Developing a Drought Early Warning System (DEWS) for the Coastal Carolinas

BY KIRSTEN LACKSTROM
Carolinas Integrated Sciences & Assessments

THE COASTAL CAROLINAS DEWS APPROACH

Launched in 2012, the Coastal Carolinas DEWS is a collaborative federal, state, and local interagency effort to improve early warning capacity and resilience to drought with an emphasis on the unique coastal ecosystems of North and South Carolina. Drought in coastal areas can contribute to changing water quality conditions, particularly increased salinity levels and fluctuations, and changes in the availability and timing of freshwater to support animals, plants, and habitats.

Coastal Carolinas DEWS activities focus on improving the understanding of drought's effects on coastal environmental resources and developing information to enhance drought monitoring and planning processes. DEWS priorities (Table 1) were developed with stakeholder guidance. See page 2 for a listing of specific projects.

2016 STRATEGIC PLAN

In summer 2016, Coastal Carolinas DEWS stakeholders will develop a strategic plan that details DEWS program priorities and guides activities through 2018. This effort will begin with a one-day meeting in Wilmington, NC, on June 2, 2016. Meeting participants will be asked to refine priorities and major tasks for the Coastal Carolinas DEWS and develop ideas and input that will be incorporated into a Coastal Carolinas Strategic Plan. Meeting participants will also discuss how best to foster communications, collaborations, and coordination around coastal drought issues and activities.


Photo Credit: CoCoRaHS Observer Christopher Lumpp

What is NIDIS?

The National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System (NIDIS) program was authorized by Congress in 2006 (Public Law 109-430) with an interagency mandate to coordinate and integrate drought research, building upon existing federal, tribal, state, and local partnerships in support of creating a national drought early warning information system.

What is a Drought Early Warning System (DEWS)?

A NIDIS DEWS utilizes new and existing partner networks to optimize the expertise of a wide range of federal, tribal, state, local and academic partners in order to make climate and drought science readily available, easily understandable and usable for decision makers; and to improve the capacity of stakeholders to better monitor, forecast, plan for and cope with the impacts of drought.

Priority	Key Need
Evaluate and develop drought indicators appropriate for coastal ecosystems	Many of the commonly used drought indices were developed with agriculture, reservoir management, and water supply in mind, rather than the unique characteristics of coastal ecosystems.
Facilitate the use of drought forecasts and other products for decision making	Numerous drought, hydrometeorological, and climate products exist, but potential users may not be aware of all available products, have the products they need to make decisions (i.e. the spatial or temporal scale may not be adequate), or know the best way to tailor the products to their location or situation.
Improve drought impacts monitoring and reporting	Drought monitoring and planning would benefit from increased awareness of drought, improved documentation of drought impacts, and better understanding of the linkages between drought indicators and impacts.

FOR MORE INFORMATION: https://www.drought.gov/drought/dews/coastal-carolinas

ACKNOWLEDGEMENTS
Projects have been funded by the National Integrated Drought Information System (NIDIS) and NOAA's Regional Integrated Sciences & Assessments (RISA) program.

COASTAL CAROLINAS DEWS PROJECTS & ACTIVITIES

Coastal Salinity Index: The location of the freshwater-saltwater interface in surface-water bodies along the coast is an important factor in ecological and socio-economic dynamics. Utilizing real-time salinity data from USGS gages in coastal riverine systems, the Coastal Salinity Index (CSI) can be used to characterize and monitor drought conditions in coastal areas.

Ecological drought indicators: It is important that a CSI be correlated to coastal drought response variables for monitoring and planning purposes. This project is taking the Coastal Salinity Index one step further by investigating how ecological indicators vary according to salinity levels expressed by the CSI.


Photo Credit: Ben Haywood


Photo Credit: Michael Childress

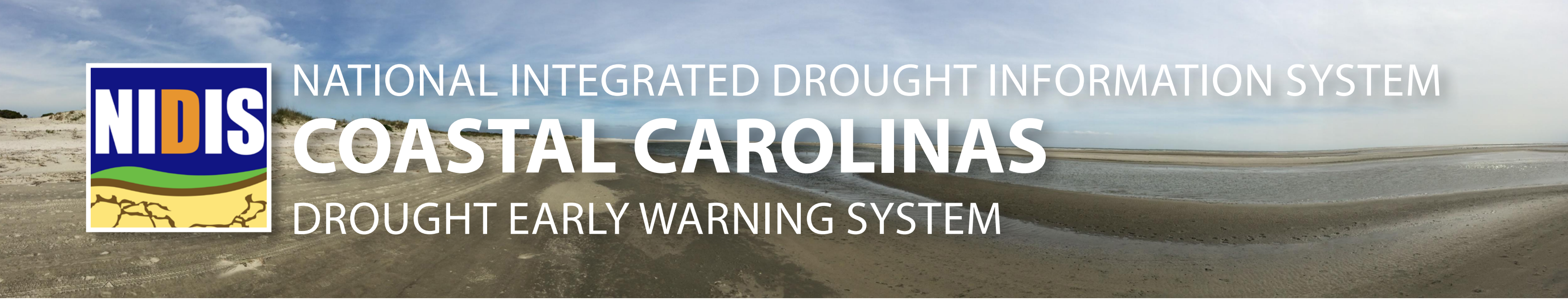
Forecasting the SC Blue Crab Fishery: This project developed a model to improve understanding of the complex relationship between crab abundance and drought. The model can be used as a decision support tool to examine how the rate of declining flow and the degree of interannual variability in freshwater discharge and salinity might interact to influence crab abundance, commercial landings, and disease prevalence.

Drought indicators for coastal zone fire risk: Objective drought indicators were examined to assess how they represent local fire risk in coastal areas, where soils are high in organic content and become increasingly hydrophobic as they dry out. Additional work is necessary to identify which combination of parameters (e.g., surface fuel moisture, soil conditions, and groundwater levels), in conjunction with other monitoring tools and networks, will provide more meaningful information for managing coastal zone fire risk.

Citizen Science Condition Monitoring: Citizen science volunteers report daily precipitation measurements and weekly reports about local conditions to connect weather and climate with on-the-ground drought impacts. Information is submitted through the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network. These reports generate valuable baseline and drought impacts information that can used in drought monitoring. Between September 2013 and December 2015, over 1500 condition monitoring reports were submitted through CoCoRaHS as part of this project.

An Atlas of Hydroclimate Extremes for the Carolinas: The web-based atlas will be available in 2017, providing useful visual and quantitative information on patterns of drought and extreme precipitation events and the impacts associated with these events. The atlas will be tailored to meet decision maker questions and information needs related to resource management and planning.


Photo Credit: Kathy Stone



A RELATIVELY NEW CONCEPT: COASTAL DROUGHT

Using salinity data to develop a Coastal Salinity Index

BY PAUL CONRADS
U.S. Geological Survey, South Atlantic Water Science Center

Coastal droughts have a different dynamic from upland droughts, which are typically characterized by agricultural, hydrologic, meteorological, and (or) socioeconomic impacts. The location of the freshwater-saltwater interface in surface-water bodies is an important factor in the ecological and socioeconomic dynamics of coastal communities. Because of the uniqueness of drought impacts on coastal ecosystems, a Coastal Salinity Index (CSI) was developed using an approach similar to the Standardized Precipitation Index (SPI). Instead of using precipitation data, as the SPI does, the CSI utilizes salinity data. The CSI is a standardized probability index with zero indicating historical median salinity amount, and positive and negative values representing increasingly fresh and saline conditions, respectively. The CSI characterizing 1-, 6-, 12-month and monthly salinity values for the Waccamaw River at Hagley Landing are shown in figure 1. Thresholds similar to the SPI values were used to set incremental coastal salinity classifications (fig. 2, table 1).

