SOUTHERN CLIMATE IMPACTS PLANNING PROGRAM

ANNUAL REPORT

JUNE 2017- MAY 2018

SCIPP
A NOAA RISA TEAM

RISA
Regional Integrated Sciences and Assessments

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The Southern Climate Impacts Planning Program (SCIPP) is a south central United States focused climate hazards and research program whose mission is to increase the region's resiliency and level of preparedness for weather extremes now and in the future. The area we serve includes the 6-state region of Oklahoma, Texas, Arkansas, Louisiana, Tennessee, and Mississippi. From severe storms, flooding, drought, hurricanes and storm surge, heat waves, wildfires, to winter storms, the South experiences among the nation's most extensive collection of climate-related hazards with many southern states ranking at or near the top of the lists in disaster declarations and billion-dollar disasters.

SCIPP Phase II was funded on award NA13OAR4310183. For the past three years, our annual performance report has been submitted under the title "Southern Climate Impacts Planning Program (SCIPP) Phase II" and has been accepted.

The SCIPP Team

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New Areas of Focus or Partnership

The following represent the areas of focus or partnerships (in bold) that SCIPP began in the past year, including a brief description of the questions and/or issues the team is working to address.

Dr. Michael Hayes is a member of a **Science for Nature and People Partnership (SNAPP) Ecological Drought Team**. This team published an article on developing a conceptual definition of ecological drought in the *Bulletin of the American Meteorological Society* during the past year (Crausbay et al. 2017).

Rachel Riley and Leah Kos participated in the **Oklahoma City Community Foundation (OCCF) Central Oklahoma Hazard Resiliency Project Hazard Mitigation Focus Group.** Through their involvement, Riley and Kos provided recommendations for hazard mitigation projects that could be implemented in low-income areas of Oklahoma City with funding available from OCCF. Their expertise was sought by the focus group's organizing leader.

Dr. Michael Hayes participated in a drought planning summit sponsored by the National Drought Mitigation Center (NDMC), the **American Planning Association** (APA), and the National Integrated Drought Information System (NIDIS) held in Lincoln, NE, in December 2017. Subsequently, he worked with NDMC and the APA to develop a drought planning survey that was administered to approximately 40,000 APA members during Spring 2018 and received 1,833 responses. Survey analysis is in progress.

Rachel Riley and Leah Kos presented the *Simple Planning Tool for Oklahoma Climate Hazards* to the **State of Oklahoma Hazard Mitigation Team** in March 2018. They were invited to speak as a direct result of their initiative to get planners and emergency managers to collaborate and improve hazard mitigation planning and implementation across the state.

Vincent Brown worked closely with meteorologists from the NWS Lower Mississippi River Forecast Center on a case study about the August 2016 flooding event in Baton Rouge, LA, and **how antecedent soil moisture conditions may have influenced the flooding.**

LSU researchers partnered with the **U.S. Department of Energy** on a grant regarding Big Data Analytics. The grant funds the development of a Voyage Planning Analysis Tool (VPAT) to enhance inland water transportation in the U.S. and involves the prediction of river stage information for optimal loading of barges and inland marine vessels.

SCIPP began a new project with the U.S. Department of Agriculture Southern Plains Climate Hub and the University of Oklahoma, focusing on the wildfire events that occurred in the Southern Plains during 2016 and 2017. This **2016-2017 Kansas and Oklahoma Wildfire Assessment** aims to engage stakeholders across western Kansas and the Oklahoma and Texas panhandles to assess their impacts and current recovery statuses from the recent fires and help increase their adaptive capacity to reduce wildfire risk in the future. A facilitated regional workshop occurred in Beaver, OK in February 2018 and planning is underway for follow-up town hall meetings across the affected areas to further assess stakeholder needs.

Dr. Michael Hayes is serving on the advisory committee for a NOAA grant investigating the incorporation of drought into **FEMA's Threat and Hazard Identification and Risk Assessment (THIRA)** process.

Vincent Brown worked with the **Experimental Statistics Department at LSU** over the past year on several experimental methods and tools. They may be a partner on several future peer-reviewed publications.

SCIPP's Climate Assessment Specialist is one of three individuals currently focused on sustained assessment work within the RISA program. Involvement with this core group, the **Sustained Assessment Specialist (SAS) Network**, along with the national sustained assessment vision, increased considerably in 2017. Communication increased between the individuals of the SAS network through developing recommendations for ideal Sustained Assessment Specialist duties, as well as a one-pager on the importance of the network. National efforts on building a sustained assessment process have continued, including stressing the importance of regional assessment work. Additionally, there are now quarterly calls between individuals of NCA, NOAA and USGCRP, and the SAS network is currently working on a cross-RISA collaborative project focused on assessment case studies.

Dr. Barry Keim is working on a study to determine **Probable Maximum Precipitation (PMP) for the States of Louisiana, Mississippi, Arkansas, and Oklahoma**. PMP is the theoretical upper limit of the atmosphere to produce rainfall, and it is estimated for durations of hours up to 5 days. The express use of this information is for the construction and remediation of dams across the region. The current PMP estimates come from a document called Hydrometeorological Report (HMR) 51. It is generally believed that HMR 51 tends to overestimate PMP values, which resulted due to limited understanding of extreme storms when the document was produced in 1978. For example, Mesoscale Convective Systems and Complexes were not understood at all at the time, and they produce some of the heaviest rainfall events ever recorded across the Great Plains and Midwest. Due to our increasing knowledge of severe rainfall events, meteorologists are in a better situation to know where certain storm types can and cannot occur. As such, revisiting PMP estimates across our region may lead to reductions in the rainfall magnitudes for certain regions, which could potentially lead to tens of millions of dollars in savings in dam construction and unnecessary dam remediation on a single dam. Keim is collaborating with the **Arkansas Natural Resources Commission-Dam Safety and Floodplain Management Section**, as well as the **Louisiana Department of Transportation-Dam Safety Program**.

Figure 1: Louisiana dams, such as the one above, may benefit from PMP estimates through the reduction of construction costs of both building and repairing dams under new, lower rainfall magnitudes.

Oklahoma: Simple Planning Tool for Oklahoma Climate Hazards

SCIPP developed the *Simple Planning Tool for Oklahoma Climate Hazards* in response to feedback from emergency managers and city planners across Oklahoma who expressed that locally-relevant hazard data is difficult to find and/or it is unknown in which data or what organizations to trust. SCIPP staff Rachel Riley and Leah Kos used this information in addition to other initial feedback from the first meeting in March 2017 to create a template for a tool that would improve this problem, the *Simple Planning Tool* (SPT). The SPT is a compilation of relatively easy-to-use online interactive tools, maps, and graphs to assist planners and emergency managers in the state of Oklahoma who are assessing their long-term climate risks, both historically and in the future. It aims to cut through the internet clutter and point to relatively simple climate data tools that can be used during planning processes and in plans. It includes instructions for how to use online data tools for 10 climate hazards and two other natural hazards. Each hazard section also contains a data limitation summary to help users apply the data in accurate and responsible manners. Finally, each hazard section contains a concise summary of the state-of-the-science on whether the hazard is projected to be influenced by climate change and if so, how, specifically across Oklahoma. Riley and Kos carefully vetted available online climate data tools and only included those they thought someone with little to no background in climate data could use. In a few cases, Riley and Kos partnered with the individuals at the NWS Storm Prediction Center and the University of Oklahoma Cooperative Institute for Mesoscale Meteorological Studies to provide updated or additional analyses not already available.

The Oklahoma version of the tool was released in April 2018 and is available on the SCIPP Website at http://www.southernclimate.org/documents/SPTOK.pdf. Following this release, work has begun on developing a similar tool for Arkansas.

