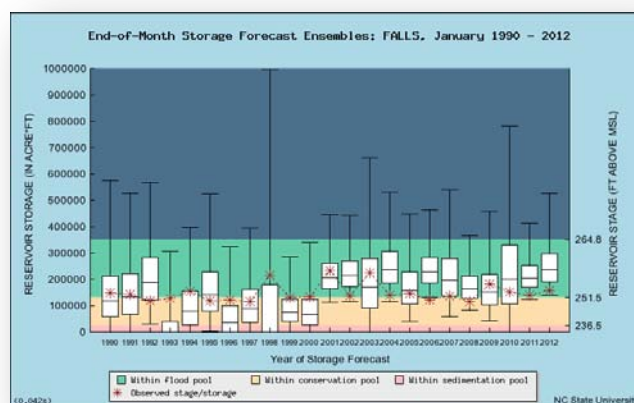
climate projections in ecosystem impact assessment. The results of this workshop provided insight into the needs of ecologists in the southeast US and will drive an initial evaluation of the six downscaled datasets in the project during the summer 2013. *Collaborators on the project include Kara Smith and Frederick Semazzi (NCSU), Lydia Stefanova and Vasu Misra (Florida State University), Adam Terando (Southeast Climate Science Center), Tom Smith (USGS Southeast Ecological Science Center), and David Blodgett (USGS Center for Integrated Data Analytics). Team: Adrienne Wootten, Ryan Boyles, Heather Dinon Aldridge, Corey Davis.*

Climate Decision Tools for Water Resources

Precipitation Monitoring and Alerts for DOT Stormwater Management: NC DOT continues to support the SCO to provide radar-based precipitation alerts and monitoring tools. There are currently 418 active user accounts for this product with 1,310 active sites monitored. This partnership with NC DOT has received 3 state and national awards. *Team: John McGuire, Aaron Sims, Ashley Hiatt, Ryan Boyles*



Experimental Inflow Forecasts: In collaboration with Dr. Sankar Arumugam (NCSU Civil, Construction, and Environmental Engineering), SCO developed a web portal to visualize experimental seasonal inflow forecasts using methods developed by Dr. Arumugam. With funding from the NC Water Resources Research Institute and the Urban Water Consortium, SCO focused this past year on automating and delivering monthly and seasonal forecasts for reservoir inflow and storage. *Team: Ashley Hiatt, Ryan Boyles*



NOAA Southeast Regional Climate Center

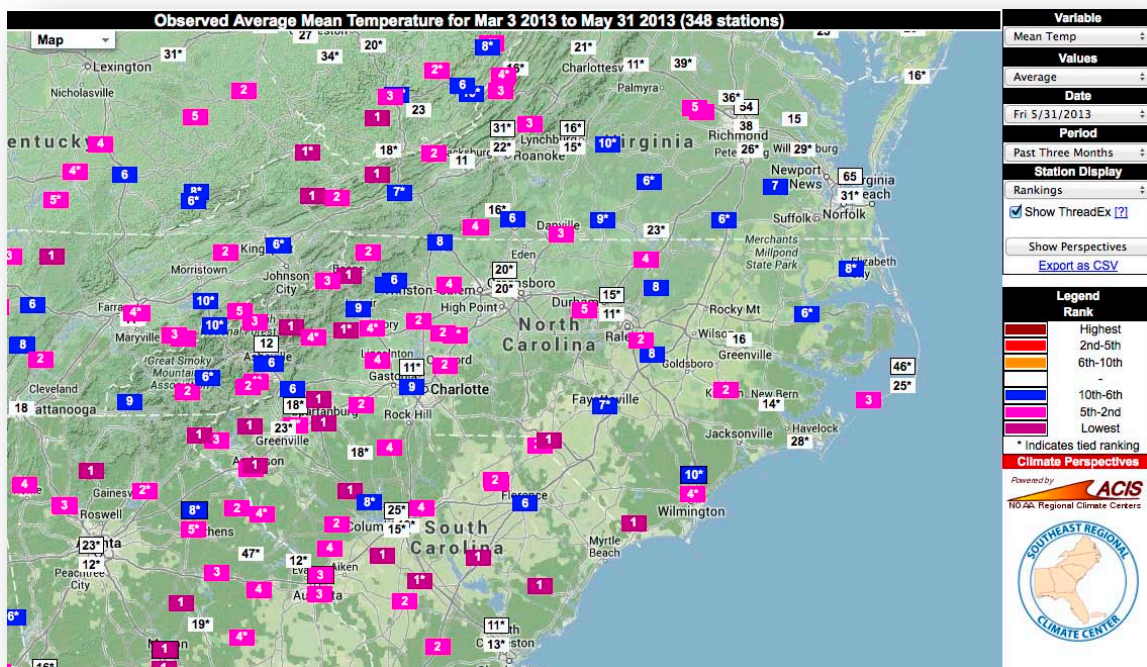
UNC-Chapel Hill and NCSU were awarded the NOAA Southeast Regional Climate Center (SERCC) in 2007. As part of that award, the SCO is responsible for supporting and maintaining the Applied Climate Information System (ACIS), which serves as the climate database for all six NOAA Regional Climate Centers. Additionally, SCO is responsible for developing and maintaining the SERCC web services and online climate tools.