Evaluation of the CSI indicates that the index can be used for different estuary types (for example, brackish, olioghaline, or mesohaline estuaries), for regional comparison between estuaries, and as an index for wet conditions (high freshwater inflow) in addition to drought conditions. The development of the various drought characteristic intervals (1-, 3-, 6-, 9-, and12-month) allow for the CSI to be correlated with environmental response variables that occur on different time intervals. Figure 3 shows the computed CSI for the Waccamaw River (upper plot) and the Little Back River (lower plot). The background colors are the drought declarations (CD0 to CD4) and wet declarations (CW0 to CW4). The plots show there are times when there are different drought conditions in the Waccamaw River basin than the Savannah River basin. For example, a period in October 2007, the CSI was compared to the Drought Monitor map for the week of October 16th. The map shows that the Yadkin-Pee Dee Basin was in greater drought than the Savannah River Basin. The CSI also indicated a similar change in drought along the coast. The background map shows potential USGS real-time gaging locations where the CSI could be applied.

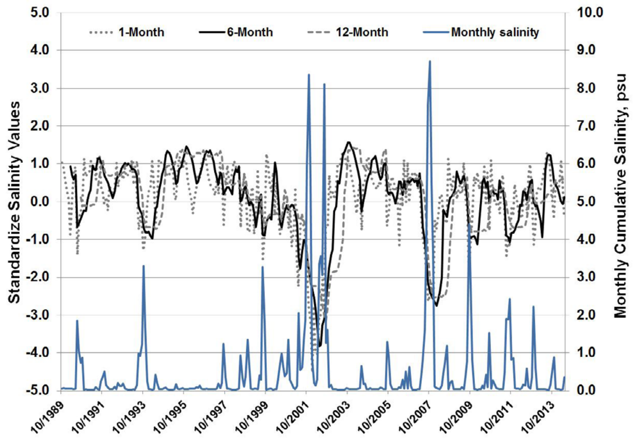


Fig. 1. The 1-, 6-, and 12-month standardize salinity values for the Waccamaw River at Hagley Landing, South Carolina.

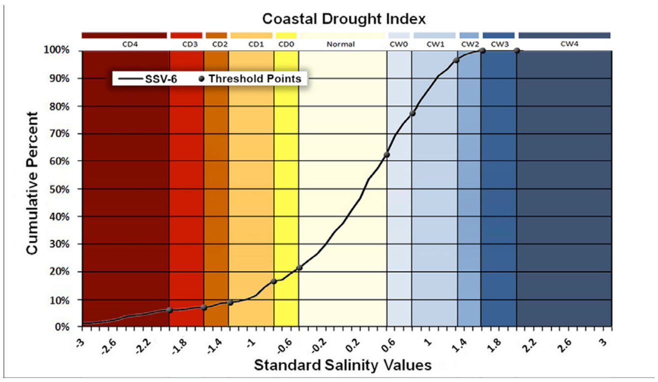


Fig. 2. The cumulative frequency curve for the 6-month standardize salinity values for the Waccamaw River at Hagley Landing, South Carolina, and the background color ramp represents the coastal salinity classifications (table 1).

Coastal salinity classification	Description	Threshold values
CW4	Exceptional Freshwater Conditions	2
CW3	Extreme Freshwater Conditions	1.6
CW2	Severe Freshwater Conditions	1.3
CW1	Moderate Freshwater Conditions	0.8
CW0	Abnormal Freshwater Conditions	0.5
N0	Normal Salinity Conditions	0
CD0	Abnormal Salinity Conditions	-0.5
CD1	Moderate Salinity Conditions	-0.8
CD2	Severe Salinity Conditions	-1.3
CD3	Extreme Salinity Conditions	-1.6
CD4	Exceptional Salinity Conditions	-2

Table 1. Classification labels, descriptions, and threshold values used for the coastal salinity index.

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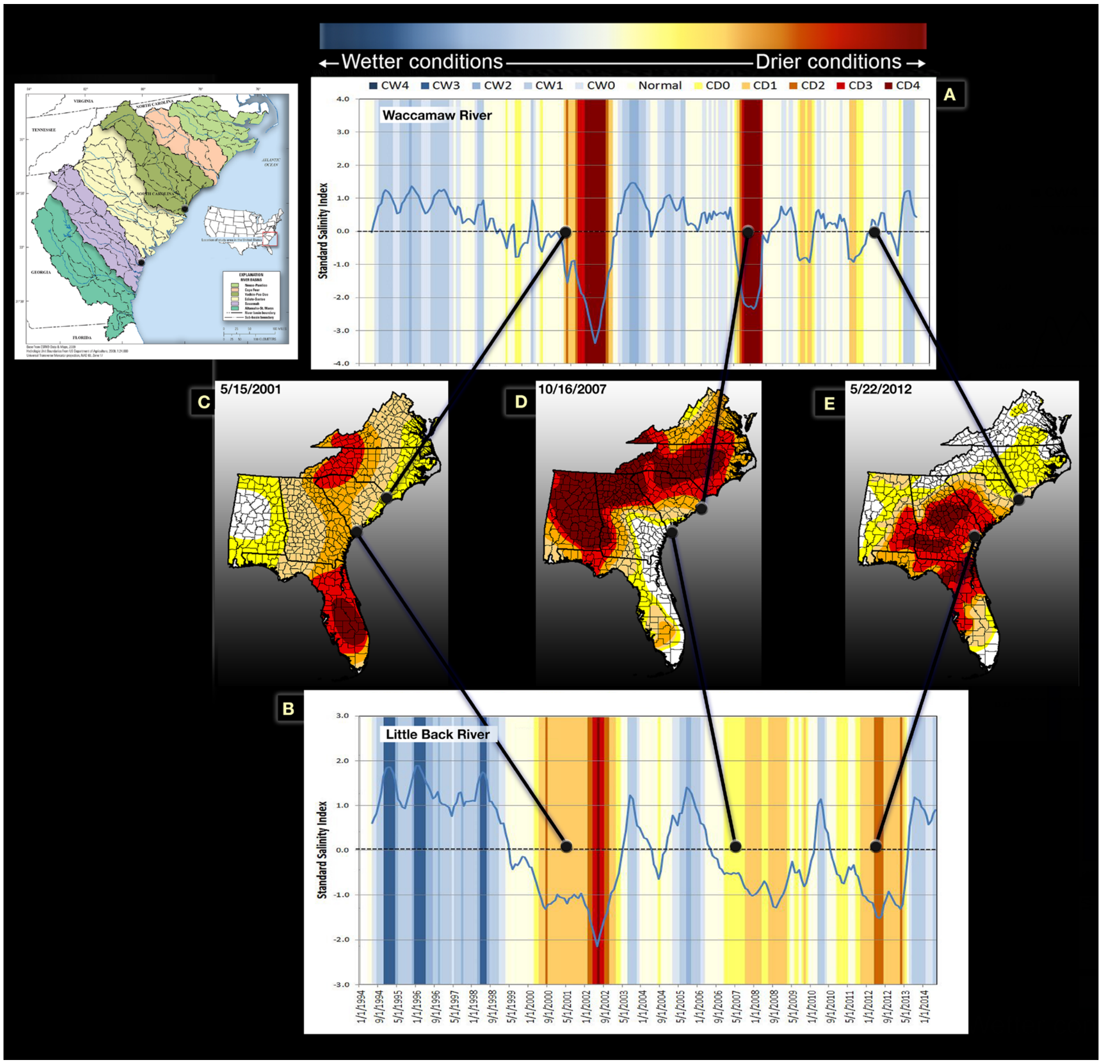
FOR MORE INFORMATION :
http://sc.water.usgs.gov/drought/coastal-drought

CONTACT Paul Conrads at pconrads@usgs.gov



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What is the Coastal Carolinas DEWS?