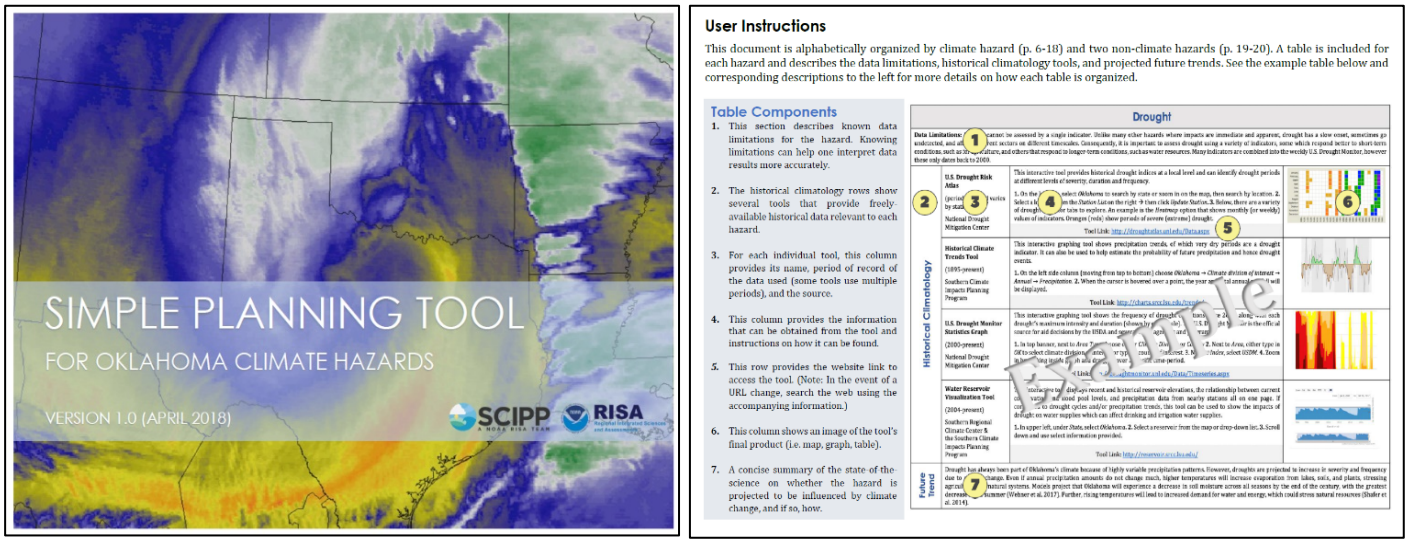

Figure 2: Cover of the Simple Planning Tool for Oklahoma Climate Hazards (left) and instructions for how to use the tool, including a description of how each of the hazard sections are organized (right).

Texas and Louisiana: Real-Time Storm Surge and Rainfall Trackers

Texas and Louisiana have benefitted from the implementation of a live storm surge tracking tool produced by SCIPP and the Southern Regional Climate Center (SRCC). Using data from NOAA, the tool displays storm surge values as tropical cyclones approach the coast and move inland. Data are displayed on a graph that allows users to visualize storm surge at many locations through time, so they can examine the progression of surge along the coast.

At the request of the Louisiana Department of Health (LDH), SCIPP and SRCC also built a tool to track rainfall totals due to landfalling tropical cyclones. LDH uses the tool to assess freshwater runoff from these storms. This runoff can transport pollutants and lead to contamination of oysters, which can pose a risk to health if consumed. Archived storm surge and rainfall tracker maps are available at http://surge.srcc.lsu.edu.

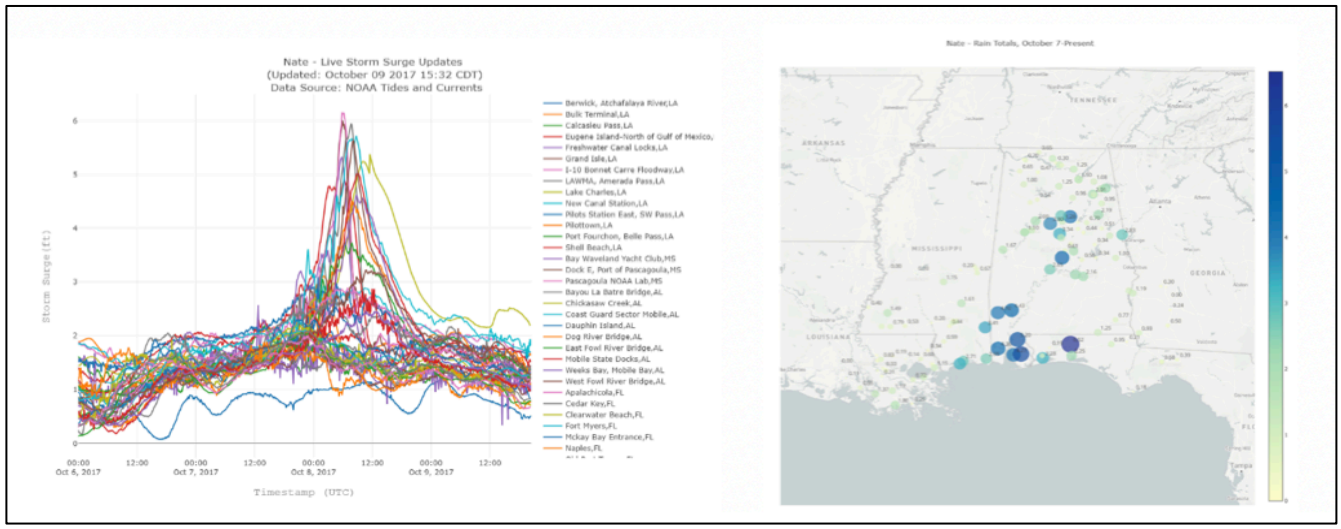

Figure 3: Example of a real-time surge graph during Hurricane Nate in October 2017. Users can toggle individual locations on and off as desired (left), and an example of the rainfall tracking map during Hurricane Nate in October 2017 (right).

Greatest Accomplishment

SCIPP is proud that our relationships with several influential emergency management (EM) and city planning colleagues have grown from being acquaintances to established colleagues. This accomplishment is worth highlighting because reaching this level with a decision maker is not trivial given the various demands and constraints of job duties. The established relationships have been demonstrated through decision maker initiations of conversation and requests for information. Examples of this include a large city EM suggesting that SCIPP submit an article for publication in the *International Association of Emergency Management Bulletin*'s August 2018 special issue on climate change, the OK EM Association president assisting SCIPP staff in securing a spot on the agenda at their annual conference to showcase the OK SPT and discuss hazard mitigation options, an EM asking SCIPP to join the OCCF Central Oklahoma Resiliency Project Hazard Mitigation Focus Group, the OK Chapter of the American Planning Association president notifying us of their chapter award nomination process, and the Oklahoma State Hazard Mitigation Officer inviting us to introduce the SPT to state hazard mitigation team members. The aforementioned relationships are built on trust, mutual goals of reducing disaster risk and vulnerability, and the foundational acknowledgement that no single discipline has sufficient expertise to solve the problems we are working to address.

Measuring Program-Level Impact

SCIPP implemented stakeholder interaction tracking over the past year to aide in understanding program-level impact. Seven SCIPP staff members tracked details of their engagement with external individuals or groups. The details included date(s) of contact, stakeholder name, affiliation and sector, mode of contact, who initiated contact (stakeholder or SCIPP), the propose of the contact, duration of the engagement, and details of the engagement. The tracking form was adopted from the Western Water Assessment RISA team. Over the past year RISA has been developing consistent evaluation metrics and over the next year, SCIPP plans to formalize an evaluation methodology for its team. The tracking form was a step that had not previously been taken to understand the number and type of stakeholders with whom SCIPP is interacting and the outcomes of those interactions. Other ways program-level impact is measured is through Twitter and Facebook, which are used opportunistically to push out information. Online tool statistics are also occasionally reviewed through our partnership with SRCC. Unfortunately, we do not have the capability to track downloads of individual documents such as major reports or the Simple Planning Tool.

The infographic below showcases some of the results from the aforementioned stakeholder interaction tracking, social media presence, and web hits over the reporting period for three tools that were developed in collaboration with SRCC several years ago including SURGEDAT storm surge tools, the Southern U.S. Drought Tool and the Water Reservoir Data Visualization Tool.

