Southern Climate Impacts Planning Program

Annual Report: June 2016 - May 2017

RISA
Regional Integrated Sciences and Assessments

SCIPP
A NOAA RISA TEAM

CONTENTS

Table of Contents

The Southern Climate Impacts Planning Program (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. Please accept the annual report entitled “Southern Climate Impacts Planning Program (SCIPP) Phase II for the period 6/1/2016-5/31/2017.

TEAM

SCIPP Team

Principal Investigators: Mark Shafer (OU); Barry Keim (LSU)

Co-Principal Investigators: Harold Brooks (OU); Renee Edwards (LSU); Michael Hayes (NDMC); Yang Hong (OU); Renee McPherson (OU); Randy Peppler (OU); Steven Quiring (TAMU); Kevin Robbins (LSU)

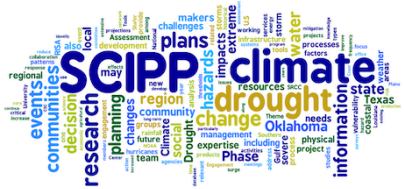
Core Office: Margret Boone - Program Manager (OU); Alan Black - Program Manager (LSU); Rachel Riley (OU) Associate Program Manager; Leah Kos - Climate Assessment Specialist (OU); Vincent Brown - Research Associate (LSU); Gina Fujan - Student Assistant (OU); Ty Dickinson - Student Assistant (OU); Ericka Short - Student Assistant (OU); Jasmine Montgomery - 2016 Summer Intern (OU); Cara Vanarsdel - 2016 Summer Intern (OU)

Research and Support Staff: Jared Bostic (OU); Kyle Brehe (LSU); Kyle Davis (OU); Luigi Romolo (LSU); David Sathiaraj (LSU); Ada Shih (OU)

Graduate Students: Rudy Bartels (LSU); Darrien (Noyes) Bertrand (OU); Logan Gerber-Chavez (OU); Coryn Collins (LSU); Josh Gilliland (LSU); Stephen Kreller (LSU); Mike Navarro (LSU); Derek Thompson (LSU); John Troutman (LSU)

Advisory Committee: David Brown (NOAA); Jeffrey Gaffney (University of Arkansas); Gregg Garfin (University of Arizona); Marilu Hastings (Cynthia and George Mitchell Foundation); Bill Hooke (American Meteorological Society); Rebecca Jennings (Federal Emergency Management Agency); Bill Kiene (NOAA); Tim Lovell (Disaster Resilience Network); Victor Murphy (NOAA); Jamie Olson (Cynthia and George Mitchell Foundation); Sascha Petersen (Adaptation International); Putnam Reiter (Oklahoma Department of Emergency Management); Bob Rose (Lower Colorado River Authority); David Schlotzhauer (NWS Lower Mississippi River Forecast Center); Melissa Stults (University of Michigan); Trevor Timberlake (Arkansas Natural Resources Commission) and Tom Wilbanks (Oak Ridge National Laboratory)

SCIPP Affiliates: Jeff Basara (OU); Lynne Carter (fhi360/Uganda); Sean Crowell (OU); Scott Greene (OU); Dawn Jourdan (TAMU); Cody Knutson (NDMC); Patrick Marsh (NWS SPC); Heather McCarthy (OU); Mike Richman (OU); Kodi Nemunaitis Berry (OU); John Nielsen-Gammon (TAMU); Cindy Rosenthal (OU); Chie Sakakibara (OU); Theodore Trafalis (OU); and Kai Zhang (UTHealth)



The Southern Climate Impacts Planning Program team consists of the following investigators, core office staff, research & support staff, summer interns, and graduate students from the University of Oklahoma (OU), Louisiana State University (LSU), Texas A&M University (TAMU), and the National Drought Mitigation Center (NDMC). SCIPP's Stakeholder Services Committee (Advisory Committee) is also detailed above. Team personnel are current as of May 31, 2017.

NEW AREAS

New Areas of Focus or Partnerships

Planning for extreme weather and climate events are central to the work of the Southern Climate Impacts Planning Program, though are not our only focus. The following represent the various new areas of focus and partnerships of SCIPP with a brief description of the questions and issues the SCIPP team is working to address.

National Association of Insurance Commissioners (NAIC): SCIPP Climate Assessment Specialist, Leah Kos, began interacting with the insurance sector over the past year, most specifically with the National Association of Insurance Commissioners (NAIC). This association consists of working groups covering a variety of focus areas, including a Climate Change and Global Warming Working Group. Starting in January 2016, we were contacted by an NAIC representative looking for a speaker to present at their upcoming Climate Change and Global Warming Working Group in New Orleans, LA. After a successful recommendation for a SCIPP member to present on hurricane impacts and expectations, the NAIC requested our assistance in finding speakers for each of their following conferences in 2016, which occur three times per year. Since several of the conference locations occurred outside of our SCIPP region, we were able to utilize the RISA network to initiate conversations and recommend appropriate speakers. At their most recent conference in the spring of 2017, we were given the opportunity to attend the Climate Change and Global Warming Working Group and meet with the NAIC representative. Our conversations included learning more about each of our programs, as well as discussing potential collaboration opportunities. One such potential opportunity included hosting a climate and loss mitigation workshop for agents and adjusters. This workshop is based on previous work conducted with the Oklahoma insurance industry. Oklahoma's previous insurance commissioner was interested in improving awareness of weather extremes and mitigation actions for agents and adjusters, due to high insurance rates related to weather events. From 2006-2010, the Oklahoma Climate Survey (OCS) successfully held 5 workshops for the state. Our contacts within the NAIC showed interest in these workshops and spoke about the potential to help provide assistance on bringing them back. Current efforts include working with the NAIC to identify appropriate states in which to hold the workshop, as well as developing an appropriate agenda. These workshops have the potential to occur in states across our SCIPP region, as well as the broader RISA network.