A diverse group of stakeholders convened in August 2012 in Wilmington, NC, to identify issues of concern about drought in the coastal regions of the Carolinas. Out of the meeting came the Coastal Carolinas Drought Early Warning System, a collaborative federal, state, and local interagency effort to improve early warning capacity and resilience to drought. CC DEWS activities focus on improving the understanding of drought's effects on coastal environmental resources and developing information to enhance drought monitoring and planning processes.

Fig. 3. The 6-month Coastal Salinity Index (CSI) for A) Waccamaw River at Hagley Landing (Yadkin-Pee Dee River basin) and B) Little Back River at Luchnow Canal (Savannah River basin) and the U.S. Drought Monitor maps for C) May 15, 2001, D) October 16, 2007, and E) May 22, 2012. Note that regional differences in drought intensities in the maps are reflected in the CSIs.

COASTAL ECOLOGICAL RESPONSE

It is essential that a CSI be correlated to a coastal drought response variable to show the importance of a unique coastal drought index. Coastal drought is a relatively new concept and existing datasets may not have been collected or understood as "drought response" datasets. Krauss et al. (2009) studied the response of baldcypress (Taxodium distichum) in tidal swamps to various levels of salinity exposure. Two of the baldcypress study sites were on the Waccamaw and Savannah Rivers, near the salinity sites used to compute the CSIs (fig. 4). Tree-ring chronologies of baldcypress tree from the study sites (Thomas et al., 2015) shows periods of growth suppression (values less than 1) and growth release (values greater than 1).

To evaluate whether the CSI can be used as an explanatory factor on baldcypress growth response, a correlation analysis was done to determine the optimum CSI interval (1- to 24-months) and response time-lag. For the baldcypress tree in the Savannah River, there is an immediate impact of salinity and fresh conditions (fig. 4). The highest correlation (r = 0.81) was with the 6-month CSI and no time lag.

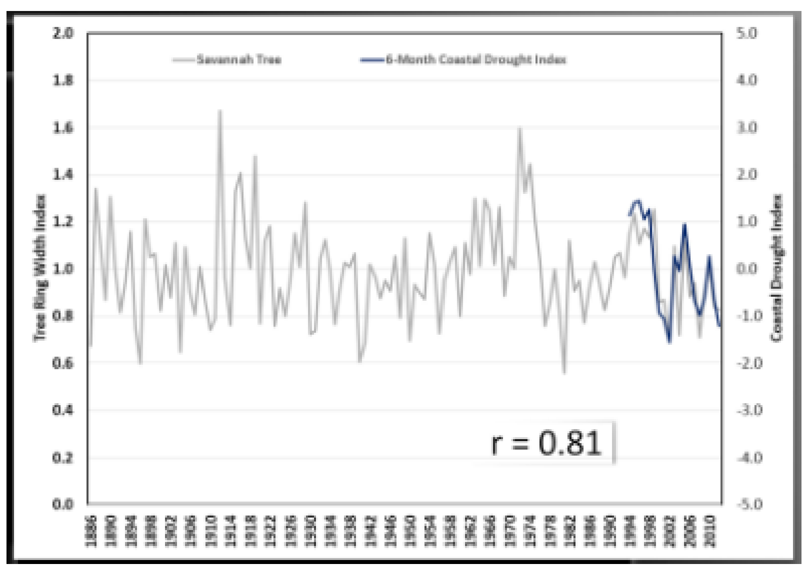

Fig. 4. Plot shows Savannah River tree ring chronology and 6-month CDI.

This article originally appeared in the November 2015 (Vol. 5, Issue 2) edition of Dry Times, the NIDIS newsletter. Access the entire publication at: http://www.drought.gov/drought/what-nidis/nidis-news.

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Thomas, B.L, T.W. Doyle, and K. W. Krauss. 2015. Annual growth patterns of bald cypress (*Taxodium distichum*) along salinity gradients. *Wetlands* 35 (4): 831-839.

STUDY EXAMINES THE FUTURE OF RIVER DISCHARGE
AND ITS IMPACT ON SOUTH CAROLINA'S VALUABLE BLUE CRAB CATCH

Forecasting a crab fishery using real-time freshwater flow data

BY MICHAEL CHILDRESS
Clemson University

Blue crabs (*Callinectes sapidus*) are one of the most important commercial fisheries in the state of South Carolina with annual landings averaging 5.5 million pounds. Inter-annual variation in S.C. crab landings is significantly correlated with annual levels of freshwater discharge, explaining more than 40% of its variation.

During droughts, freshwater input to marshes decreases and salinity increases. As salinity increases, crab abundance decreases due to increasing infection by a lethal parasite, *Hematodinium sp*. However, the degree to which the population decline is linked to decreasing freshwater depends on the level of freshwater flow into the marsh.

A four-year study of the blue crabs in the ACE Basin National Estuarine Research Reserve (named for the Ashepoo, Combahee, and Edisto Rivers), South Carolina (Figure 1, right) during the 2008-11 drought found that crabs decreased in the low flow Combahee River due to increased parasites (*Hematodinium sp.*) but increased in

FOR MORE INFORMATION regarding the SCBCRABS blue crab forecast model, visit the SC Blue Crab Forecast web blog at: http://scbcrabs.blogspot.com/.