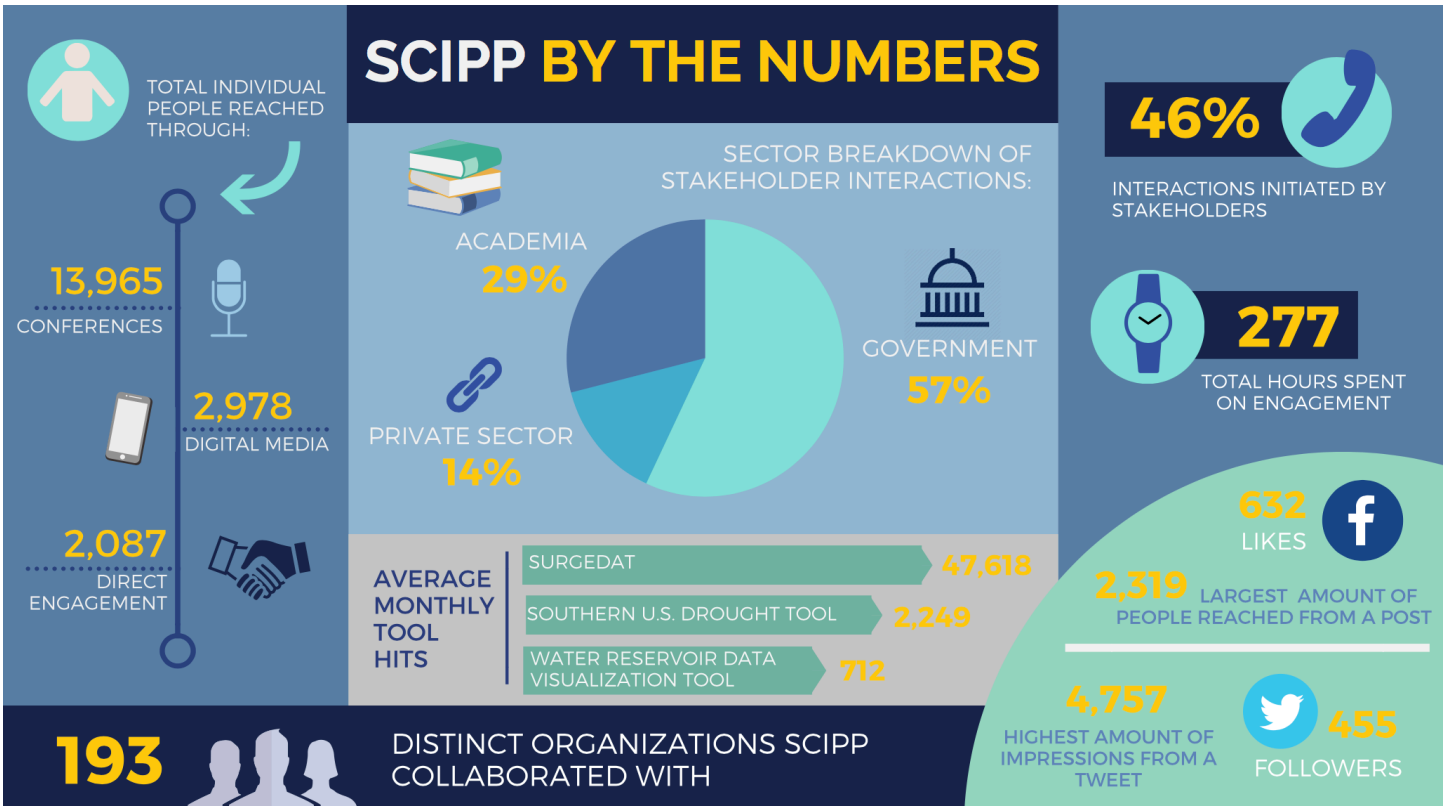

Figure 4: Infographic representing SCIPP's engagement over the reporting period.

Building Expertise

Emergency Managers and Planners: The advancing initiative with emergency managers and planners in Oklahoma and Arkansas has provided SCIPP the opportunity to communicate climate data and adaptation strategies to stakeholders, aiding in the increase of capacity during a changing climate. Through the recent outreach events in both states by Rachel Riley and Leah Kos, awareness of the current and future regional climate trends as well as climate adaptation practices was increased, and SCIPP's facilitation of roundtable discussions encouraged stakeholders to examine adapting similar practices. Ultimately this discussion led to the suggestion of the Simple Planning Tool, a practical solution to the problem of climate data overload or unawareness. Conversations with decision makers in each state continue to build capacity on understanding the implications of a changing climate and the actions needed for future decision-making in the South Central U.S.

Louisiana State Hazard Mitigation Plan: SCIPP team members at Louisiana State University have been involved in the recent revision of the Louisiana State Hazard Mitigation Plan. Barry Keim, Alan Black, and Vincent Brown provided input on the Hazard Mitigation Plan, especially in terms of atmospheric hazards and how those hazards may change under future climate conditions. This effort will impact all of Louisiana because the state hazard mitigation plan is the basis for all local hazard mitigation plans.

Climate Variability and Change: Dr. Barry Keim delivered several presentations across Louisiana regarding climate variability and change across Louisiana and along the Gulf Coast, as well as both weather and climate impacts and how they affect the region. Many of these organizations went on to use the information to inform their research and productions. Notable audiences over the past year included the Annual Meeting of the Coasts, Oceans, Ports, and Rivers Institute in Baton Rouge, LA, the Louisiana Agricultural Industries Associate Annual Meeting in Marksville, LA, and the Inland Marine Underwriters Association Annual Meeting in Braselton, GA.

Physical Processes of Climate Change: Vincent Brown engaged with various groups to help them understand the physical processes of climate change and potential impacts. Those groups included Geosyntec Consultants, civil engineering students at Louisiana State University, the agricultural industries, and attendees of the Louisiana Smart Growth Summit.

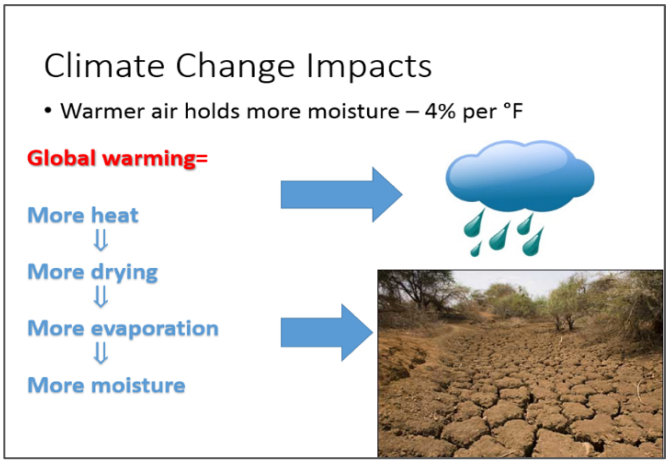

Figure 5: One example of how SCIPP communicated climate change information over the past year.

Central Gulf Coast Rainfall is More Intense Than Elsewhere in the Southeast U.S.
Investigators: Vincent Brown, Alan Black, Barry Keim

Precipitation across the Southeast United States varies substantially from year-to-year. In 2007 an extreme drought struck the region followed by excessive rainfall and flooding in 2009, both of which caused catastrophic economic loss (Manual 2008; Gotvald and McCallumm 2010). This inherent variability has a large effect on the hydrologic cycle and small shifts in the amount, timing, intensity, and duration of precipitation can impact runoff, soil moisture, and crop yields across the region (Karl and Riebsame 1989). Total accumulation, which represents a combination of rainfall characteristics, is often used to quantify precipitation. Total accumulation is vital for agriculture, fresh water resources, and water availability, but it omits a large portion of the precipitation story, such as cause, type, frequency, duration, and intensity. This study creates a climatology of hourly precipitation (1950-2017) to better understand the characteristics of rainfall across the Southeast United States. To date, no such climatology exists, and only recently has work been started on rain day climatology. In particular, this research focuses on the number of hours with precipitation (frequency), duration of events, intensity, and amounts.

Initial results show that the locations which accumulate the most precipitation annually do not experience the greatest number of hours of precipitation. Figure 6 shows that locations in eastern Tennessee and southwestern North Carolina experience the greatest number of hours with precipitation annually, but locations along the Gulf Coast (Louisiana, Mississippi, Alabama, Florida) tend to accumulate more precipitation. An exception can be seen in southwestern North Carolina where orographic lift induces totals over 90 inches annually. Nonetheless, the analyses revealed that precipitation along the Gulf Coast tends to be more intense (fewer hours with more accumulation) compared to other parts of the Southeast. Seasonal differences are pronounced, however.