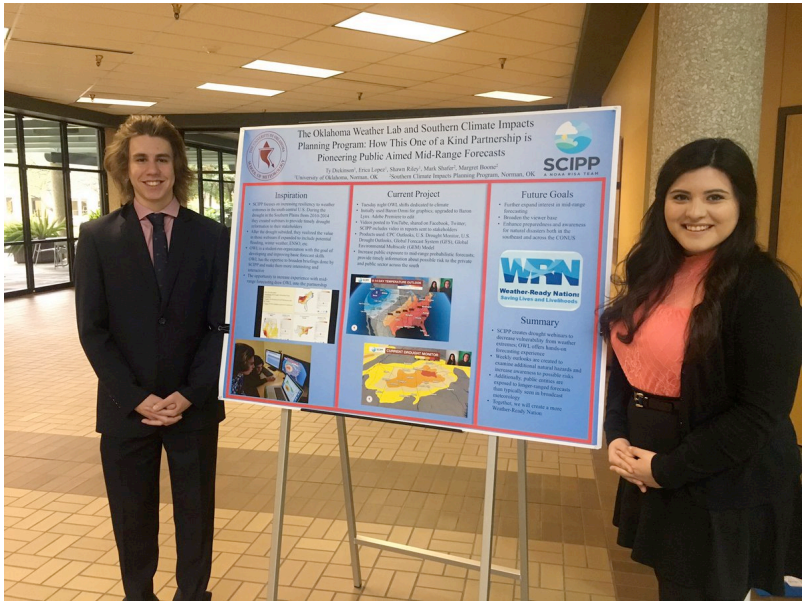
SCIPP PI Mark Shafer participated in the **Louisiana Smart Growth Summit** in November 2016 in Baton Rouge, LA. Participants included communities, planners, non-governmental organizations, businesses, and state and federal organizations. Although this was not one-on-one work with a particular community, it created new contacts for SCIPP that will be valuable in future work.

Vincent Brown, SCIPP Research Associate, is collaborating on efforts to depict climate change in the Southeastern U.S. and its impacts for the **National Climate Assessment**. Mark Shafer, SCIPP PI, is collaborating on the Southern Great Plains Chapter of the **National Climate Assessment**.

New Areas

Climate and Energy Efficiency Seminar: The idea to hold a climate and energy efficiency seminar was initially developed through SCIPP's involvement with the energy engineer sector. Starting in 2016, SCIPP formed connections with the Tulsa Chapter of the Association of Energy Engineers, as they were interested in learning more about weather and climate in their region. We were given the opportunity to present at their monthly meeting on an overview of the climatology of Oklahoma, as well as implications for the future, in which members were highly engaged. SCIPP then attended the subsequent board meeting to discuss working further with the chapter to create a one-day seminar focusing on more detailed topics related to energy and climate. Following this meeting, we interacted frequently on logistical matters and brainstormed appropriate attendees and topics of interest for the seminar. These conversations led to the development of expanding the seminar into a broader audience within the energy and sustainability sectors, which we are currently working on developing.

SCIPP PI, Barry Keim, conducted over 40 media interviews in 2-3 weeks following the **Louisiana Rainstorm and Flooding Event of August 2016**. Media outlets included the New York Times, CNBC, PBS Newshour, NPR (On Point), Climate Central, Wall Street Journal, New Scientist, Popular Science, Washington Times, The Nation's Health, and others. More information about the Flooding Event of August 2016 can be found in the Research Findings section.



SCIPP partnered with the Oklahoma Weather Lab (OWL), a student run organization that introduces the University of Oklahoma School of Meteorology students to forecasting and broadcast meteorology. For several years, SCIPP has desired to produce climate briefings focused on seasonal outlooks, the US Drought Monitor and Drought Outlook, and any major events occurring in our SCIPP region or nationally. Starting in the Fall of 2016, OWL students organized and recorded a weekly video briefing discussing the above points. These videos were shared on the OWL and SCIPP Facebook pages, Twitter, and YouTube channels. The students enjoyed learning about climate forecasts, and presented about our collaborative effort in a poster presentation at the Texas Weather Conference in March 2017.

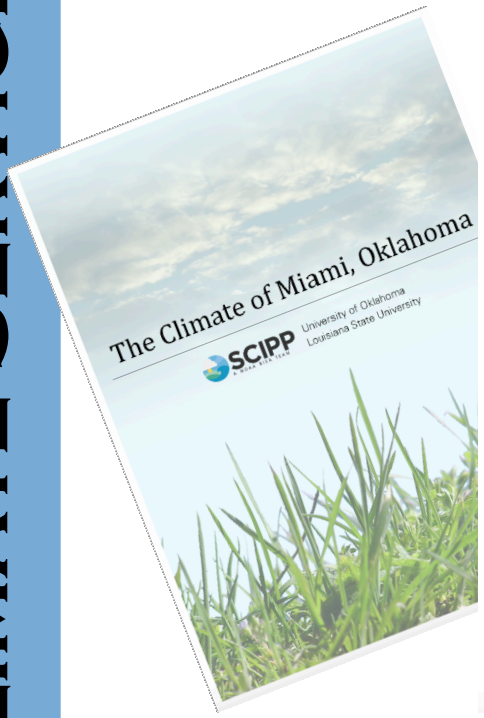
Climate Services

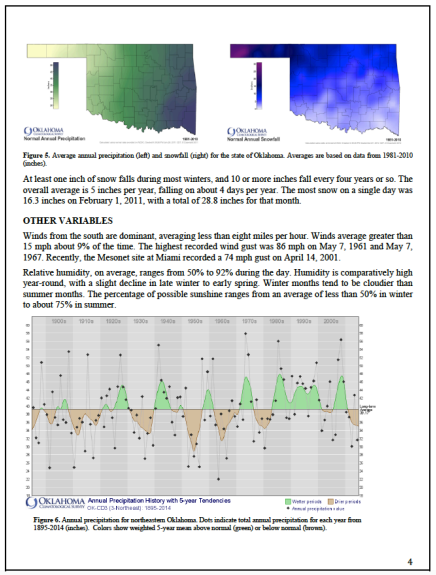
Texas and Louisiana: Climate Change and Resilience Assessment for the Strategic Petroleum Reserve

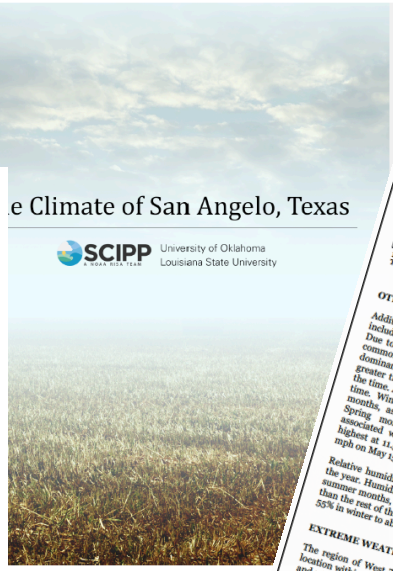
SCIPP began working with Department of Energy partners at the National Renewable Energy Laboratory and the Strategic Petroleum Reserve (SPR) in Texas and Louisiana in July 2016. The purpose was to develop a climate change resilience plan for the SPR. The SPR is the world's largest supply of emergency crude oil. The oil is stored in underground salt caverns at four sites along the Texas and Louisiana Gulf Coast: Bayou Choctaw near Baton Rouge, LA; Big Hill near Winnie, TX; Bryan Mound near Freeport, TX; and West Hackberry near Hackberry, LA, with administration offices located at a fifth site in New Orleans, LA. The work began by evaluating the mission-critical objectives of SPR; for example, the ability to extract oil from the underground salt caverns. First, we evaluated the impact of current climate conditions on SPR's ability to meet each objective. SCIPP then used future climate projections from CMIP5 to evaluate how those mission relevant climate variables would change in the future. Several brainstorming sessions resulted in a list of options to reduce the impacts of changing climate on SPR operations. These were evaluated in terms of feasibility, cost, and potential to reduce vulnerability or increase resilience to changing climate. Two meetings to exchange ideas and present results to SPR management were held at the SPR Headquarters in New Orleans in October, 2016 and April, 2017, with a final report expected to be completed by early June, 2017.