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CLEMSON UNIVERSITY

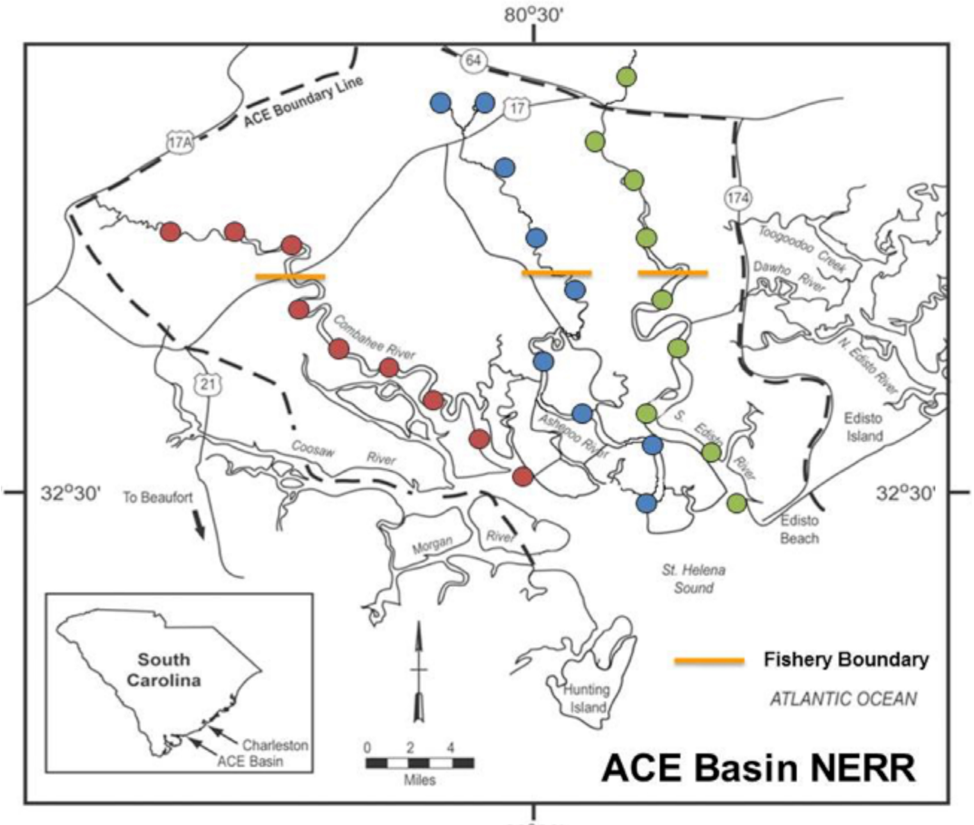

Figure 1

Map shows the locations for the field study of salinity impact on blue crab population structure in the ACE Basin National Estuarine Research Reserve, South Carolina. Twenty-seven stations (nine per river) were sampled quarterly for four years from June 2008 until May 2012. Salinity profiles along each river were related to measures of blue crab life history including disease prevalence, relative predation, post-larval settlement, and size-frequency distribution. During this drought period, blue crab abundance decreased in the low-flow Combahee River (red dots) due to increased infection by Hematodinium sp. parasites, but increased in the high-flow Edisto River (green dots) due to decreased predation by alligators. The seasonal, spatial and interannual differences in river discharge, salinity profile, growth, predation, disease, post-larval settlement, movement and fishing effort were then incorporated into a spatially-explicit individual-based population of blue crabs to estimate the non-linear effects of salinity variation on blue crab commercial landings.

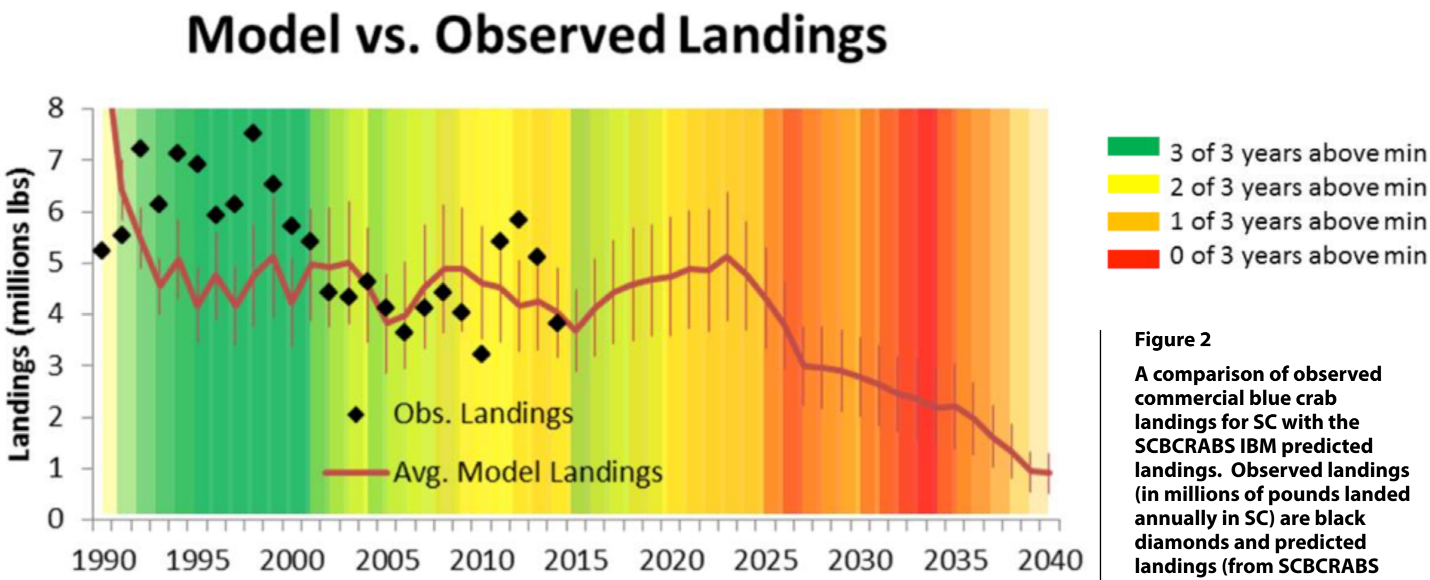

Figure 2

A comparison of observed commercial blue crab landings for SC with the SCBCRABS IBM predicted landings. Observed landings (in millions of pounds landed annually in SC) are black diamonds and predicted landings (from SCBCRABS IBM) are the red line with mean and SD for 3 replicate runs of the model.

Edisto river discharge is indicated by the color heat map based on a critical minimum discharge level of 1250 cfs average annual flow. Historical river discharge data (1990-2014) is from the USGS gaging station at Givhans Ferry, SC. Projected river discharge (2015-2040) is from a seasonal ARIMA statistical model of future river discharge levels.

When river discharge is above this critical minimum for the 3 previous years, the river condition is green for the next five years. When river discharge is below this critical minimum for the 3 previous years, the river condition is red for the next five years.

Crab landings increase during wet periods (green) and decrease during dry periods (red) and since the year 2000, observed landings typically fall within a standard deviation of the predicted landings.

the high flow Edisto River due to decreased predation by freshwater predators (alligators).

Since drought can have both positive and negative effects on blue crabs, there is considerable interest in understanding how future variation in river discharge will impact commercial blue crab landings.

This project for the Coastal Carolinas Drought Early Warning System (DEWS) used historical and forecasted Edisto river discharge levels as input for a spatially explicit, individual-based blue crab population model parameterized for conditions in the ACE Basin National Estuarine Research Reserve (http://scbcrabs.blogspot.com/).

The model crab landings for the first 25 years of historical river discharge were then standardized to the observed S.C. commercial landings for the same period. Future projections of crab landings showed that when Edisto river annual average discharge remained at or above a critical minimum level (1250 cfs annual average) for three consecutive years, statewide crab landings increased.

However, when river discharge dropped below this critical minimum, crab landings decreased.

Both statistical models of river discharge trends (seasonal ARIMA) and climate forecast surface runoff models (OpenNSPECT) suggest that the annual river discharge will continue to decrease while the interannual variation in river discharge will remain high. Given these forecasted conditions, future blue crab landings may experience periods, three to five years in duration, of increase and of decline, but ultimately, if river discharge continues to decrease, crab landings will fall to 50% of the historical commercial landings within the next 15-20 years (Figure 2).