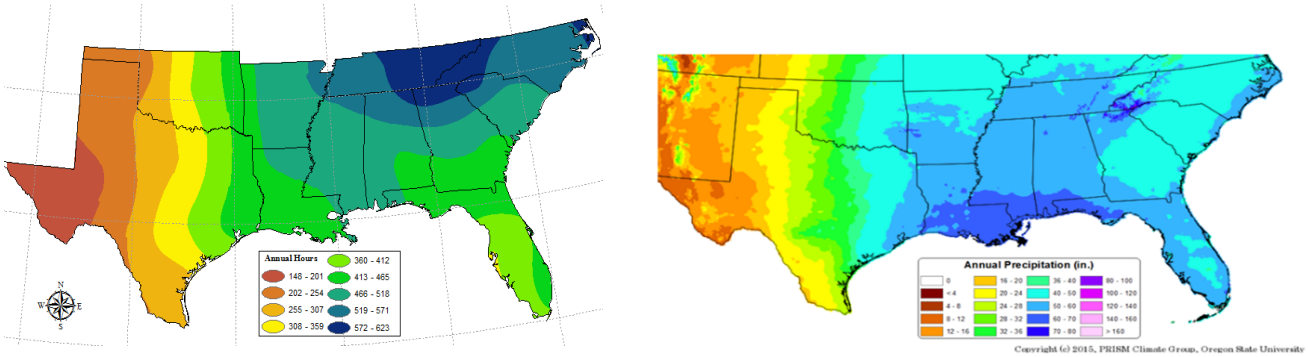

Figure 6: Annual average number of hours with precipitation (left) and 30-year average annual precipitation (right).

During the winter (DJF) (Figure 7; top) the maximum number of hours of precipitation again occurs in eastern Tennessee and southwestern North Carolina and the minimum occurs in western Texas, Oklahoma and southern Florida. The minimum in southern Florida aligns well with the lack of accumulation observed, which is related to a shift in storm tracks. However, a majority of the accumulation in the winter across the Southeast is focused near Louisiana and Mississippi, close to but not where the most hours occur. This demonstrates that precipitation is more intense across those states during the winter as well. Finally, during the summer (JJA) (Figure 7; bottom) the maximum number of hours of precipitation shifts to coastal locations along the Gulf and Atlantic. This lines up well with where the most rainfall accumulates. The maximum in both hours and accumulation is

caused by summertime convection, aided by moisture from the Atlantic Ocean and Gulf of Mexico. Tropical cyclones also play a role in the accumulations seen along the Gulf coast. Future research will highlight the duration and diurnal patterns of precipitation events across the Southeast, as well as how large-scale climate oscillations influence sub-daily precipitation characteristics.

Results of this research will be shared with NWS Weather Forecast Offices and River Forecast Centers. This research improves scientific understanding of hourly precipitation and could lead to better flood forecasting.

References:

Gotvald, A.J. and B.E. McCallum, 2010. Epic Flooding in Georgia, 2009. US Geological Survey Fact Sheet 2010-3107, 2 pp.

Karl, T.R. and W.E. Riebsame, 1989. The Impact of Decadal Fluctuations in Mean Precipitation and Temperature on Runoff: A Sensitivity Study Over the United States. *Climatic Change*, 15(3), 423-447.

Manuel, J., 2008. Drought in the Southeast: Lessons for Water Management. *Environmental Health Perspectives*, 116(4), p. A168.

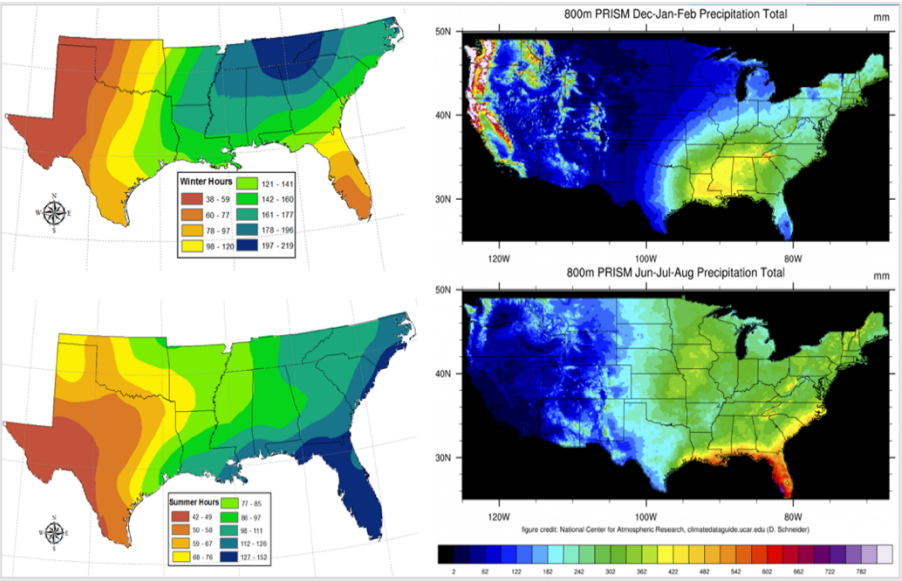

Figure 7: Annual average number of hours with precipitation for the winter (top left) and summer (bottom left) and 30-year average annual winter (top right) and summer (bottom right) accumulation.

Southeast Louisiana Precipitable Water Record Exceeded During August 2016 Storm

Investigators: Vincent Brown, Alan Black, Barry Keim

Louisiana is the wettest state in the conterminous United States according to data from the National Centers for Environmental Information and frequently experiences flood-producing rainfall events. Despite a long and colorful history of heavy rainfall events, Louisiana recently experienced a record breaking precipitation event on August 10–14, 2016 that shattered numerous meteorological and hydrological records. A remarkable 31.39 inches of precipitation was recorded at one location in just 48-hours, spurring widespread flooding that cost the state of Louisiana billions of dollars. This research seeks to place this storm in a historical context by examining rainfall amounts and corresponding annual exceedance probabilities using the Storm Precipitation Analysis System (SPAS) and describing the meteorological characteristics that assimilated to produce such a rare event.

Initial results reveal that the storm was able to make use of record precipitable water levels to generate hours of unremitting rainfall. In fact, at Slidell, Louisiana, roughly 40 km northeast of New Orleans and on the northeast side of Lake Pontchartrain, a radiosonde observation (Figure 8, left) showed a precipitable water value of 73.63 mm (2.898 in.) on August 12th, higher than the previous all-time record at Slidell of 73.15 mm (2.88 in.). The Baton Rouge Ryan Metropolitan Airport experienced 48 consecutive hours of thunderstorms and moderate/heavy rainfall (starting at 19z on August 11th).

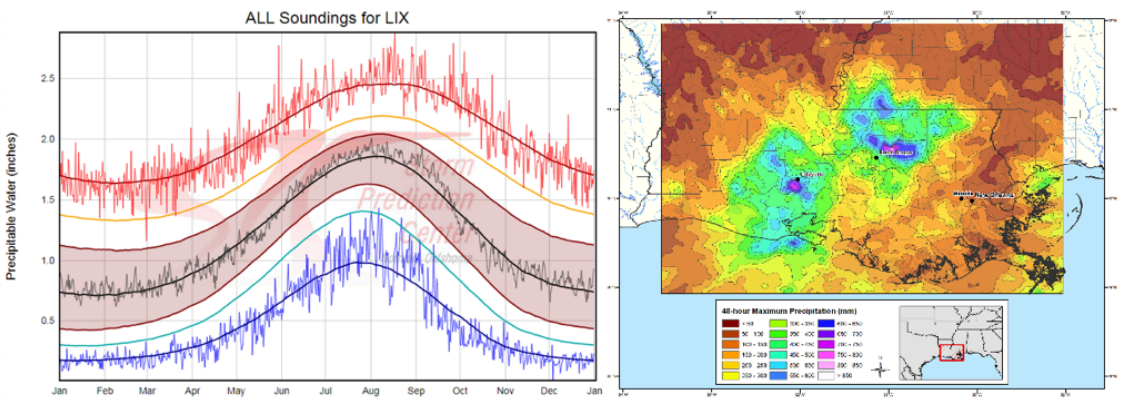

Figure 8: Precipitable water climatology from Slidell, Louisiana. The point from August 12th, 2016 is off of the chart (not depicted), demonstrating how high moisture rich the atmosphere column was prior to and during the event (left), and 48-hour maximum rainfall from SPAS (right).