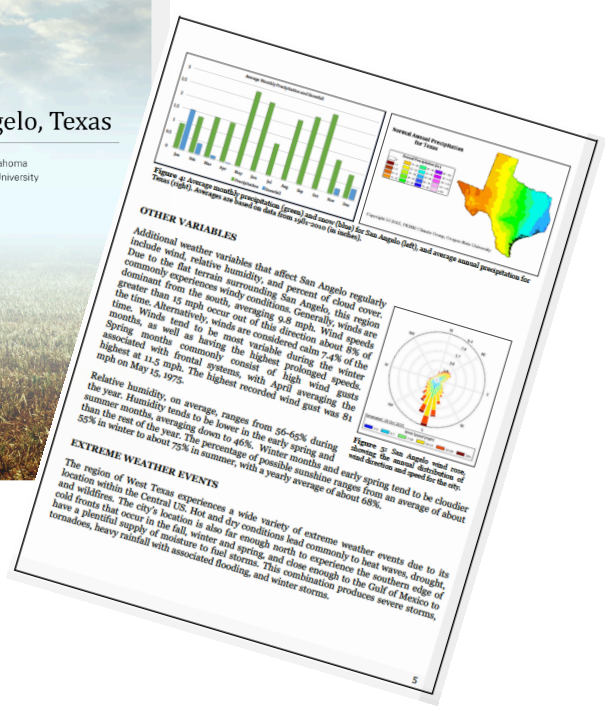
CLIMATE SERVICES

Oklahoma and Texas: City staff and stakeholders in Miami, Oklahoma and San Angelo, Texas were provided "Climate Of" documents that included historical climatologies and projections for their local areas through our work on behalf of a NOAA Sectoral Applications Research Program (SARP) grant. The need for the documents was identified through workshops held in those communities where stakeholders worked to identify the thresholds at which weather goes from being a nuisance to a problem.





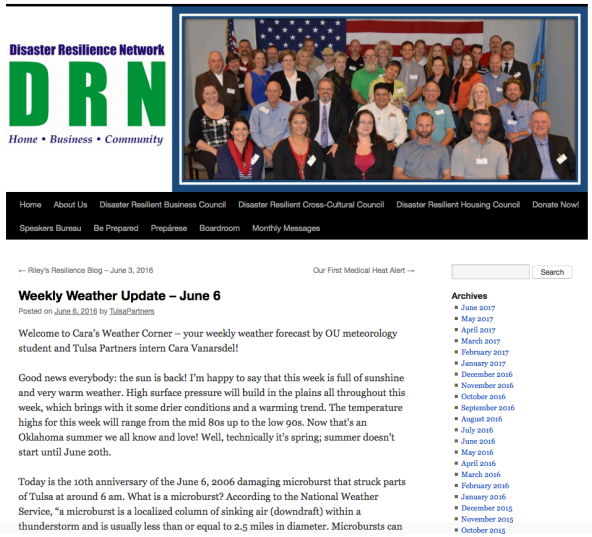




Arkansas: SCIPP, in collaboration with the Arkansas Natural Resources Commission, convened a drought planning workshop in Little Rock, Arkansas on June 8, 2016. The goal of the workshop was to engage stakeholders in Arkansas about drought planning in their state. SCIPP also produced a report after the workshop. The report summarizes the content of the workshop, outcomes, and provides recommendations for next steps for how to improve drought planning in Arkansas. This report will be the first tangible product given to help catalyze a drought committee in Arkansas. Establishing a committee is the first step to realizing the goal of developing a statewide drought plan.

Disaster Resilience Network (formerly Tulsa Partners, Inc.), Tulsa, Oklahoma: The Disaster Resilience Network is a nonprofit organization working to build safe, sustainable communities. SCIPP interviewed and hired a summer intern who worked with the Disaster Resilience Network, the Mayor's Office, the Rockefeller Foundation's 100 Resilient Cities program and AmeriCorps Resilient Neighbors Network to develop metrics of effective risk communication and assess the effectiveness of communication related to multiple weather-related hazards, including flooding.

SCIPP Intern University of Oklahoma meteorology student Cara Vanarsdel spent some time networking and listening to presentations on events happening in the city of Tulsa. She attended the City of Tulsa Program for Public Information (PPI) meetings, and updated the committee on her efforts of getting the various organizations across Tulsa partnered with the Disaster Resilience Network. The goal of this partnership was to aid in distributing the PPI key messages. Ms. Vanarsdel met with each organization to not only learn about what their organization does, but to encourage them to help send out monthly key messages. Ms. Vanarsdel learned that people would be much more likely to send out key messages if they were shorter, more fun to read, and have something that really catches your eye. Therefore, Ms. Vanarsdel worked on each month's message and changed it into multiple messages, each one written specifically for each social media outlet (Twitter, Facebook, Instagram, etc.)



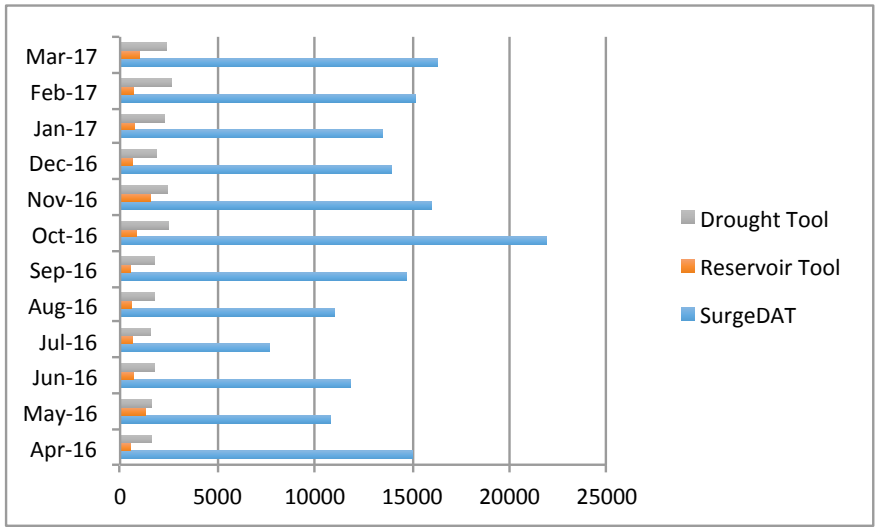
PROGRAM IMPACT

Overall Program Impact

Although SCIPP does not engage in a formal evaluation of impact across our region, we intuitively evaluate the success of our efforts with each of our stakeholders. We listen to our stakeholder's needs and interests, and fine tune our work to appropriately mirror them to the best of our abilities. We are conscious in the projects to which we devote our time, and we do this by evaluating the effectiveness and potential outcomes for our stakeholder, and how they align to our broader RISA goals. On a more technical aspect, we started tracking website visits last year, and are now working on tracking the use of our tools and monthly SCIPP Monitor.