SERCC Web Traffic

Usage: The volume of unique visitors to the SERCC website has increased **over 20%** (137,420) over the previous year. Overall, the SERCC website has received 164,254 visits.

- 83% of SERCC web traffic comes from new visitors
- June 29th, 2012 brought the highest web traffic of any single day (2,156 visits), nearly triple the next highest visit of December 3rd, 2012 (747). This was associated with a heat wave and near record temperatures.
- There were more than 1,000 visits from each of the SERCC states, led by North Carolina (20,005), Florida (19,769), Georgia (14,783) and Virginia (9,460).
- 63% of SERCC web traffic comes from search engines
- 20% of SERCC web traffic comes from direct traffic (e.g. bookmarks, going directly to the URL).
- 17% of SERCC web traffic comes from non-search engine referral sites (e.g. link to article or story)

Regional Climate Tools: We continued to enhance several regional climate information tools in 2012, including radar-based precipitation maps, local storm report summaries, and the nationally used Climate Perspectives tool. Climate Perspectives places recent weather into a historical climate context, and produces automated summaries for 760 locations in the southeastern US and 1,100 cities across the United States.



Climate and Public Health: In 2012, we focused more effort on developing a prototype tool to combine climate data with hospital admissions. This tool, still in testing and development, allows researchers to explore the relationships between emergency room admissions data and local climate conditions. These relationships, if robust, will enable early warning for public

health officials. The prototype tool was presented to the NC Climate and Health working group in spring 2013. Currently this tool allows users to search for emergency department records based on input primary and secondary diagnostic codes, dates and years of interest, and locations. Users can also pull corresponding weather records, 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.

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

Applied Research

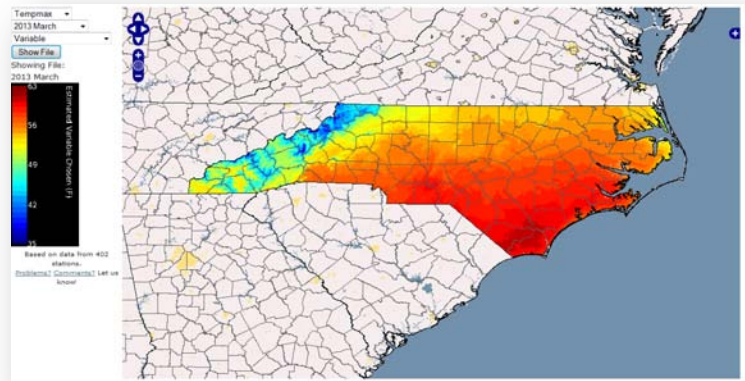
Research efforts in the SCO are connected to our unique data resources and established relationships with other disciplinary scientists. SCO scientists and students published scholarly manuscripts, presented at several scientific conferences, and received awards for their research. In the past year we continued work to improve our ability to model and estimate climate conditions for times and locations where observations are not available. We also continue to develop methods for improved drought monitoring, precipitation monitoring, and climate forecasting both with partners at NCSU, through the Southeast Climate Consortium, and with research collaborators across the nation. In 2012, we began a new research project supported by US Department of Defense to explore the climate sensitivities of Marine Corps Base Camp Lejeune.