The good news is that blue crabs occupy a large latitudinal gradient, and thus, when blue crabs are declining due to drought in the southern portion of their range, blue crabs in the northern portion of their range may be increasing due to elevated river discharge levels.

Future work will attempt to expand the blue crab forecast to examine the ability of blue crabs to persist given the likely scenarios of climate change and river discharge across their entire geographic range. We can accomplish this by incorporating both better predictions of future surface flow (ongoing collaboration with Dan Tufford and Greg Carbone of the University of South Carolina) and incorporating a real-time coastal drought index as a metric for estimating critical minimum flow conditions for blue crabs across their entire geographic range (ongoing collaboration with Paul Conrads, USGS).

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NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

COASTAL CAROLINAS

DROUGHT EARLY WARNING SYSTEM

COMPARING ENVIRONMENTAL INDICES IN EASTERN NORTH CAROLINA

Assessment of indicators for coastal zone fire risk

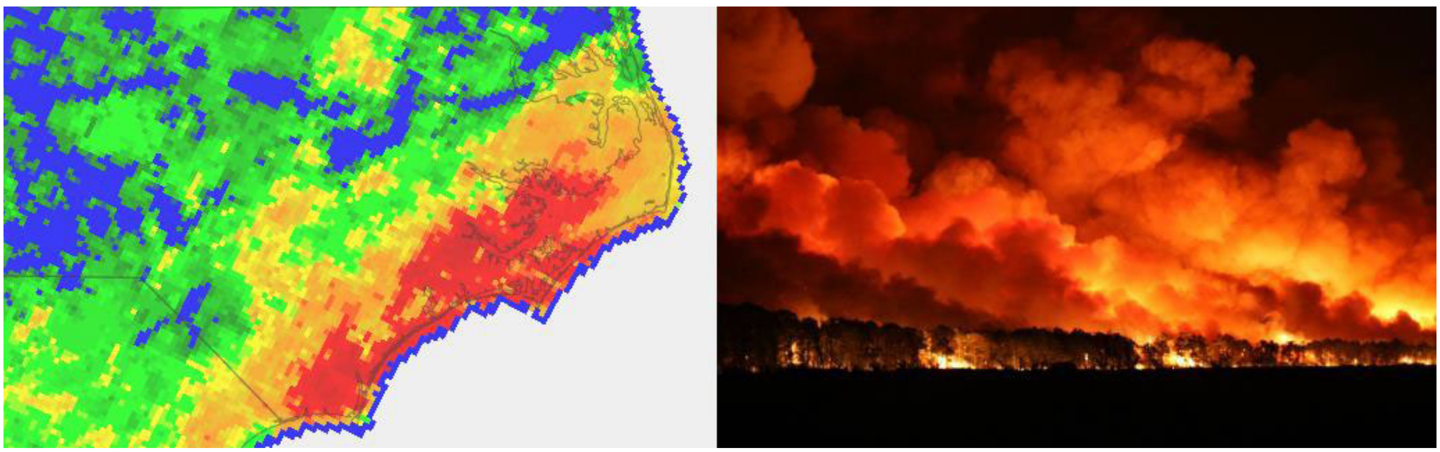

Figure 1: Gridded KBDI values in eastern North Carolina (left) exceeded 500 in mid-June 2011, when the Pains Bay fire (right, by Lloyd Brown) and several others burned.

BY COREY DAVIS, REBECCA CUMBIE, RYAN BOYLES
State Climate Office of North Carolina

Monitoring burning conditions in eastern North Carolina's organic soils can be challenging. Existing measures of near-surface dryness, such as drought indices and National Fire Danger Rating System (NFDRS) parameters, have often been considered poor indicators of fire risk in organic soils, which have complex compositions, can burn and smolder several feet underground, and are often found in regions with subtle but meaningful terrain differences. This project sought to further compare these commonly used environmental indices, including several new gridded products, with an experimental Estimated Smoldering Potential dataset in search for better indicators of organic fire risk.

A GRIDDED KBDI DATASET

One commonly used fire risk parameter is the Keetch-Byram Drought Index (KBDI), which estimates dryness in the uppermost eight inches of the soil. KBDI has historically been available only at Remote Automatic Weather Stations (RAWS), so much of eastern North Carolina did not have direct coverage. Using daily radar-derived precipitation estimates from the National Weather Service and daily maximum temperature and annual average precipitation data from the PRISM dataset, a gridded KBDI dataset was created at 4 km resolution for the period beginning in March 2007.

A comparison with the RAWS KBDI observations showed that the gridded data generally underestimates values, with annual maximum values 136.65 points lower in the gridded dataset, on average. This difference is likely due to the underestimation of maximum temperatures in the PRISM dataset and/or a warm bias in RAWS temperature observations.

ESP COMPARISONS

Several gridded indices including KBDI, daily precipitation, and the Standardized Precipitation Index (SPI) over one- to four-month periods, were then compared with soil moisture data from an experimental Estimated Smoldering Potential (ESP) dataset.

This ESP data was collected intermittently from 2012 to 2014 at three coastal stations: in the Pocosin Lakes National Wildlife Refuge in Hyde County, in the Alligator River National Wildlife Refuge in Dare County, and near Green Swamp in Brunswick County (Figure 2).

FOR MORE INFORMATION CONTACT: Ryan Boyles at ryan_boyles@ncsu.edu

NORTH CAROLINA CLIMATE OFFICE

The results showed that all three gridded indices were only weakly correlated with the ESP data. (Table 1). Separate comparisons with Energy Release Component (ERC) data from nearby RAWS stations using both fuel models G and O also showed only weak relationships with the soil moisture observations from the ERC dataset.

The weak correlations are likely because these indices cannot capture the terrain, drainage, and composition of organic soils. To that extent, few to no existing indices can model this combination of environmental and non-meteorological characteristics.

Because of this, no single index based on current widely available data is likely to be a consistent indicator of organic fire risk. A combination of monitoring recent NFDRS parameters to assess surface fuel burning, local soil sampling, and groundwater levels is recommended until further improvements are made.

	Alligator River (n = 349 days)	Allen Road (n = 278 days)	Green Swamp (n = 51 days)
Soil moisture vs. 1-month SPI	0.253	-0.075	0.833
Soil moisture vs. 2-month SPI	0.483	-0.235	0.725
Soil moisture vs. 3-month SPI	0.479	-0.316	0.648
Soil moisture vs. 4-month SPI	0.391	-0.352	0.711
Soil moisture vs. gridded daily precipitation	0.017	0.125	0.091
Soil moisture vs. gridded KBDI	0.372	-0.331	-0.563
Soil moisture vs. ERC (fuel model O)	-0.116	-0.057	-0.254
Soil moisture vs. ERC (fuel model G)	0.147	0.011	-0.217

Table 1: Correlation coefficients (r) between soil moisture data from ESP arrays and other gridded and point-based datasets.

FUTURE WORK

Additional research may suggest better options for monitoring organic fire and smoldering conditions. Separate studies are currently examining remotely sensed soil moisture data as an indicator of smoldering in organic soils. The deployment of soil moisture probes across eastern North Carolina could also establish a reliable sensor network and provide a longer period of record than the ESP stations.