Meeting stakeholder needs as well as those of program partners such as NIDIS, CSC and the USDA Hub leaves little capacity for formal evaluation. With additional resources we would like to add an evaluation expert to our team. We track visits to our website, but have not had that infrastructure in place for very long. We also often ask webinar or workshop participants to fill out short evaluations but the purpose is typically to qualitatively inform future work in that area rather than a rigorously evaluate the event.

SCIPP plans to work with Western Water Assessment (WWA) in the next year to improve the metrics it tracks related to stakeholder interaction. Some of the metrics WWA assesses include: whether contact was related to an official WWA project, whether it was repeat contact, who initiated the contact, sector represented, the purpose of the interaction, and the mode of contact. These will be implemented by SCIPP in the next annual cycle.



Website visits to SurgeDAT, the Drought Tool and the Reservoir Tool.

As mentioned previously, we can track the use of our tools. In the table to the left, the usage by month through March 2017 of SurgeDAT, US Drought Tool, and the Water Data Visualization Tool are shown. On average, SurgeDAT receives roughly 14,000 visits per month. The US Drought Tool receives 2000 visits per month, and the Reservoir Tool receives 800 visits per month.

BUILDING EXPERTISE

Building Expertise

Engaging Planners and Emergency Managers: Over the past year we have engaged with emergency managers and planners in Oklahoma and Arkansas with the goal of determining how dialogue on hazards and climate can be translated into action. This effort began by engaging with both of these sectors in each state, as well as assessing their current status on this topic through individual conversations and presenting at their state conferences. At the Oklahoma and Arkansas state chapters of the American Planning Association (APA) annual conferences we collaborated with Danielle Barker, City of Bethany, OK Community Development Specialist, to hold a joint session covering a hazards profile for each state as well as the importance of emergency managers and planners working together. A hazard scenario exercise also took place. Additionally, at the Arkansas Emergency Management Association annual conference in Fall 2016, we presented a hazards climatology and implications for the future, as well as a hazards scenario exercise. From there, small planning committees were formed to plan a workshop and a webinar that would engage a larger group of emergency managers and planners from each state. These committees were formed with a planner and emergency manager from each state and included the contacts we made at both the Oklahoma and Arkansas APA conferences. Representatives from FEMA and the National APA also participated. The workshop took place on March 23, the webinar on March 30. The focus was to facilitate collaboration between emergency managers and planners with the goal of improving hazard mitigation and resiliency initiatives in local and state arenas. Now that the groundwork and motivation have been established, we will be forming working groups in each state, focusing on sharing relevant climate hazard data, and determining what data are necessary for improving hazard mitigation and resiliency initiatives.

Building Expertise

Through a partnership with Adaptation International, SCIPP worked with the cities of San Angelo, Texas and Miami, Oklahoma to assess vulnerabilities to climate variability and change, critical thresholds at which point weather goes from a nuisance to a problem, and to discuss strategies to lessen vulnerabilities. NOAA SARP provided funding for most of the project, with SCIPP resources being leveraged to enable study of the process and identify strategies for effective stakeholder interaction that SCIPP can use with other communities. Case studies and additional project details are on AI's website: http://adaptationinternational.com/projects/.

In conjunction with a NOAA SARP-funded project, we, along with project team members from other organizations, engaged with stakeholders from communities in San Angelo, Texas and Miami, Oklahoma. The purpose of the project was to develop and test a community-specific participatory process to identify and develop climate projections around impact-relevant extreme events and guide climate change adaptation and resilience efforts. Through this process, stakeholders in each community increased their knowledge on how climate impacts their local area and through $10,000 seed funding, each community took one action to build resilience. In Miami, that action was to teach an extreme weather preparedness lesson to 8th graders, as well as distribute "go-bags" and programmable weather radios. In San Angelo, the community purchased and installed a weather monitoring station near some recreational fields and a rainwater harvesting system at the Bosque Park in downtown San Angelo. Focusing on addressing current weather-related concerns created a foundation for taking action and discussing future climate.

ACCOMPLISHMENT

Accomplishment

Our recent interactions with the state of Arkansas revealed that there is an interest across the state to address the challenges associated with extreme weather and climate events. SCIPP developed a connection with the Arkansas Natural Resources Commission (ANRC) and held a one day drought planning workshop, sponsored by ANRC, SCIPP and the National Drought Mitigation Center (NDMC) in June of 2016. This workshop brought together regional, state and federal representatives in Arkansas with the goal of building capacity for better decision-making related to drought planning and adaptation. Discussion focused on the recent 2010-2015 drought events and provided participants the opportunity to share experiences and identify the impacts, challenges,

lessons learned, and opportunities for collaborations regarding future drought events. The suggested outcomes of this workshop include building working groups, and along with a workshop summary report provided by SCIPP, will serve as the first steps in preparing Arkansas for a state drought plan.

SCIPP's further engagement in Arkansas over the past year includes the Arkansas' planning community. Connections built with the Arkansas Chapter of the American Planning Association led to the opportunity for SCIPP to present at their fall 2016 conference, as well as develop further conversations with planners on their role in assisting adaptation efforts across the state.