Using SPAS, 48-hour maximum rainfall maps were generated depicting the greatest 48-hour rainfall accumulation for locations during the duration of the storm (figure 8, right). Two zones of immediately stand out, northeast of Baton Rouge and south of Lafayette. These locations received upwards of 700 mm (27.5 in.). To put these amounts in a historical context, annual exceedance probabilities were also generated using SPAS (figure 9). This map shows the areas northeast of Baton Rouge and south of Lafayette received maximum 48-hour rainfall amounts exceeding the expected 1 in 1000-year event, or a probability of less than 0.001% in any given year. These accumulation and exceedance probability maps were generated for 6, 24, 48, and 72 hours and for total storm duration. Hourly data were also produced and displayed in mass curves. This type of analysis helps in understanding the spatiotemporal patterns of rainfall and the meteorological factors that aligned to produce such historic amounts of precipitation.

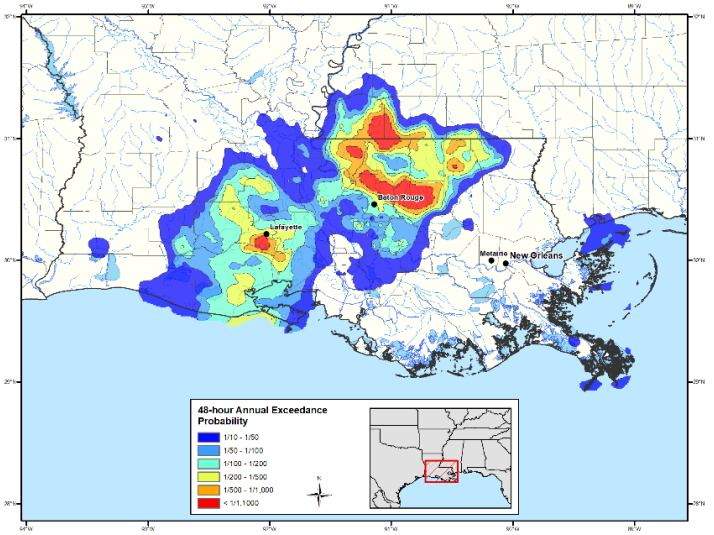

Figure 9: 48-hour annual exceedance probabilities generated from SPAS.

The results of this research have been communicated to various stakeholder groups in Louisiana such as the Ascension Parish Council, the Amite River Basin Commission, and the LSU Center for River Studies. The research improves scientific understanding of the event which may lead to better preparedness and mitigation efforts that could reduce the impact of future events.

Visual Drought Index Shows Drought Impacts Are Not Well Captured by Either U.S. Drought Monitor or Other Drought Indicators

Investigators: Darrian Bertrand, Gina Fujan, Mark Shafer, Henry Reges, and Nolan Doesken

The Visual Drought Index categorizes photos received in the Field Photos Weekends project by the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) and SCIPP. CoCoRaHS and SCIPP engaged citizen scientists to periodically submit photos of their landscape during Memorial Day, Labor Day, Independence Day, and Presidents Day weekends beginning in 2012. With funding by NOAA SARP, these photos were categorized by landscape type (grasslands, croplands, forests, deserts, and water bodies) and by region. The photos indicate severity from no drought to exceptional drought, similar to the way in which the Enhanced Fujita scale was constructed for tornado damage severity.

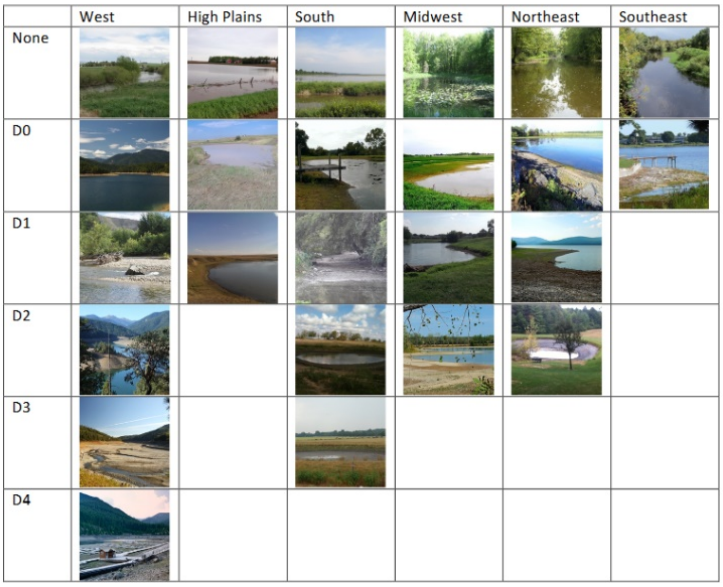

Figure 10: Example of the visual drought index created for water bodies, based on the submissions received.

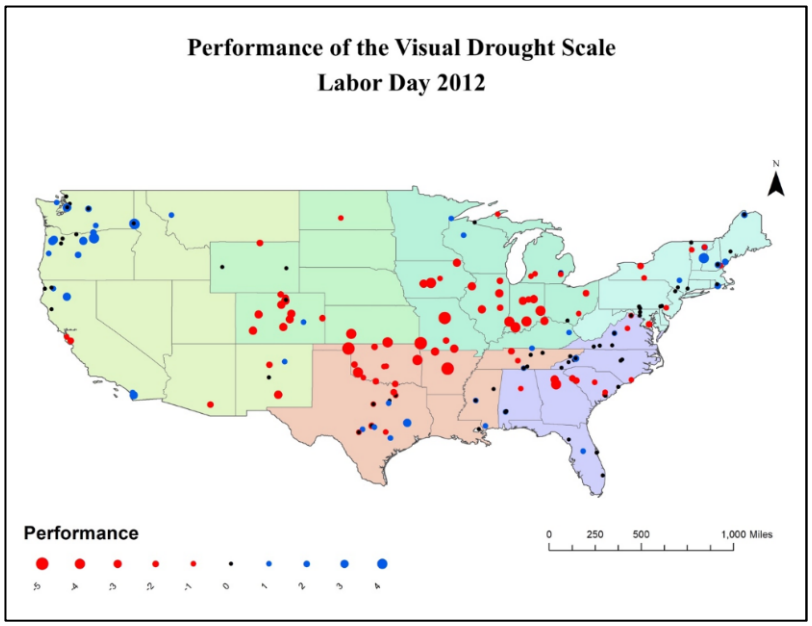

Figure 11: Performance of the Visual Drought Scale for Labor Day Weekend in 2012, based on the submissions received.

The Field Photos project collected more than 8,000 landscape photos. Each photo was classified as good, useful, or not useful, with those labeled good showing clear images of the overall landscape. Each of the good or useful photos was then categorized by region and land cover type by event and compared to the U.S. Drought Monitor and other established drought indices at the time the photo was taken. Approximately 2,000 photos were deemed good or useful and included in the analysis. These photos were ranked according to visual appearance of impacts from D-nothing to D4, independent of the U.S. Drought Monitor or drought indices. Grasslands appeared to match U.S. Drought Monitor and indices most closely; water bodies in many cases were affected by factors beyond drought (such as human storage and use), croplands may have been irrigated, forests were slowly varying, and deserts were difficult to discern. The South and West regions compared more favorably to drought indices (PDSI and SPI) as compared to the U.S. Drought Monitor, which was a better performance indicator in the Northeast.

At the time of the project, there was too much variability between the Visual Drought Index values and the USDM to recommend the scale for public use. With more localized drought research and more participation in Field Photos Weekends, the scale could improve.

The U.S. Department of Agriculture and the Natural Resource Conservation Service have expressed interest in building off of the study.