Presentations and Publications

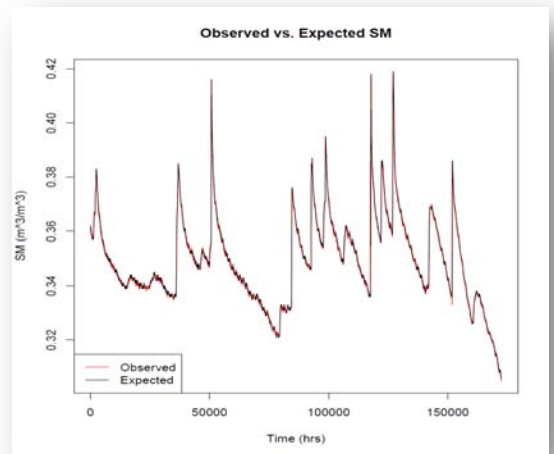
- 3 manuscripts were successfully published in peer-reviewed journals
- 6 manuscripts are in development or currently in submission
- 10 presentations were given at 4 scientific conferences
- 5 staff and students attended 4 scientific meetings and conferences
- Joseph Taylor won best oral presentation at the 20th AMS Conference on Applied Climatology

Development of High Resolution Temperature and Precipitation Estimates for North Carolina:

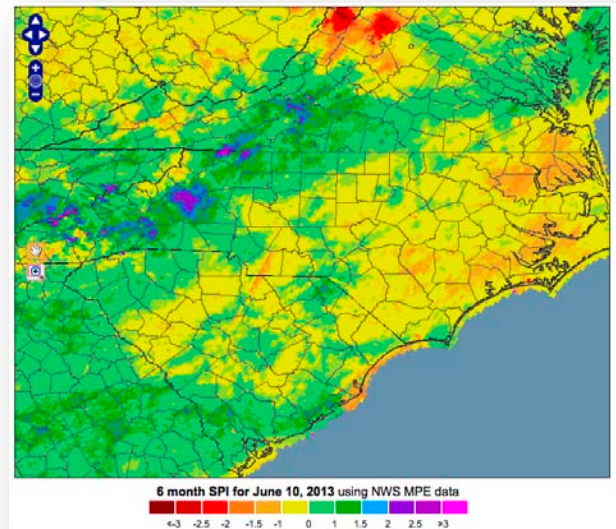
SCO is working to develop climate interpolation methods that provide better estimates of temperature and precipitation to assess historical daily climate conditions for locations where observations are not available. Using an existing modeled data set available from Oregon State University as a base (PRISM), the SCO is working to develop mapped estimates of monthly average temperature and total precipitation for much of the historical record. Estimates are developed using gridded normal temperatures and precipitation from PRISM overlaid with departure from normal for any given month and year interpolated to the PRISM grid. Currently, monthly estimates have been calculated for temperature and precipitation and an experimental interface has been developed. During summer 2013, this project will be expanded to produce estimates of daily maximum and minimum temperature across the state. *Team: James McClellan, Adrienne Wootten.*



Predicting observed soil moisture using statistical modeling: In order to improve quality control of ECONet soil moisture data and prediction of missing data, a statistical ARIMA model has been developed to predict an observed value. The research done in this project is currently being implemented into a quality control routine for soil moisture for the ECONet soil moisture data. This research received awards from the NCSU Undergraduate Research Symposium, Sigma Xi, and the American Meteorological Society. *Team: Joseph Taylor, Adrienne Wootten, Sean Heuser, Heather Dinon Aldridge, Ryan Boyles.*