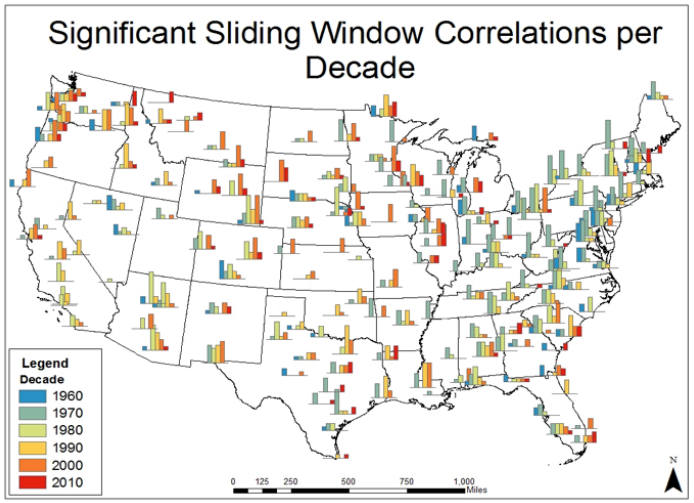
RESEARCH

Research Findings

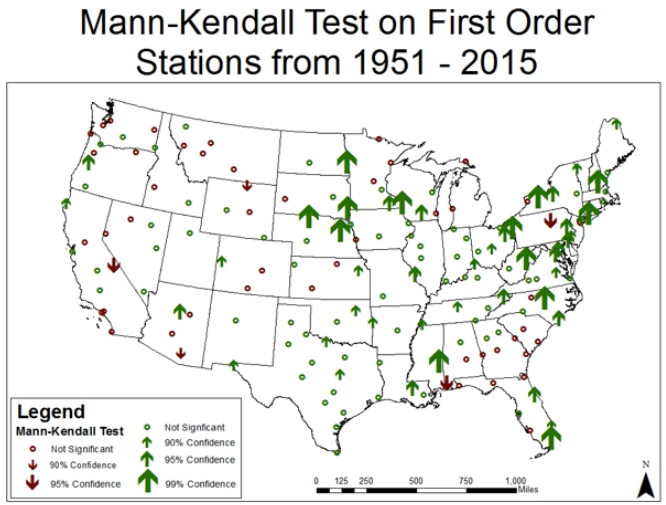
An Annual Analysis of Frequency and Magnitude of Rain Days in the United States

Investigators: Rudy Bartels, Barry D. Keim

Precipitation—or the lack thereof—impacts the world's population. Recent increases in flooding and drought events have furthered speculation that global precipitation trends are changing. To date, much research has focused on annual and seasonal precipitation totals and how they may change, but there is a dearth of research on rain days and how they have changed. Therefore, an analysis of precipitation days is warranted to determine both spatial and temporal patterns, which may assist with mitigation practices. This study investigated trends in past precipitation patterns using precipitation days at first-order weather stations across the United States from 1951-2015. The Mann-Kendal test and sliding window correlation analysis are used to assist in inspecting past precipitation days. Future precipitation days are forecasted via usage of the stepwise auto-regressive model. The Mann-Kendal test found that the majority of the Northeast and Midwestern states show an upward trend in precipitation days, while negative trends are located in the Southeast and in clusters throughout the Northwest. Also, sliding window correlation analysis found significant correlations throughout many decades. The northeastern United States had more significant changes in the number of precipitation days during the earlier decades whereas the center part of the country had more significant changes in later decades. There were more significant increases in precipitation days than decreases. Precipitation days are predicted to increase for the upper Midwest and Northeast United States in the future.



Significant Sliding Window Correlations per Decade throughout the United States.



Mann-Kendall test for trend in rain days for the first order stations from 1951-2015. Significant increasing trends are upward arrows, significant decreasing trends are downward arrows, and neutral are all displayed.

RESEARCH

Impacts of ENSO on Tornado Frequency, Intensity, and Geography across the Eastern United States

Investigators: Coryn Collins, Barry D. Keim, Alan W. Black, Ashton Robinson-Cook, Lei Wang

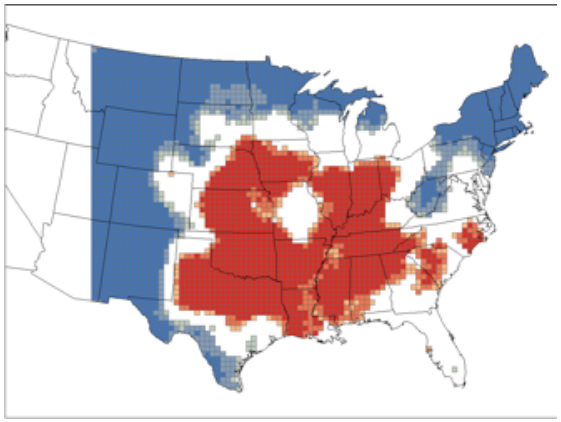


Figure 1. Spring weak La Nina Tornado Hot and Cold Spots

Tornadoes are a reoccurring severe weather hazard, with the highest rates globally occurring in the central United States. Despite their high frequency in the U.S., the scientific community's disagreement of tornado activity during varying phases and intensities of the El Niño Southern Oscillation (ENSO) justifies a need for further research. In this study, tornado events from 1950 to 2014 in the U.S. east of the Rocky Mountains were investigated for seven phases of ENSO: strong, moderate, and weak El Niño/La Niña, and the neutral phase. A seasonal Niño 3.4 index was used as the definition of ENSO. ENSO influences on tornado frequency, intensity, geographical distribution, and track area were tested using sophisticated mapping (i.e. GIS optimized hot spot analysis and atmospheric composites) and spatial statistics (i.e. average nearest neighbor and global Moran's I). Results indicate that in spring, a weak La Niña correlates with higher tornado intensity and stronger, long-lived tornadoes that shift eastward from the central U.S. as ENSO transitions from El Niño to La Niña. Summer has high tornado frequencies that do not vary dramatically across ENSO phases, with weak, short-lived tornadoes occurring in tornado outbreaks. Fall has similar tornado frequencies across six of the seven ENSO phases, apart from largely higher annual counts during a strong La Niña phase. Winter exhibits more tornadoes that are stronger and longer-lived during a moderate La Niña phase, with a northward expansion in tornado hot spots as ENSO transitions from El Niño to La Niña. In general, La Niña is most conducive for higher tornado counts and stronger, longer lived tornadoes.