The report, including example photos for each category and region, is available from the SCIPP website, http://www.southernclimate.org/documents/Visual_Drought_Index.pdf.

Outreach & Communication

Wildfire Assessment Project Outreach Events: SCIPP collaborated with the USDA Southern Plains Climate Hub and the Redlands Community College to host two events during this reporting period, including a preliminary listening session and a larger one-day forum focusing on recent wildfire events of 2016 and 2017 in the Southern Plains. The listening session was held in Fall 2017 in northwestern Oklahoma with key stakeholders across the region. The session focused on assessing the current interests of individuals impacted by wildfire as well as discussing a preliminary agenda for the upcoming forum. Subsequently, the Southern Plains Wildfire Forum was held on February 13, 2018 in the panhandle of Oklahoma in Beaver, OK (a location impacted by the March 6, 2017 wildfires). The forum drew over 100 local participants across western Oklahoma, western Kansas and the panhandle of Texas. This meeting facilitated the collaboration of participants and aimed to increase awareness and preparation of wildfire resiliency efforts. Focusing on the recent wildfire events in 2016 and 2017, the event included presentations and panel discussions covering topics such as common weather conditions associated with wildfire and future implications, impacts and recovery perspectives, and management strategies to reduce future wildfire risk. As the trend for larger and more intense wildfire events continue, this event was one way to assist locals in their planning efforts to reduce risk for future wildfire events. SCIPP will continue engagement by hosting town hall events in Oklahoma, Texas and Kansas, and further assess the impacts and management strategies to increase resiliency to wildfire now and in the future.

Figure 12: Attendees at the Southern Plains Wildfire Forum in February 2018 in Beaver, Oklahoma (left), and a wheat field in Forgan, Oklahoma during drought in February 2018 (right).

Texas Water Development Board Presentation: Mark Shafer was invited to present "Connecting Climate Information to Real Decisions" to staff at the Texas Water Development Board. The presentation focused on co-production processes and utilization of scientific research in operational contexts. Examples from SCIPP were highlighted and included SCIPP's work with developing a drought knowledge community, SCIPP's interaction with emergency management and planning, and several SCIPP tools.

Middle School Climate Change Expo: Mark Shafer participated in Irving Middle School's (Norman, OK) Climate Change Expert Expo in January 2018. The Expo introduced 230 7th grade students to causes and impacts of climate change. SCIPP's presentation included findings from the Great Plains Chapter of the 2014 National Climate Assessment and visualization of global temperature changes from NASA. Students used the information from the Expo to conduct semester-long projects in investigating various aspects of climate change.

Figure 13: Mark Shafer presenting climate change information to students at Irving Middle School in Norman, OK.

Media: Barry Keim participated in over 100 media interviews over the past year including to The Weather Channel, CNN, Bloomberg Report, La Nacion (Argentina), Portuguese National Radio, Climate Central, Louisiana Radio Network, Louisiana Public Broadcasting, WWL Radio-New Orleans, Times Picayune, Advocate, and Palm Beach Post, among others.

Metropolitan New Orleans-Hurricane Katrina Environmental Tour: Barry Keim gave the Metropolitan New Orleans-Hurricane Katrina Environmental Tour to several groups over the past year, including the South-Central Climate Science Center Summer Internship for Underrepresented Minorities, American Geophysical Union-Media, and at the annual meeting of the Association of American Geographers.


Figure 14: House on stilts in far southeast Louisiana, seen during Dr. Keim's tour.

Key Publications

Bertrand, D., 2017: Changing Fire Regimes and Management Strategies. Southern Climate Impacts Planning Program, 72 pp. Available online at http://www.southernclimate.org/documents/Changing_Fire_Regimes.pdf.

Fire is a natural and necessary component of the South Central Plains ecosystem. However, fire suppression and more frequent droughts in the region have resulted in a build-up of dry fuels loads such as dead wood, resulting in fires that burn hotter and impact the landscape more severely. Uncontrolled wildfires have cost the region several billions of dollars in the past five years. Further, fire suppression has resulted in substantial losses in native plant biodiversity and wildlife habitat, which also has costly implications. In Oklahoma alone, it's estimated that $157 million will be required to restore rangelands to their native conditions. Of further concern is the fact that projected changes in climate indicate that the region will continue to experience hotter and drier conditions, meaning that fire risks will continue to increase unless proper management strategies, such as prescribed fire, are implemented.

Keim, B. D., W. D. Kappel, G. A. Muhlstein, D. M Hultstrand, T. W Parzybok, A. B. Lewis, E. M. Tomlinson, and A. W. Black. In Press: Assessment of the Extreme Rainfall Event at Nashville, Tennessee and the Surrounding Region on May 1-3, 2010. *Journal of American Water Resources Association.*

This paper analyzes the May 1–3 2010 rainfall event that affected the South Central U.S., including parts of Mississippi, Tennessee, and Kentucky. The storm is evaluated in terms of its synoptic setting, along with the temporal distributions and spatial patterns of the rainfall. In addition, the recurrence interval of the storm is assessed and the implications for hydrologic structure designs are discussed. The event was associated with an upper-level trough and stationary frontal boundary to the west of the rainfall region, which remained quasi-stationary for a period of 48 hours. Heavy rainfall was produced by two slow-moving mesoscale convective complexes (MCC), combined with abundant atmospheric moisture. Storm totals exceeding 330 mm occurred within a large elongated area extending from Memphis to Nashville. Isolated rainfall totals over 480 mm were reported in some areas, with NEXRAD weather radar rainfall estimates up to 501 mm. An extreme value analysis was performed for 1- and 2- day rainfall totals at Nashville and Brownsville, Tennessee, as well as for gridded rainfall estimates for the entire region using the Storm Precipitation Analysis System (SPAS). Results suggest that maximum rainfall totals for some durations during the May 1–3, 2010 event exceeded the 1,000-yr rainfall values from NOAA Atlas 14 for a large portion of the region and reached up to 80 percent of the Probable Maximum Precipitation (PMP) values for some area sizes and durations.

McEvoy, J., D. Bathke, N. Burkardt, A. E. Cravens, T. Haigh, K. R. Hall, M. J. Hayes, T. Jedd, M. Poděbradská, and E. Wickham, 2018. Ecological drought: Accounting for the non-human impacts of water shortage in the Upper Missouri Headwaters Basin, Montana, USA. Resources, 7, 14, doi:10.3390/resources7010014.

Water laws and drought plans are used to prioritize and allocate scarce water resources. Both have historically been human-centric, failing to account for non-human water needs. In this paper, the development of instream flow legislation and the evolution of drought planning are examined to highlight the growing concern for the non-human impacts of water scarcity. Utilizing a new framework for ecological drought, five watershed-scale drought plans in southwestern Montana, USA were analyzed to understand if, and how, the ecological impacts of drought are currently being assessed. It was found that while these plans do account for some ecological impacts, it is primarily through the narrow lens of impacts to fish as measured by water temperature and streamflow. The latter is typically based on the same ecological principles used to determine instream flow requirements. Also found, is that other resource plans in the same watersheds (e.g., Watershed Restoration Plans, Bureau of Land Management (BLM) Watershed Assessments or United States Forest Service (USFS) Forest Plans) identify a broader range of ecological drought risks. Given limited resources and the potential for mutual benefits and synergies,

results suggest greater integration between various planning processes could result in a more holistic consideration of water needs and uses across the landscape.

Peppler, R. A., K. E. Klockow, and R. D. Smith, 2018: Hazardscapes: Perceptions of tornado risk and the role of place in central Oklahoma. In *Explorations in Place Attachment*, J. S. Smith, ed. London: Routledge, 33-45.

This study used results from town hall meetings, interviews, and surveys in central Oklahoma to understand how and why people conceptualize tornado risk in the places where they live, including formation of personal tornado climatologies and reasons why tornadoes may or may not favor their locations. These methodologies could be useful for studying climate related risk in other places, such as flood risk along the Gulf Coast.