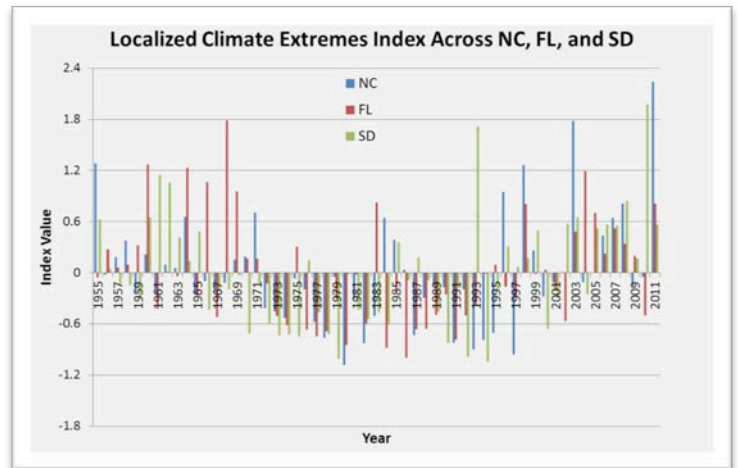


USDA High-Resolution Drought Triggers: Most drought products that exist today are county-level at their finest resolution or are based on interpolated rain gauge data. A Standardized Precipitation Index (SPI) algorithm that uses Multi-sensor Precipitation Estimates (MPE) in its calculation was developed by Texas A&M University (TAMU). The resolution of MPE and the resulting 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 MPE. This product is now available in an experimental form and has undergone beta testing since winter 2012. The current SPI maps are generated using statistics for stations that were grouped into regions based on their 1971-2000 precipitation normals using cluster analysis. Present work focuses on updating these statistics for clusters formed for the 1981-2010 normals period. Two additional gridded drought indices, the Palmer Drought Severity Index and the Standardized Precipitation Evapotranspiration Index, are planned for addition to the tool in 2013. Collaborators are John Nielsen-Gammon (TAMU) and Dev Niyogi (Purdue). *Team: Rebecca Cumbie, Melissa Mainhart, John McGuire, Aaron Sims, Corey Davis, Ryan Boyles*

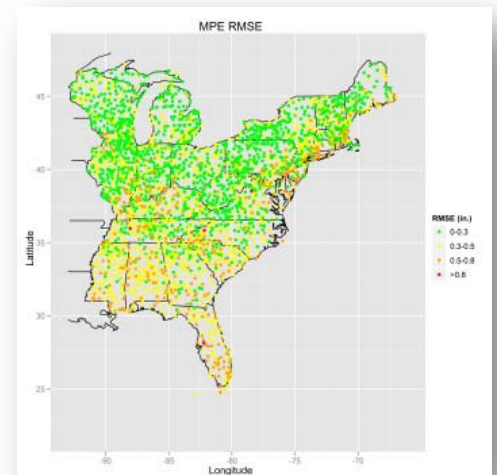


Model Reanalysis / Model Climatology: To improve the combined use of climate observation and atmospheric models, we are testing several model data assimilation methods for a case study of a mesoscale cold-air drainage event in the North Carolina mountains. This is intended to be a test for small-scale processes that happen across the entire state. Once complete, this information will be used to help generate a high-resolution climatology across the state of North Carolina. *Team: John McGuire, Aaron Sims, Ryan Boyles*