Along with providing a finer-scale monitoring network in this part of the state, this would allow for a more robust comparison with existing datasets to search for good indicators of organic fire risk.

Although it does not provide meaningful guidance for organic regions, the gridded KBDI dataset should become a valuable monitoring tool, especially for assessing response and mop-up with lightning-caused fires, in non-organic regions since it provides local estimates between weather stations.

Additional evaluation of temperature datasets may suggest a more accurate option than the daily PRISM data. If a daily relative humidity dataset was also found, gridded 100-hour and 1000-hour fuel moisture and ERC datasets could also be created to aid in routine fire risk monitoring.

This article originally appeared in the November 2015 (Vol 5, Issue 2) edition of Dry Times, the NIDIS newsletter. Access the entire article at: https://www.drought.gov/drought/what-nidis/nidis-news.

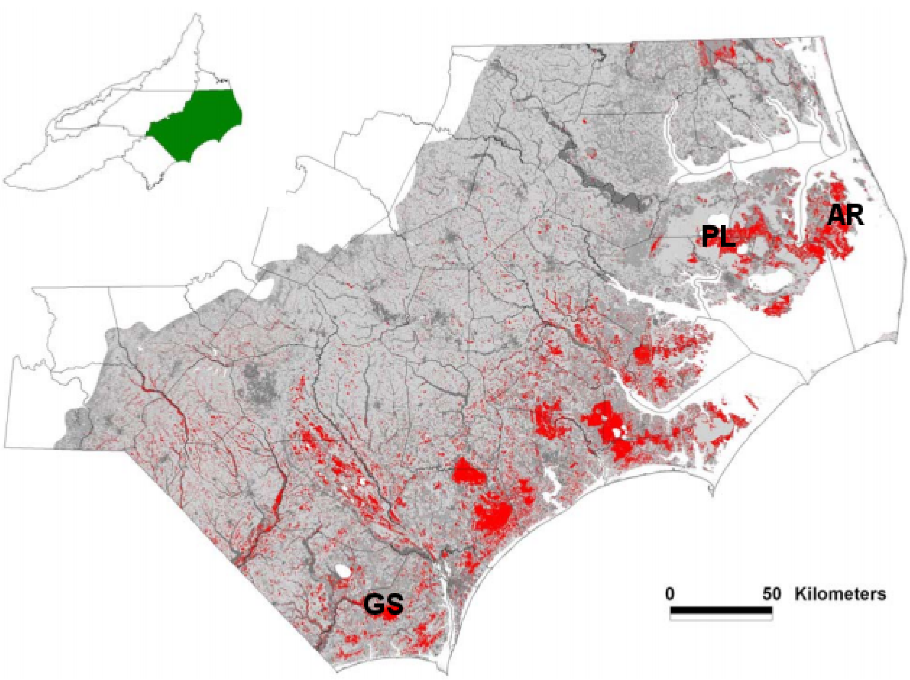

Figure 2: Organic soils in eastern North Carolina (in red, from NCGAP 1992) and ESP station arrays at Green Swamp (GS), Pocosin Lakes (PL), and Alligator River (AR).

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NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM
COASTAL CAROLINAS
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WHAT CAN CITIZEN SCIENTISTS TELL US ABOUT DROUGHT?

Using the CoCoRaHS Network to Improve Drought Monitoring and Reporting

BY AMANDA FARRIS
Carolinas Integrated Sciences & Assessments

Drought impacts data can be used to improve understanding of drought vulnerabilities and to develop and target strategies for drought response and mitigation. Online tools such as the national Drought Impact Reporter provide a valuable repository of drought impacts information. However, observers typically submit one-off impact reports, when drought conditions are severe or extreme, rather than report on a consistent basis which would allow for a better understanding of how and when drought impacts emerge and evolve.

In collaboration with the National Integrated Drought Information System (NIDIS), the National Drought Mitigation Center (NDMC), and the Community Collaborative Rain, Hail & Snow (CoCoRaHS) network, the Carolinas Integrated Sciences and Assessments (CISA) developed an experimental method of drought monitoring and reporting by citizen scientists. This new method of condition monitoring encourages CoCoRaHS volunteers to submit regular reports about the effects of local precipitation on the environment and society, creating a baseline against which to assess change through time (i.e., seasonally, with varying levels of precipitation). It also allows for assessment of the impacts of wet as well as dry conditions, which can help with flood hazard mitigation and other water-related impacts.

SAMPLE CONDITION MONITORING REPORTS

"Happy Leap Year! 2016 is off to a great start. We received 0.21" of rain this past week, and while the last 2 or 3 weeks have been a little shy for rain, we still managed to beat our average rainfall for the area by 0.31". Lagoons are still high and draining, there is still moisture in the soil of the garden, and spring is coming!"
Beaufort, SC, February 29, 2016

"A thunderstorm last night dropped almost a half inch of rain on us in a very short time but there was almost no run-off because the dry ground sucked up the moisture as it fell. The pond level continued to fall this week and is now almost a foot below normal. The pond water has a murky appearance with algae floating on about half of the surface. The water in the stream is clear and small fish dart about in it, however there is very little water flow from upstream."
Wake County, NC, June 19, 2015

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CISA
Carolinas Integrated Sciences and Assessments
A NOAA RISA TEAM

National Drought Mitigation Center

CoCoRaHS
Community Collaborative Rain, Hail & Snow Network

MORE INFORMATION can be found at www.cisa.sc.edu/CoCoRaHS.html.

CONTACT Amanda Farris at afarris@sc.edu.