Shafer, M., 2017: Local Drought Management: A summary of how counties and parishes use drought information in the South Central United States. Southern Climate Impacts Planning Program, 23 pp. Available online at http://www.southernclimate.org/documents/Regional_Drought_Survey_Summary.pdf

NOAA and other partners have made amazing strides over the past decade to improve drought monitoring, preparedness, response, and mitigation. How do these national efforts reflect at the local level? The Southern Climate Impacts Planning Program (SCIPP), a NOAA RISA Team, conducted a survey of county-level offices in a six-state region in the South Central United States to answer this question. The project revealed an active local network, especially in the relatively drier states in the western part of the region (Texas and Oklahoma), working to help their communities, businesses, and individuals manage drought. Those in the network had access to a wealth of information, but there are opportunities to improve their connection, particularly through the U.S. Drought Monitor process and representing local conditions.

Narrative Examples

Planning and Emergency Management Workshops Spur City and County Public Surveys

The City of Norman, OK (pop. 122,000) and Cleveland County (pop. 275,000), the county in which Norman is located, recently sought input from residents about their hazard mitigation and resiliency priorities. Both the City and the County, in collaboration with the University of Oklahoma Public Opinion Learning Laboratory, conducted a survey to obtain input for their upcoming FEMA Multi-Hazard Mitigation Plan update. The idea for the public survey came about during conversations that the City's emergency manager and a planner had while participating in workshops that SCIPP held in March and November 2017.

SCIPP's Involvement Leads to Climate Adaptation at Coastal Strategic Petroleum Reserve Sites

Climate change impacts are being accounted for in planning for the future of Strategic Petroleum Reserve (SPR) sites along the coast of the Gulf of Mexico based on SCIPP's work with the National Renewable Energy Laboratory (NREL) and the SPR. Following the collaboration described in SCIPP's previous annual report, decisions were made to integrate specific climate adaptation actions into SPR's Life Extension Two (LE2) $1.4 billion infrastructure upgrade plan:

1. SPR will raise the floor height of one building that is being replaced at the Bayou Choctaw site near Baton Rouge, LA around five feet, which will place it approximately 3 feet above the 100-year flood plain and provide some measure of resilience against storm surge and sea level rise. The additional cost to build an elevated building compared to a ground level building is less than $100,000 and may save SPR from having to replace a ground level building in the future at a cost of around $800,000.

Figure 15: West Hackberry Strategic Petroleum Reserve site.

2. Site-specific elevation/subsidence surveys recommended in SCIPP's report revealed an increased flood potential for the West Hackberry site in southwest Louisiana. Cost/benefit analyses are underway, but the results could lead to building a levee around the most vulnerable area of the site (e.g. northern portion, top of Figure 4), raising roads, or raising berms and/or wellheads at caverns.
3. Hurricane resistant doors and windows are being installed at all sites to increase resilience to these hazards.

Additional collaboration between SCIPP and NREL is ongoing.

SCIPP's Expertise Sought for Hazard Mitigation Recommendations in Oklahoma City Area

SCIPP was invited in early 2018 to participate in the Oklahoma City Community Foundation (OCCF) Central Oklahoma Resiliency Project's Hazard Mitigation Focus Group. Priorities of this working group included identifying natural hazards that impact the Oklahoma City metropolitan area and recommending projects to reduce those risks through the use of philanthropic funds. SCIPP's input played a significant role in the prioritization process and impacted the final recommendations for how to spend the available OCCF funds. The implemented projects will directly impact vulnerable areas within the Oklahoma City metropolitan area. Further, the hazard mitigation project list can be referenced when updating hazard mitigation plans and when other funding becomes available in the future which will save City of Oklahoma City staff time. Other communities, particularly in central Oklahoma but also elsewhere across the state, can benefit from the project list as well since many of the hazard mitigation options are relevant to the hazard profiles of communities throughout the state.

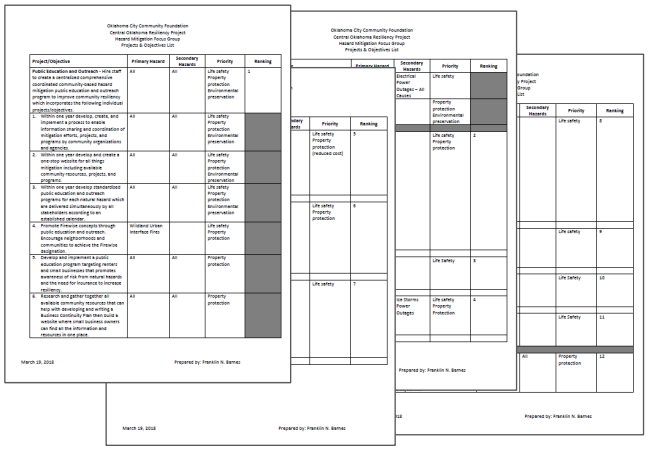
Figure 16: Thumbnail images of the hazard mitigation project list developed as a result of the Oklahoma City Community Foundation Central Oklahoma Resiliency Project Hazard Mitigation Focus Group.

NIDIS – Coping with Drought

In FY18, SCIPP's Coping with Drought efforts were aimed toward three topics: coordination of partner interactions, connecting information to stakeholder needs, and development of a new LiDAR-based assessment of water resources.

Coordination of partner interactions

A focus this year on coordination of partner interactions and stakeholder engagement enabled prompt response to these emerging areas of concern and supported activities identified in the DEWS strategic plan. At the time the Statement of Work was scoped, there was little drought within the SCIPP region, which permitted advancement of network-building when decision makers' attention is not as focused on responding to ongoing events. However, drought re-emerged in Fall 2017 and quickly escalated in severity, with a large portion of Oklahoma and the Texas Panhandle reaching D4, exceptional drought. This caused a slight shift toward more operational support.

There are numerous efforts at communicating, researching, and coordinating drought information across the Southern Plains DEWS region. The focus of this project during the reporting period was to inventory the partners, providers, and stakeholders in the DEWS region to develop an effective strategy to engage each at times when they need to take action without over-burdening them with frequent meetings, webinars, and calls. For example, SCIPP, the South Central Climate Science Center, and the USDA Southern Plains Climate Hub all have drought-related research and engagement efforts. These three entities have established routine meetings to coordinate activities, but similar work is needed to engage other partners and stakeholders. These efforts fit within the NIDIS Southern Plains DEWS strategic plan priorities of (1) fostering stakeholder collaboration, coordination, and relationship building, and (2) improving drought early warning outreach and communication capacity. By combining multiple elements detailed in the strategic plan into this project, it identifies synergies among them that will make each more efficient and more effective. As Elizabeth Weight, NIDIS DEWS Coordinator, became more familiar with the network, SCIPP transferred lead of these activities to her or others whom NIDIS designated.

Specific activities within this focus area included:

1. Drought webinar series – The National Weather Service Southern Region Headquarters, supported by NIDIS, SCIPP, the National Drought Mitigation Center, state climatologists, and other partners, launched a new regional monthly webinar series on drought status and outlook. Due to the rapid development of exceptional drought, this supplanted the planned webinar series that was to be hosted by SCIPP. SCIPP participated in planning calls and debriefings, advertised these NIDIS-sponsored webinars within the Southern Plains DEWS region, and helped coordinate presenters as needed. SCIPP will conduct a survey in Summer 2018 to assess the effectiveness of the webinars, based upon a survey conducted during the 2011-2014 regional drought, http://www.southernclimate.org/documents/Webinar_Survey_Summary.pdf. SCIPP will coordinate with Elizabeth Weight to update survey questions. This is in support of Activity 2.2 in the NIDIS Southern Plains DEWS Strategic Plain.
2. Also, in support of Activity 2.2 in the Strategic Plan, SCIPP continued its bi-weekly video updates of drought status via its YouTube channel and social media. These 5-minute overviews are designed for a quick update at the convenience of the stakeholders, to supplement the more in-depth webinars.

3. Partnership calls with federal agencies, coordinating with climate services providers in the region, and hosting NWS outlook calls. These are described in activities 1.1, 1.2, and 1.3 in the Strategic Plan. SCIPP operates in a supporting role for NIDIS as it leads these activities.
4. To develop regional awareness of other non-NIDIS drought activities, SCIPP maintained a list of upcoming regional meetings, workshops, events, and recent reports by regional climate services providers and stakeholders. Monica Mattox provided the list to Christina Stone as new entries were identified (on at least a monthly basis) for inclusion in the portal. NIDIS has chosen to not include non-NIDIS-sponsored activities on their calendar, so this list is primarily used for internal awareness.