Localized Climate Extremes Index: The National Climatic Data Center produces a Climate Extremes Index for the United States that describes the impact of temperature and precipitation extremes on the U.S. from year to year. The goal of this project is to develop a localized version of the Climate Extremes Index that also includes severe weather events, winter weather events, and tropical activity. This localized index will also be flexibly crafted to allow for adaptation to other states. Currently, the index methodology has been evaluated for North Carolina, Florida, and South Dakota. The index has also been calculated for Virginia, South Carolina, Georgia, and Alabama, with a web tool in development to access and visualize all aspects of the index. Collaborators include Melissa Griffin and David Zierden (Florida Climate Center) and Laura Edwards (South Dakota State University Extension). *Team: Adrienne Wootten, Joseph Taylor, Ryan Boyles*



Evaluation of Multi-Sensor Precipitation Estimates (MPE): SCO uses MPE products provided by NWS River Forecast Centers and the National Center for Environmental Prediction 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), and are preparing two manuscripts for publication. Recently, an evaluation of the NWS Mosaic of MPE has been performed and compared to the NCEP Mosaic of MPE done previously for the continental United States. This additional analysis is currently ongoing, but another manuscript will be prepared based on this analysis. *Team: Adrienne Wootten, Ryan Boyles*



Evaluation / Implementation of Geospatial Downscaling of Precipitation in the Southeast US: Working with Dr. Guillermo Baigorria at the University of Nebraska Lincoln, SCO is implementing and evaluating a technique to translate coarse global seasonal forecast to localized (downscaled) seasonal and climate change forecasts for the southeastern US. Results of the evaluation suggest that the basic technique underestimates extreme precipitation events and the variability associated with tropical precipitation. This technique has been improved to better simulate extreme events. An evaluation reveals that this improved technique more accurately represents extremes events but overestimates precipitation in general. Two manuscripts are still in preparation, and an experimental seasonal forecasting interface has been implemented and is under review internally and by select external clients. Additional work on this project will include the addition of temperature forecasts as well as evaluation of the operational results and adjustments to model bias correction. *Team: Adrienne Wootten*

Southeast Climate Consortium (SECC): The Southeast Climate Consortium is a group of Universities in FL, AL, GA, NC, and SC working to develop climate risk research and decision support tools for agriculture in the southeastern US. Funding for the SECC is provided through USDA RMA, NOAA Climate Program Office, and a congressional earmark (primary funding source). NCSU was invited into this Consortium in 2008. This effort has research, education, and extension components. Research in the past years focused on missing data and climate forecasting:

- **Missing Data Challenge:** A Missing Data Working Group was established to create standard methods for estimating missing / erroneous data for SECC. The chosen methods for estimating missing values will be based on best methods suggested in literature, and from evaluation by the project team where necessary. Available datasets will also be used to provide estimates for missing data where appropriate. During the past year, an evaluation of satellite and empirical estimates of solar radiation has been performed by collaborators Greg Buol and Gail Wilkerson (NCSU Crop Science) to determine which method is best for situations of missing or erroneous solar radiation data. In addition, a multiple linear regression approach for estimates of temperature has been tested for NWS Cooperative Observer Network Stations across the Southeast, and an initial comparison of the NCEP Mosaic of MPE and PRISM to the ECONet precipitation data was performed.
- **Development of Historical Climate Analog Scenarios:** Working with Dr. John Christy (University of Alabama – Huntsville), the SCO is developing historical climate analog scenarios to represent the possible future scenarios of temperature and precipitation at local scales in the next 20 years given prescribed larger scale trends in temperature and precipitation, which are based on climate change projections. This method has been built into a prototype web tool that provides historical climate analog scenario information for actively recording stations with at least 50 years of data in the Southeast US. In addition, an initial evaluation into the application of this method to alternate areas of the country using larger scale trends based on ensembles of regional climate model temperature and precipitation data is being performed.
- *Team: Adrienne Wootten, Heather Dinon Aldridge, Ryan Boyles*