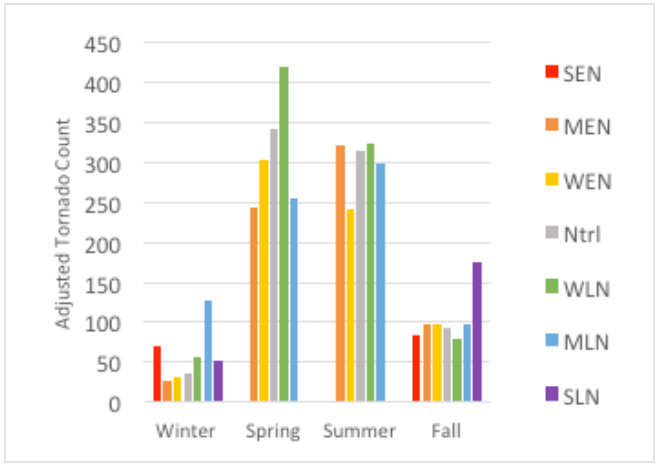


Figure 2. Adjusted Annual Tornado Frequencies by season and ENSO phase

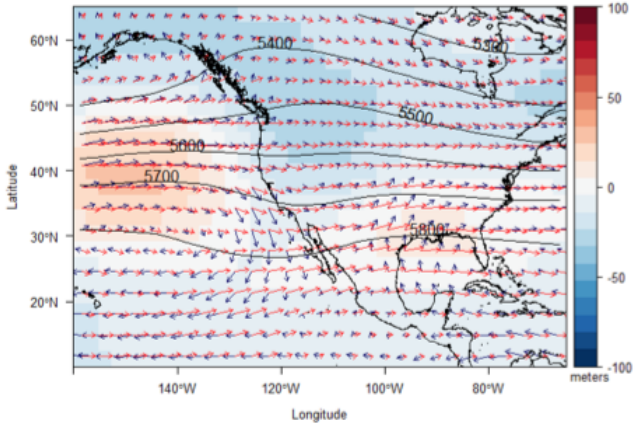


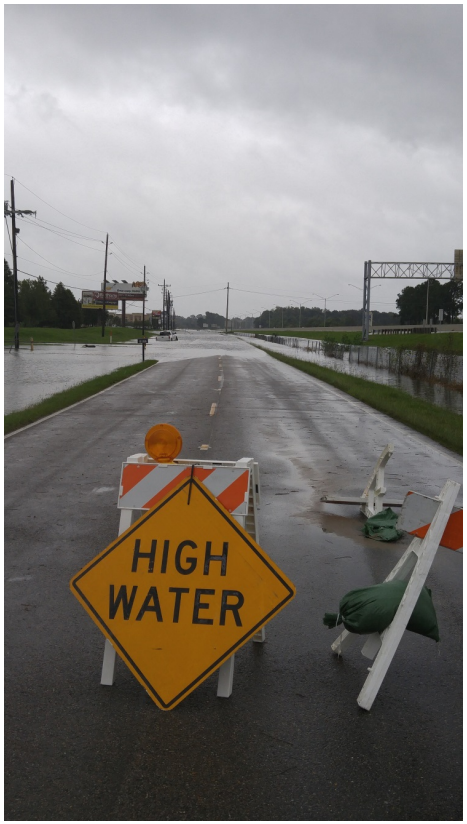
Figure 3. Atmospheric composite for Spring Weak La Nina. 500mb geopotential heights are contoured, 500mb geopotential height anomalies are colored, 800mb winds are in blue, 300mb winds are in red.

RESEARCH

Louisiana and Rainstorm Event of August 2016

Investigators: Barry Keim, Alan Black

The epic rainfall and flooding caused by the August 10-14, 2016 Louisiana storm event has been an ongoing research focus. The storm produced an incredible two day rainfall total of 31.39 inches just north of Baton Rouge, setting a new record for the largest two-day rainstorm in Louisiana and exceeding the 1000 year event estimate by over 10 inches. Research by SCIPP is examining the meteorological conditions associated with this storm. The most extreme rainfall totals in Louisiana are usually associated with organized tropical cyclones such as tropical depressions, tropical storms, or hurricanes; in contrast, while this storm originated from a tropical wave, it never formed the closed low pressure or wind field to be designated a tropical depression. The storm also exhibited an unusual vertical structure with the surface low pressure over land with the low pressure in the mid and upper atmosphere located over the Gulf of Mexico. Another unusual feature of the storm was the duration of rainfall that it produced. Steady and unremitting rain fell across much of southern Louisiana, with many stations reporting 50 or more consecutive hours of rainfall and storm total accumulations of greater than 20 inches. Record-setting flooding accompanied this rain, with several locations along the Amite and Comite rivers experiencing record crests. This flooding inundated an estimated 140,000 structures, closed major interstates in the region, and led to 13 deaths. In the wake of the floods, SCIPP presented these research findings to a number of groups, including the Ascension Parish Council, the Amite River Basin Drainage & Conservation District, the LSU Center for River Studies, the Baton Rouge Press Club, and the Baton Rouge Roundtable, among others.



OUTREACH

Outreach and Communication

SCIPP continues publishing our Southern Climate Monitor newsletter. We have 167 subscribers. We also receive 100-200 impressions per month based on promoting the feature article through Twitter.

SCIPP presented at the Oklahoma Chapter of the APA fall conference in September 2016, which had about 150 attendees. This opportunity was made available through our existing relationship with the chapter. Our presentation, focusing on improving resiliency to natural hazards, was a dual effort between SCIPP and a local planner in Oklahoma. This collaboration was fostered by our similar objectives to provide an accurate hazards profile for the state, as well as introduce the idea for planners and emergency managers to work together on improving resiliency. Following this workshop, the assessment of our joint presentation showed that there is great value in presenting both a climate and planner perspective, as the audience can hear both sides at once and better see how they relate. Our relationship with the planning community was also a key resource in our development of the statewide Emergency Manager and Planner workshop in March of 2017.

Also in September 2016, SCIPP presented at the Arkansas Chapter of the APA fall conference, where about 50 members attended. Following recognition of the value in presenting with both a planner and climate perspective, this presentation mirrored the joint session between SCIPP and a local planner as seen at the OK APA conference. This dual presentation was refined to add a hazard planning scenario and led to a very interactive session. Engagement at this conference led to lasting contacts that were important in our development of the Emergency Manager and Planner webinar held for Arkansas in March of 2017.

In conjunction with the previously held Emergency Manager and Planner workshop in Oklahoma, we increased communication with the APA Hazard Mitigation and Disaster Recovery (HMDR) Division, as the division leader presented at the workshop. Further discussions with the HMDR division revealed potential opportunities for SCIPP to get involved with planners and various resiliency efforts across our region.

PUBLICATIONS

Key Publications

1)Bertrand, Darrian and Mark Shafer, 2017. Defining Hazards, *Bulletin of the American Meteorological Society*, **98(4),** 659-663. doi:10.1175/BAMS-D-15-00236.1

This article delves into the issue of variances in how hazards are defined and how it affects those who write state hazard mitigation plans. For this brief text, the hazards discussed in state plans that fall in the SCIPP's region are covered with a comparison of definitions from the National Weather Service (NWS) and the American Meteorological Society (AMS). States within the SCIPP region include Oklahoma, Texas, Arkansas, Louisiana, Mississippi, and Tennessee. This study found that it is more common for states to use key words from NWS and AMS hazard definitions than to use exact definitions, although even then more than one-third of descriptions in the state plans did not match either NWS or AMS keywords.

2) Shao, W., J.C. Garand, B.D. Keim, and L.C. Hamilton. 2016. Science, Scientists, and Local Weather: Understanding Mass Perceptions of Global Warming. *Social Science Quarterly* 97(5):1023-1057. DOI:10.1111/ssqu.12317

We find that long-term trends in summer temperatures influence perceptions of global warming. Individuals who reside in communities with long-term warming of summer temperatures that are coupled with long-term cooling of spring temperatures are significantly more likely to perceive that global warming exists and is due to human activity. We also find that Americans' attitudes toward scientists and science, political dispositions, evangelical religious affiliation, education, and some demographic attributes all have discernible effects on their perceptions of anthropogenic (man-made) global warming.