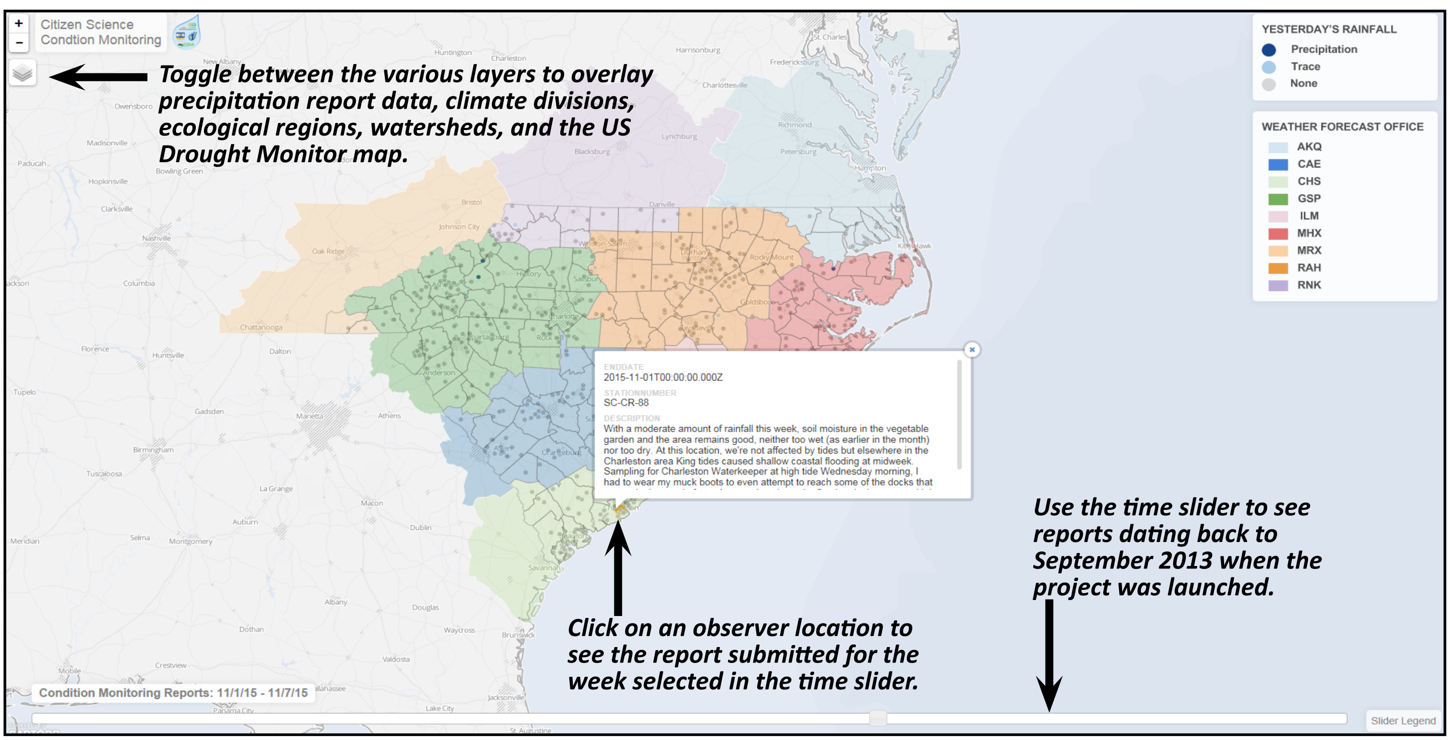
Between September 13, 2013 and December 31, 2015, CoCoRaHS observers in the Carolinas submitted 1,572 reports condition monitoring reports. CISA researchers analyzed report content according to drought impact categories and other variables of interest, such as spatial scale.

Interviews were conducted with representatives from the North and South Carolina state climate offices and drought committees, the CoCoRaHS national office, the National Drought Mitigation Center, National Weather Service Weather Forecast Offices, and county-level soil and water conservation districts. From these interviews, CISA researchers learned how the information might be incorporated into drought monitoring and related decision making. Feedback revealed that, although the qualitative reports are perceived as useful, there is a need for improved accessibility to the information and a quantitative metric to more quickly assess changing conditions.

This has led to a revised reporting format which includes a quantitative metric to supplement the qualitative reports. Observers select from one of seven categories indicating how wet or dry conditions are in their area.

Additionally, a web map has been developed to spatially display reports in conjunction with other decision-relevant information (e.g., precipitation measurements, current US Drought Monitor map, etc.).

Left: Drought decision makers, CoCoRaHS observers, and computer-use experts were consulted in determining the type of scale bar to develop (radio buttons vs. sliding scale) as well as the appropriate number of categories to represent levels of wet and dry conditions. Ultimately, it was determined that seven categories provide the appropriate balance to allow for clear choices for the observers as well as useful information for decision makers. Links to guidance documents are also provided on the report form as additional support for observers in selecting the most representative category on the scale bar and entering useful information in the description box.



Above: The interactive web map allows users to view condition monitoring reports by clicking on the observer location. The observer location is represented by a dot of the same color as the level of wetness or dryness selected for that week's condition monitoring report. A time slider at the bottom of the screen provides access to the reports in one week increments. Users can toggle between layers to view additional layers of precipitation data, the US Drought Monitor map for the selected week, or geographic boundaries such as counties.

Access the Web Map

www.cisa.sc.edu/webmap

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

COASTAL CAROLINAS

DROUGHT EARLY WARNING SYSTEM

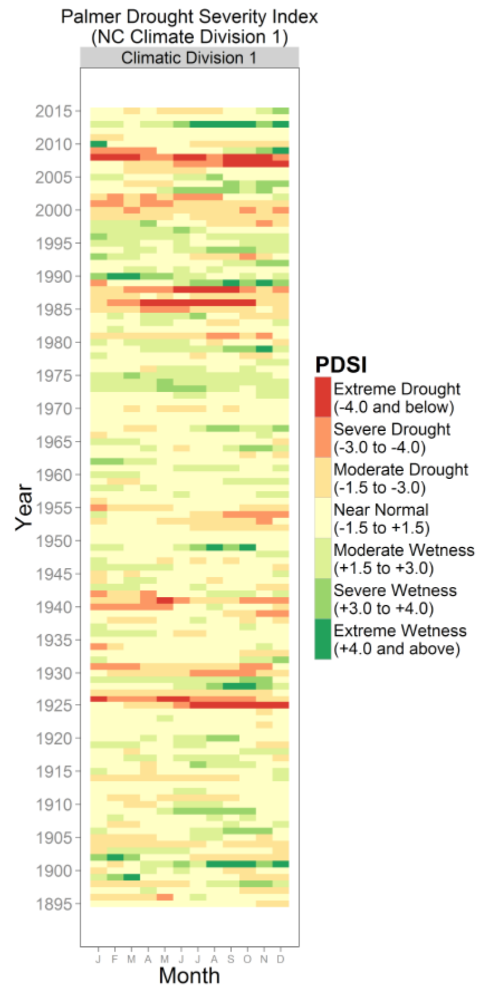
Developing a Hydroclimate Extremes Atlas for the Carolinas

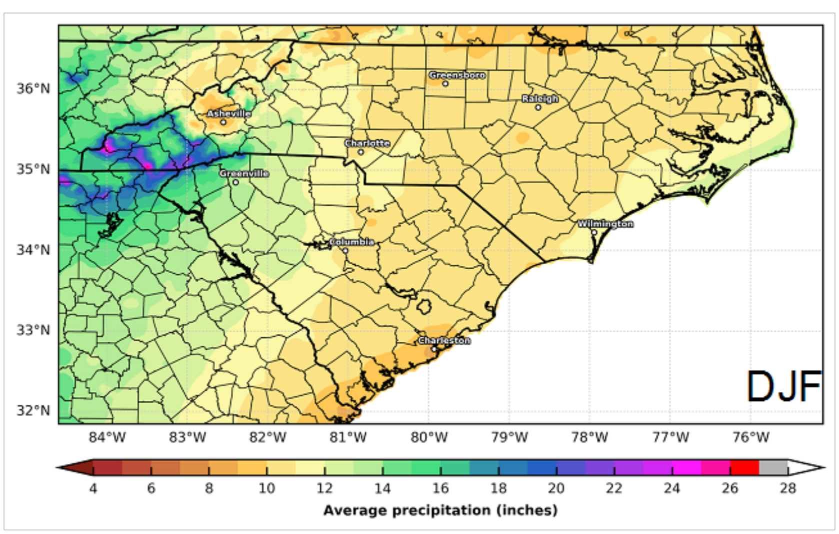
BY GREG CARBONE
Carolinas Integrated Sciences & Assessments

The Carolinas Integrated Sciences and Assessments (CISA) team is creating a digital atlas of hydroclimate extremes in the Carolinas. The atlas will complement existing information sources on extreme precipitation (e.g. NOAA's Atlas 14) and drought (e.g., products from the National Drought Mitigation Center). It will include maps and figures characterizing various measures of precipitation, drought, and the water balance. Some of the drought indices are those used operationally by resource managers, others are new, or offer spatial or temporal resolution not readily available from other sources. The atlas will allow users to explore probability distributions and recurrence intervals for a large number of stations across the Carolinas by season. It will integrate station and regional products, and photographs, videos, and narratives of drought and heavy precipitation events.