The 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. Using the Marine Corp Base Camp Lejeune as the study domain, the first phase of DCERP (2007 –2012) focused on creating ways to assess the impact of base operations and management practices on ecosystems and species on the base including terrestrial, barrier islands, coastal wetlands, and aquatic ecosystems. The second phase of DCERP (2013 –2017) will focus on integrating the impacts of climate change on the base ecosystems and ways that management practices may be changed to mitigate these impacts. The role of the SCO in this project is to provide fine resolution climate change projections and historical climatologies over the base for the ecological modeling applications of DCERP. In addition, the SCO will be documenting the needs of the ecological researchers in DCERP with regards to the climate sensitivities of the different studies being done as part of DCERP. More information is available at <http://dcerp.rti.org>. *Team: Adrienne Wootten and Ryan Boyles*

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 20,000 direct educational outreach contact hours. We provide direct outreach for dozens of school and community groups, participate in large science education events such as StormFest, NC Science Festival, and NC Science Olympiad, and push a range climate news and information to the public via our blog and social media. We also hosted our 10th class of student interns from Centennial Campus Middle School and engaged NC teachers through our online climate education material and through the CoCoRaHS grass roots rainfall network.



Undergraduate & Graduate Student Training

- SCO supported 9 undergraduate and 4 graduate students over the past year.

Invited Presentations and Visitor Programs

- Total Direct Educational Outreach Contact Hours: 20,642
- SCO staff provided 19 presentations by invitation
- SCO provided tours and programs for 19 visitor groups.
- SCO participated in several large group events, including StormFest, the NC Science Festival, and NC Science Olympiad

Climate Science Communication via Social Media

- In late 2012, *North Carolina Climate* transitioned from a monthly newsletter to an online blog containing news and updates sent out on a more frequent basis. The goal of the blog is built on the earlier newsletter format to:
 - Highlight new products and services
 - Provide monthly climate summaries focusing on recent climate patterns and impacts to agriculture and water resources
 - Expand readership in the social media world and build a more climate-literate population
- 525 individuals and group listservs are currently receiving notifications of new blog entries as they are published.
- We use Twitter to push information to the public regarding SCO products and services,

as well as general climate information. Tweets are generated with each blog entry publication, during ECONet station maintenance and SCO outreach events, and as any new and interesting weather and climate events occur. We currently have 141 followers for the SCO Twitter account.

- *Team: Heather Dinon Aldridge, Corey Davis, Bradley McLamb, Ashley Hiatt, Sean Heuser, Ryan Boyles*

Centennial Campus Magnet Middle School Internship: SCO hosted two 8th grade student interns from Centennial Campus Magnet Middle School (CCMMS) from mid-October 2012 through early March 2013. This is the 10th year of the internship program, where students spend an afternoon every week in the SCO to learn about NC climate and develop their own research projects. In 2012, we renovated the internship program to allow students to also work on weekly lab activities that covered basic weather and climate concepts, instrumentation and data measurement, and meteorology careers.

Team: Rebecca Cumbie, Corey Davis, Adrienne Wootten, Megan Hall, Bradley McLamb, Sean Heuser, Ashley Hiatt, Heather Dinon Aldridge



Data Project for Reedy Creek Middle School: Last fall, the career development coordinator from Reedy Creek Middle School (RCMS) contacted our office requesting help in putting together a project that would give their 7th grade students experience using climate data. The project developed by SCO staff and graduate students gave the RCMS 7th graders the opportunity to determine whether various locations across the state were suitable for growing peanuts, based on growing degree days and precipitation observations from the closest weather station in their area of interest. Teacher and student instruction documents were generated for the project, and weather observations were retrieved using the CRONOS database. The project ultimately encouraged both individual and group research throughout the exercise, and honed in on the students' critical thinking skills as they explored the many ways in which weather and climate information is often used in the real world. *Team: Ashley Hiatt, Megan Hall, Adrienne Wootten.*

NC Science Olympiad (NCSO): NC Science Olympiad is an annual science contest for middle and high school students held on North Carolina State University's campus. The SCO worked extensively to implement the "Meteorology" event for the NCSO State Tournament, held on April 27, 2013. *Team: Megan Hall, Heather Dinon Aldridge, Ashley Hiatt, Corey Davis, Joseph Taylor*