3) Shao, W., S. Xian, B. Keim, K. Goidel, 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.

The scientific debate on the impact of climate change on hurricane intensity/strength continues. Regardless of its causes, the consequence of increasing hurricane intensity is undeniably immense among coastal residents. In this study, we investigate how various objective measures of hurricane strength affect people's perception of changing hurricane strength over time. We utilize original survey data to examine the relationship between perceived and actual shift in hurricane strength. In this article, hurricane strength is indicated as maximum wind speed at landfall, storm surge, and economic damage. We find that the characteristics of hurricane strength associated with the most recent landfall are much more closely associated with perceptions of changing hurricane strength than objectively measured trends.

PUBLICATIONS

4) Qiao, L., Zou, C., Gaitán, C., Hong, Y., McPherson, R. A. (2016). Precipitation extremes projection over the climate gradient of Arkansas-Red River Basin. *J. Appl. Meteor. Climatol.*

Increases in the frequency and intensity of extreme precipitation are projected for most U.S. regions under climate change. There is a high degree of uncertainty, however, in precipitation regime changes across the large precipitation gradient of the Arkansas-Red River basin (ARRB). The authors analyzed future precipitation regimes using two statistical downscaling datasets based on the scenarios from phase 5 of the Coupled Model Intercomparison Project (CMIP5). Seasonal precipitation in low-to-high quantiles was calculated and compared for the southern ARRB where the downscaled data were available. The results showed a generally comparable shift in precipitation patterns and amounts between the two datasets. However, some spatial variation of precipitation amount change exists, and the direction of change could be opposite for the summer.

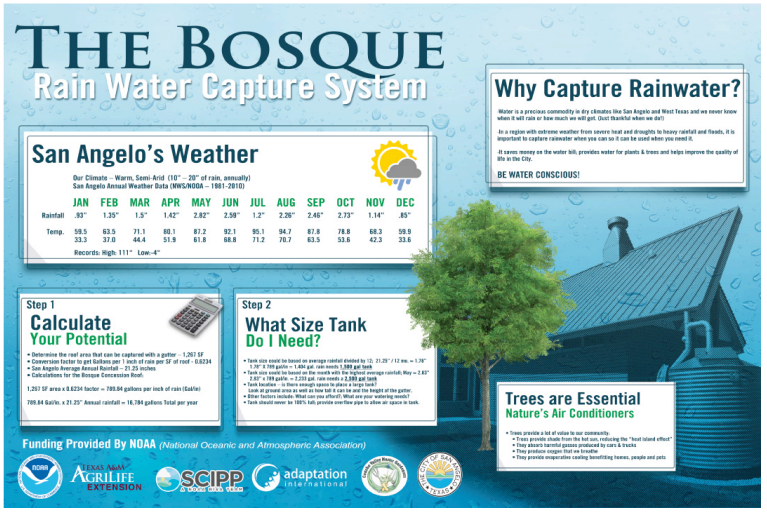
5) Klemm, T., McPherson, R. A. (2017). The development of seasonal climate forecasting for agricultural producers. *Ag. Forest Meteor., 232*, 384–399. http://dx.doi.org/10.1016/j.agrformet.2016.09.005

This review summarizes advances in seasonal climate forecasting with a focus on agriculture, predominantly since the year 2000. The main research methods used were keyword searches in publisher-unaffiliated databases such as Web of Knowledge and in publication libraries of institutions known for their interdisciplinary work in climate forecasting and agriculture. Crop and livestock producers use seasonal climate forecasts for management decisions such as planting and harvest timing, field fertilization, or grazing. Agricultural users have often criticized lack of forecast skill and usability as well as a lack of understanding of user needs among forecast developers. Recently, interdisciplinary studies started exploring agricultural decision-making and integrating social science and climate science in order to improve the value of seasonal forecasts. Producer requests include direct and derived forecast products, such as total rainfall and consecutive dry days, information on uncertainty, and comparisons to previous years. The review explores single-model and ensemble forecasts, describes different measures of forecast value, and highlights economic and other agricultural decision factors besides weather and climate.

NARRATIVE

Narrative Examples

The City of San Angelo, TX installed a 1,500 gallon rainwater harvesting cistern and evapotranspiration (ET) station as well as conducted public engagement on rainwater harvesting, landscape water conservation, and efficient use of water on landscapes in Winter 2016/Spring 2017 as a result of $10,000 seed funding they received through a NOAA SARP grant that was led by Adaptation International (AI). SCIPP was a co-PI on the grant, and in addition to engaging with the City through processes outlined in the grant, SCIPP provided in-kind support to conduct a historical climate analysis and compile the information into a document called "Climate of San Angelo." The climate analyses, in part, spurred the city's decision to focus on a water conservation-oriented resilience action. Located in semi-arid west Texas, San Angelo has a population of nearly 100,000. In addition to partnering with AI and SCIPP, the City was able to bolster the work they were already doing with Texas A&M AgriLife Extension and the Concho Valley Master Gardeners because of the seed funding and SCIPP's involvement in the project. The cistern and ET station, both of which contain educational signage, are located in prominent public locations to maximize their visibility: a park and near a soccer field. If residents follow in the city's footsteps by installing rainwater capture systems on their properties and irrigate more efficiently, residents will save money on their water bills and the City's utility will see a reduction in water demand, which is beneficial in a water-stressed region.



SCIPP partnered with the National Renewable Energy Laboratory (NREL) and the Strategic Petroleum Reserve (SPR) to perform a climate change risk and resilience assessment for the SPR. SCIPP first worked with these partners to identify mission-critical processes at SPR and assess how these processes were affected by extreme events in the past. SCIPP then provided guidance and projections of how extreme events are expected to change in the future. Existing resilience options were evaluated and new resilience options were generated to arrive at a list of options that will allow SPR to maintain critical operations under a changing climate. These plans and strategies are being implemented by SPR now as part of their Life Extension Phase Two project, a $1.4 billion program designed to ensure that the U.S. strategic petroleum reserves will be safely stored and available for emergency use well in to the future.

Coping With Drought

RISA and DEWS activities inform each other. Through interaction with stakeholders, areas in need of further research are highlighted, providing avenues for research and deeper engagement as part of the longer-term efforts of RISA to build resilience, along with opportunities to engage other partners such as the Climate Science Centers and USDA Hubs. In some cases, the interaction can lead to new tools, such as the Water Reservoir Visualization Tool that was created because the difficulty of assessing water resources across a region became apparent through DEWS interactions via drought forums and webinars. Other stakeholder needs that have been identified include a better understanding of the drought recovery process, wildfire risks in relation to wet/dry cycles, and social, economic, and ecological impacts of drought.