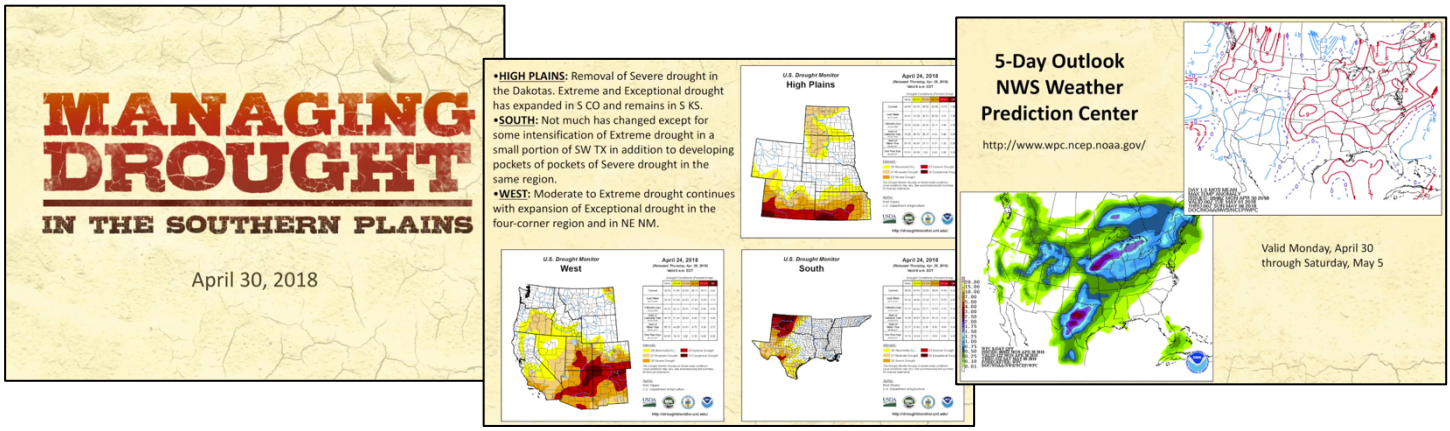

Figure 17: Thumbnail images of SCIPP's bi-weekly updates of the drought status in the Southern Plains.

Connecting information to stakeholder needs

While webinars, calls, and briefings provide coordination, it does not afford much opportunity to understand how stakeholders are using information and assessing unmet needs. To do so requires direct interaction with stakeholders via focused workshop topics, interviews with key stakeholders, and similar assessment methodologies.

Activity 2.4 in the Strategic Plan aims to improve consistent drought messaging to the general public. SCIPP is collaborating with NDMC and other partners to develop a strategy to assess stakeholder needs for materials that may support more effective communication. This includes a strategy for identifying the topics needed by stakeholders and formats that would be of most interest to the stakeholders. Formats may include short documents describing physical processes and management strategies, short videos, tip sheets, or draft press releases.

LiDAR-based assessment of water resources

A third area in SCIPP's FY18 Statement of Work was new research on mapping farm pond locations and volumes, in support of monitoring efforts led by the Oklahoma Water Resources Board (OWRB). A team of researchers at the University of Oklahoma have developed a new methodology for utilizing remotely-sensed data to provide reliable estimates of water retained in ponds and other catchments that are presently not included in water accounting models. The project will test the methodology in a watershed in Oklahoma. Successfully developing this capacity at this time will prepare for potentially a larger project in 2020 when LiDAR datasets become available nationally and will position OWRB, the Texas Water Development Board, and other partners to implement this technology and methodology to improve water accounting methods throughout the DEWS region. This project will be conducted during Summer and Fall 2018.

Appendix: Publications

Bertrand, D., 2017: Changing Fire Regimes and Management Strategies. Southern Climate Impacts Planning Program, 72 pp. Available online at http://www.southernclimate.org/documents/Changing_Fire_Regimes.pdf.

Bertrand, D., G. Fujan**, M. Shafer**, H. Reges, and N. Doesken, 2017. Developing a Visual Drought Index. Southern Climate Impacts Planning Program, 34 pp.
Available online at http://www.southernclimate.org/documents/Visual_Drought_Index.pdf.

Crausbay, S., A. Ramirez, S. Carter, M. Cross, K. Hall, D. Bathke, J. Betancourt, S. Colt, A. Cravens, M. Dalton, J. Dunham, L. Hay, **M. J. Hayes**, J. McEvoy, C. McNutt, M. Moritz, K. Nislow, N. Raheem, and T. Sanford, 2017. Defining ecological drought for the 21st century. *Bulletin of the American Meteorological Society*. http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-16-0292.1.

Hu, X., M. Xue, and **R.A. McPherson**, 2017. The importance of soil-type contrast in modulating August precipitation distribution near the Edwards Plateau and Balcones Escarpment in Texas. *Journal of Geophysical Research-Atmospheres*, 122, 10, 711–10, 728, doi: 10.1002/2017JD027035.

Huang, X., D. Sathiaraj, L. Wang, and **B. Keim**, 2017. Deriving Data-Driven Insights from Climate Extreme Indices for the Continental US. International Conference on Data Mining Workshops, 303-312, doi: http://doi.ieeecomputersociety.org/10.1109/ICDMW.2017.46.

Keim, B. D., W. D. Kappel, G. A. Muhlstein, D. M Hultstrand, T. W Parzybok, A. B. Lewis, E. M. Tomlinson, and **A. W. Black**. In Press: Assessment of the Extreme Rainfall Event at Nashville, Tennessee and the Surrounding Region on May 1-3, 2010. *Journal of American Water Resources Association.*

Klemm, T. and **R. A. McPherson**, 2017. The development of seasonal climate forecasting for agricultural producers. *Agricultural and Forest Meteorology*, 232, 384–399, doi: https://doi.org/10.1016/j.agrformet.2016.09.005.

McEvoy, J., D. Bathke, N. Burkardt, A. E. Cravens, T. Haigh, K. R. Hall, **M. J. Hayes**, T. Jedd, M. Poděbradská, and E. Wickham, 2018. Ecological drought: Accounting for the non-human impacts of water shortage in the Upper Missouri Headwaters Basin, Montana, USA. *Resources*, 7, 14, doi:10.3390/resources7010014.

Mullens, E. D. and **R. A. McPherson**, 2017. A Multialgorithm Reanalysis-Based Freezing Precipitation Dataset for Climate Studies in the South-Central U.S. *Journal of Applied Meteorology and Climatology*, 56, 495–517, doi: https://doi.org/10.1175/JAMC-D-16-0180.1.

Peppler, R. A., 2017. "It's not balancing out like it should be." Perceptions of local climate variability in Native Oklahoma. *Weather, Climate, and Society*, 9, 317-329.

Peppler, R. A., K. E. Klockow, and R. D. Smith, 2018. Hazardscapes: Perceptions of tornado risk and the role of place in central Oklahoma. In *Explorations in Place Attachment*, J. S. Smith, ed. London: Routledge, 33-45.

Qiao, L., C. Zou, C. Gaitán, Y. Hong, and **R. A. McPherson**, 2017. Analysis of precipitation projections over the climate gradient of the Arkansas-Red River Basin. *Journal of Applied Meteorology and Climatology*, 56, 1325–1336.
Sathiaraj, D., W.M. Cassidy Jr., and E. Rohli, Improving Predictive Accuracy in Elections, *Big Data*, 5 (4), 325-336, doi: 10.1089/big.2017.0047.

Shafer, M., 2017: Local Drought Management: A summary of how counties and parishes use drought information in the South Central United States. Southern Climate Impacts Planning Program, 23 pp. Available online at http://www.southernclimate.org/documents/Regional_Drought_Survey_Summary.pdf.

Shao, W., S. Xian, **B. Keim,** K. Goidel, and N. Lin. 2017. Understanding Perceptions of Changing Hurricane Strength Along the U.S. Gulf Coast. *International Journal of Climatology*, 37(4), 1716-1727, doi:10.1002/joc.4805.