StormFest: StormFest is an annual event held at the Museum of Natural Sciences in downtown

Raleigh, in which attendees learn about North Carolina’s weather and climate through panel discussions with broadcast meteorologists, weather spotter training, and visits to booths run by various weather organizations. StormFest in June 2012 and had more than 3,000 visitors. *Team: Rebecca Cumbie, Heather Dinon Aldridge, Joe Taylor, Adrienne Wootten*

Climate Education Modules: SCO has designed, developed, and maintains a series of web-based climate education modules for agricultural clients and K-12 educators. This is currently being expanded to support education for water resource managers, natural resource and forestry practitioners, and public health officials. Such modules are created in hopes to improve basic understanding of climate science, including climate variability and climate change, across North Carolina and the Southeast. *Team: Megan Hall, Heather Dinon Aldridge, Ashley Hiatt, John McGuire, Ryan Boyles*

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

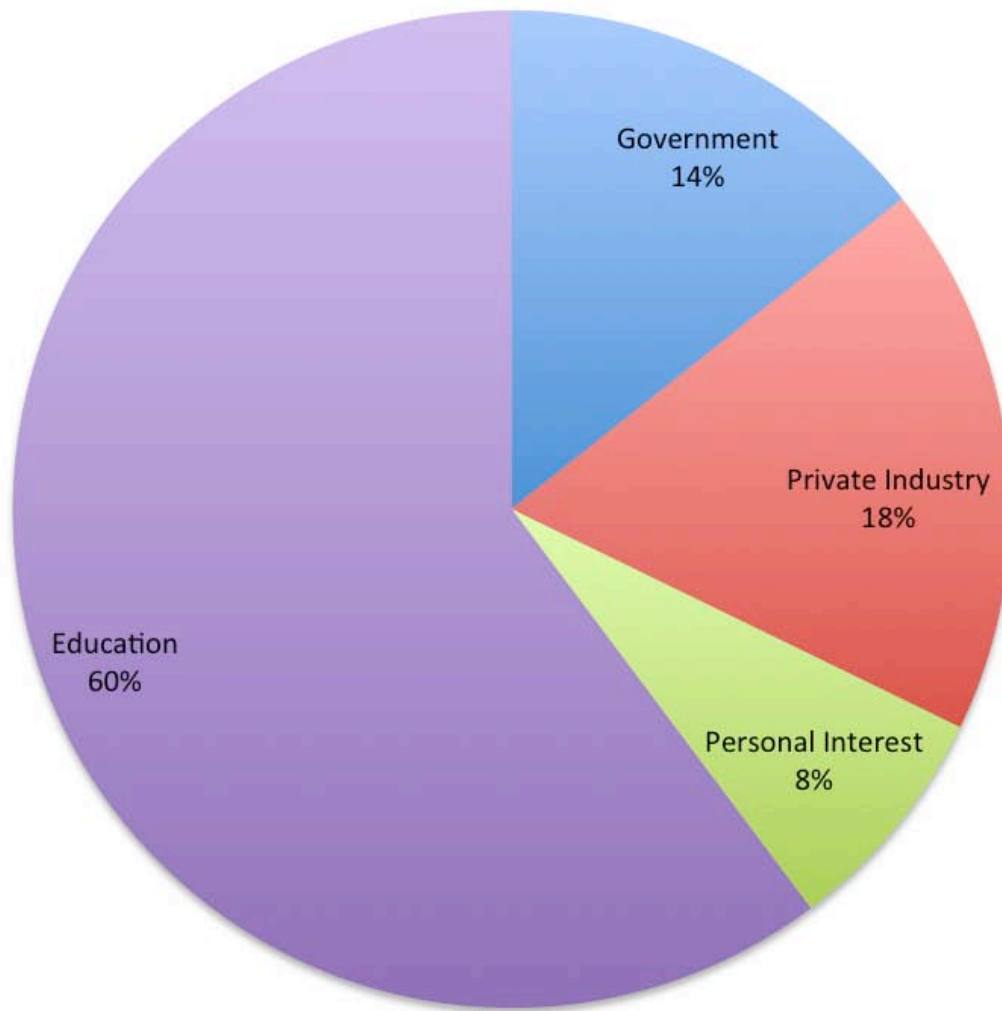
Through CoCoRaHS, thousands of volunteers, young and old, document the size, intensity, duration and patterns of rain, hail and snow by taking simple measurements in their own backyards. These reports help supplement existing observations from local weather stations and fill in gaps where there are no nearby stations. We led the establishment of CoCoRaHS in North Carolina in 2007 and over the past year we have been trying to recruit new volunteers for the program, especially encouraging participation from local schools and areas with data gaps. *Team: Heather Dinon Aldridge, Rebecca Cumbie*