Visual Display of Published Data

Some parts of the atlas will map or graph existing data sets. For example, NOAA's National Centers for Environmental Information and other sources contain raw precipitation data and a suite of indices at the climate division level. Seasonal and annual average precipitation values are mapped for the Carolinas, with precipitation statistics for 135 individual stations. The map below shows long-term average winter (Dec-Feb) rainfall. We have also created graphics to display time series for commonly-used drought indices since1895. Among them, the Palmer Drought Severity Index (PDSI), the standardized precipitation index (SPI), and the Palmer Hydrological Drought Index (PHDI) are shown on this handout. The example to the right shows a heat map for the PSDI time series in North Carolina, Climate Division 1.





CISA
Carolinas Integrated Sciences and Assessments
A NOAA RISA TEAM

CISA participants include: Karen Beidel, Greg Carbone, Kirstin Dow, Amanda Farris, Chip Konrad, Kirsten Lackstrom, Junyu Lu, Jordan McLeod, and Aashka Patel.

MORE INFORMATION can be found at http://www.cisa.sc.edu/projects_nidis.html

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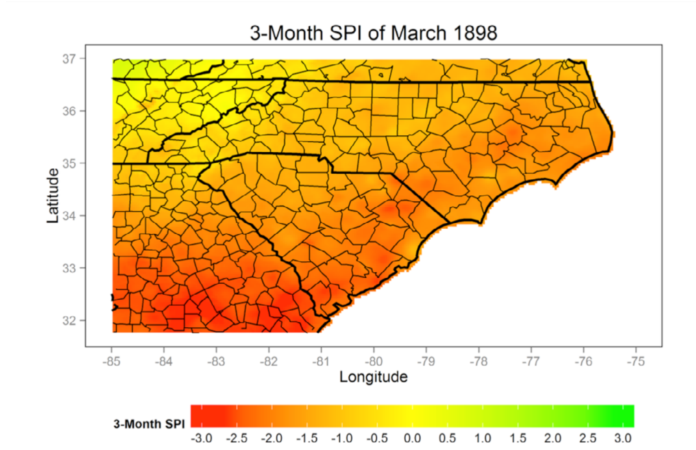
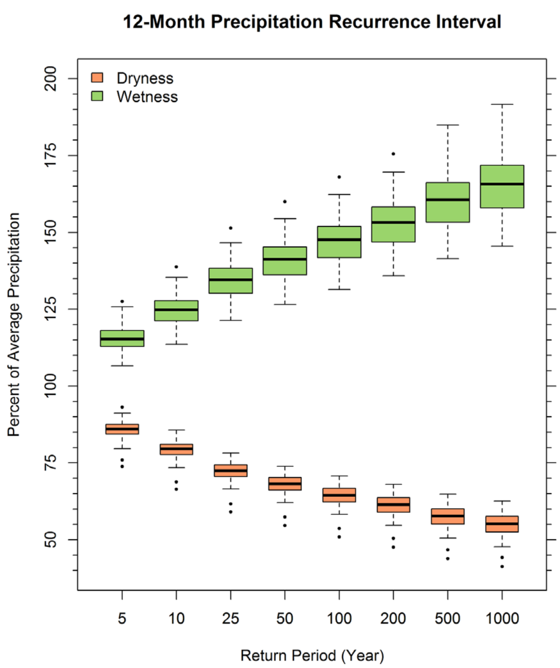
Calculation of Indices for Stations and Grids

To supplement published data, indices have been calculated at different spatial and temporal scales. For example, SPI time series have been created for 135 stations with records of at least 60 years. In addition, we have created SPI-1 to SPI-24 maps from the monthly, 4-km gridded PRISM precipitation data (1895-2015).



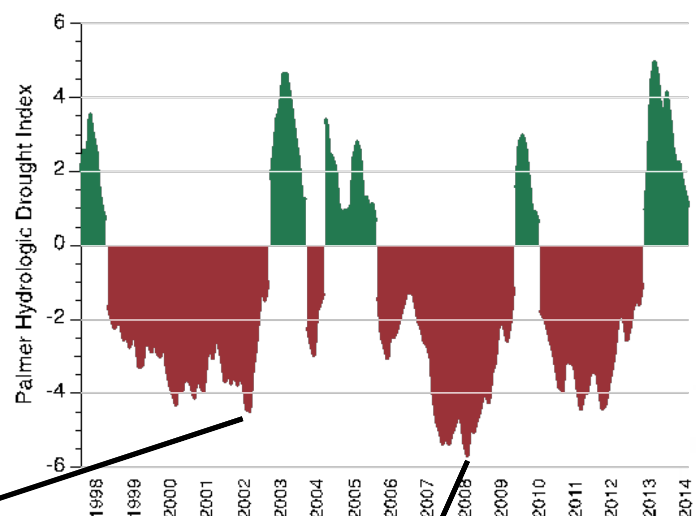
Recurrence Intervals

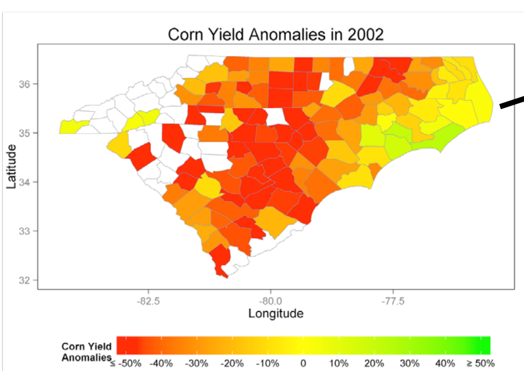
Maps and graphics will show the duration and frequency of wet and dry events at individual stations and the spread across all stations. As an example of the spread, this figure shows that in any given year, there is a 1 in 1000 (0.1%) chance that the previous 12-month precipitation total will be approximately 165% of the long-term average with higher and lower percentages at individual stations.



Impacts

The atlas will link graphics of hydroclimate anomalies with statistical measures of impacts. Below (left) are maps depicting a scaled drought index and consequent corn yield during the 2002 drought. The atlas will also use a series of photos, videos, and newspaper accounts to show various intense droughts and floods.





What is a Drought Early Warning System (DEWS)?

A NIDIS DEWS utilizes new and existing partner networks to optimize the expertise of a wide range of federal, tribal, state, local and academic partners in order to make climate and drought science readily available, easily understandable and usable for decision makers; and to improve the capacity of stakeholders to better monitor, forecast, plan for and cope with the impacts of drought.

What is the Coastal Carolinas DEWS?

A diverse group of stakeholders convened in August 2012 in Wilmington, NC, to identify issues of concern about drought in the coastal regions of the Carolinas. Out of the meeting came the Coastal Carolinas Drought Early Warning System, a collaborative federal, state, and local interagency effort to improve early warning capacity and resilience to drought. CC DEWS activities focus on improving the understanding of drought's effects on coastal environmental resources and developing information to enhance drought monitoring and planning processes.