Appendix A: Climate Services by Client Sector

Climate Information Services Effort by Client Sector

May 1, 2012 through April 30, 2013



Climate Information Services by Client Sector - Details

May 1, 2012 through April 30, 2013

Classification	Number of Requests	Hours Worked
Government: Federal-Agriculture	6	6
Government: Federal-Education: college, university	2	2
Government: Federal-Engineering	2	2
Government: Federal-Other	7	7
Government: Federal-Tourism/recreation	1	1
Government: Local-Economic development	2	3
Government: Local-Education: college, university	1	1
Government: Local-Education: K-12	4	4
Government: Local-Energy	3	3
Government: Local-Health	3	3
Government: Local-Other	3	3
Government: Local-Water	2	2
Government: multijurisdictional-Economic development	1	1
Government: multijurisdictional-Personal interest	1	1
Government: State-Agriculture	3	3
Government: State-Construction	1	1
Government: State-Education: college, university	288	300
Government: State-Education: K-12	1	1
Government: State-Energy	1	1
Government: State-Health	8	14
Government: State-Legal/insurance	1	1
Government: State-Other	18	18
Government: State-Water	7	7
NGO-Education: college, university	2	2
NGO-Legal/insurance	1	1
Private entity-Agriculture	5	5
Private entity-Construction	9	9
Private entity-Education: college, university	7	8
Private entity-Energy	4	4
Private entity-Engineering	26	26
Private entity-Health	1	1
Private entity-Legal/insurance	12	13
Private entity-Media	5	5
Private entity-Other	23	23
Private entity-Personal interest	38	38
Private entity-Tourism/recreation	1	1
Private entity-Water	3	3
Totals	503	524
Percent Change From Previous Year	-17%	-17%

Appendix B: Simplified Budget

FY2013 Budget (from May 2012)

Source	Personnel	Operating Expenses	Total	Percent
College of Physical & Mathematical Sciences	\$225,869	\$30,000	\$254,869	23%
NC Agriculture Research Service	\$132,787	\$58,000	\$192,385	17%
External Contracts & Grants	\$599,516	\$72,058	\$671,574	59%
Service Center		\$5,000	\$5,000	0%
Total	\$969,746	\$165,058	\$1,134,804	

FY2013 Expenditures

Source	Personnel	Operating Expenses	Total	Percent
College of Physical & Mathematical Sciences	\$201,992	\$63,687	\$265,679	26%
NC Agriculture Research Service	\$134,773	\$59,153	\$193,926	19%
External Contracts & Grants	\$446,600	\$103,714	\$550,314	55%
Service Center	\$219	\$2690	\$2909	0%
Total	\$783,585	\$229,244	\$1,012,829	

FY2014 Budget

Source	Personnel	Operating Expenses	Total	Percent
College of Physical & Mathematical Sciences	\$235,010	\$30,000	265,010	25%
NC Agriculture Research Service	\$132,787	\$58,000	\$192,385	18%
External Contracts & Grants	\$517,408	\$87,382	\$604,791	57%
Service Center		\$5,000	\$5,000	0%
Total	\$888,208	\$180,882	\$1,069,090	

Appendix C: 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.