Engagement with the Texas Water Development Board (TWDB) led to further interactions, including TWDB's involvement in several regional planning initiatives, a shared summer intern who investigated rainfall needed to restore reservoirs to capacity following the 2011-2014 drought, discussions with TWDB and the Oklahoma Mesonet as TWDB begins building their Texas Mesonet, and discussions with the University of Oklahoma's Advanced Radar Research Center (ARRC) on the feasibility of developing less expensive Doppler-radar-based stream gauges to improve their stream monitoring.

Core work in the RISA also informs activities in the DEWS. Engagement and Assessment processes bring a critical eye to service-based interactions. This provides an opportunity to improve the quality of services provided via the DEWS, assess the way in which information is communicated, and to use DEWS activities to identify future areas of research, both on scientific and technical needs and the processes of communication.

SCIPP's work beyond the boundaries of the Southern Plains DEWS also provides a template for building a national Drought Early Warning System. SCIPP's engagement with the Arkansas Natural Resources Commission (ANRC) on developing a state drought plan shows how lessons learned from within the DEWS can be used to assist areas that are not currently covered by a specific DEWS. SCIPP co-hosted a meeting with ANRC where we brought experts from the National Drought Mitigation Center and the University of Arkansas to discuss drought planning processes, tools, and drought history specific to Arkansas, and to lead discussions with participants about how drought affects their activities to build a basis for planning. This would not have been possible without SCIPP's work in the Southern Plains DEWS over preceding years.

Specific DEWS-related activities that were included in SCIPP's DEWS Statement of Work for the past year includes:

- Collecting condition and impact reports – this effort is dependent upon completion of a mobile drought app, being developed by Weather Decision Technologies. The app is expected to be released for prototype in Summer 2017, which will allow SCIPP to harness condition reports, including text and photos, and to coordinate with the National Drought Mitigation Center for inclusion of the information into the Drought Impacts Reporter. The system has been designed for such integration directly from the app to the DIR.

- Field Photos – collection of landscape photos and analysis of visual drought impacts has continued under a NOAA SARP-funded project (NA15OAR4310107). Support for collecting and processing those photos has continued as part of the DEWS efforts.

- Plan Analysis – SCIPP has been working with state chapters of the American Planning Association (APA) to investigate the broader context of hazard mitigation planning. Through these activities, SCIPP seeks to identify paths to include drought planning among effective mitigation planning. A review of how state hazard mitigation plans characterize hazards was published in the April 2017 issue of the *BAMS.*

- Historical Effective Precipitation – this project is an investigation of how much rainfall is needed to maintain healthy vegetation; excess precipitation is available as runoff for water supplies and stream flows. The purpose of this project was to identify at what point rainfall deficits produce agricultural and landscape impacts. Historically, large rainfall deficits have taken years to erase, if ever, but the landscape responds and recovers much more quickly. The project is ongoing and will be completed in Summer 2017.

- Trends in Rainday Frequency in the U.S. – Graduate research has been examining the changing seasonality and frequency of rainfall patterns in the Southern Plains. This is important to the DEWS because much of the agriculture in the region is rain-fed / non-irrigated.

- Webinars and Briefings – SCIPP worked with the University of Oklahoma's School of Meteorology / Oklahoma Weather Lab to institute a regular web-based briefing on extended and seasonal outlooks. These broadcasts, conducted by students in the School of Meteorology, focus upon the NOAA Climate Prediction Center's forecast products, including changes in the Drought Monitor and the Drought Outlook. These replace the drought-specific briefings that SCIPP conducted, although those briefings may be restarted if severe, widespread drought re-emerges in the DEWS. The new briefings engage people on a variety of risks, allowing drought to be included among more popular topics such as tropical storm and severe storm potential.

- State Drought Plans – SCIPP has completed a summary of the Arkansas drought planning meeting for ANRC and is working to set up a similar process in Oklahoma. Because of a large state budget deficit, it was difficult to get agency attention during the Spring 2017. As the legislative session has now ended, SCIPP is working to schedule a meeting with Oklahoma agencies, hosted by our partners at the Oklahoma Climatological Survey / Oklahoma Mesonet, to discuss drought planning and review and update Oklahoma's plan.

- Building long-term resilience – SCIPP is assembling a panel of experts, including stakeholders and researchers, to take a longer-term view of drought vulnerabilities across the DEWS region. The panel will meet virtually monthly to review challenges of drought in the Southern Plains, identify adaptation methods and gaps in information and research, and offer recommendations for policy changes. The time horizon extends beyond the near-term opportunities identified in the DEWS strategic plans and seeks to establish a roadmap that can inform DEWS activities and future plan revisions. A report will be prepared in Fall/Winter 2017.

Appendix: Publications

• Allard, J.M., J.V. Clarke, and B.D. Keim, 2016. Spatial and Temporal Patterns of *In Situ* Sea Surface Temperatures within the Gulf of Mexico from 1901–2010. *American Journal of Climate Change* 5:314-343. DOI:10.4236/ajcc.2016.53025.

• Brown, J., D. Kluck, C. McNutt, and M. Hayes, 2016. A socioecological approach to drought. *Rangelands*, 38(4): 162-168. http://dx.doi.org/10.1016/j.rala.2016.06.007

• Choi, Y-S., H-J. Gim, C-H. Ho, S-J. Jeong, S. K. Park, and M. Hayes, 2016. Climatic influence on corn sowing date in the Midwestern United States. *International Journal of Climatology,* 1-8. DOI: 10.1002/joc.4799

• Dirmeyer, P. A., Wu, J., Norton, H. E., Dorigo, W. A., Quiring, S. M., Ford, T. W., Santanello Jr., J. A., Bosilovich, M. G., Ek, M. B., Koster, R. D., Balsamo, G. and D. M. Lawrence, 2016. Confronting weather and climate models with observational data from soil moisture networks over the United States. *Journal of Hydrometeorology,* 17: 1049-1067. doi: 10.1175/JHM-D-15-0196.1

• Feng, S., M. Trnka, M. Hayes, and Y. Zhang, 2017. Why do different drought indices show distinct future drought risk outcomes in the U.S. Great Plains? *Journal of Climate*, 30: 265-278. http://journals.ametsoc.org/doi/pdf/10.1175/JCLI-D-15-0590.1

• Finnessey, T., M. Hayes, J. Lukas, M. Svoboda, 2016. Using Climate Information for Drought Planning. *Climate Research*, 70: 251-263. http://dx.doi.org/10.3354/cr01406

• Ford, T. W., Wang, Q. and S. M. Quiring, 2016. The observation record length necessary to generate robust soil moisture percentiles. *Journal of Applied Meteorology and Climatology,* 55: 2131-2149. DOI: 10.1175/JAMC-D-16-0143.1

• Ford, T. W., Quiring, S. M. and O. Frauenfeld, 2017. Multi-decadal variability of soil moisture-temperature coupling over the contiguous United States modulated by Pacific and Atlantic sea surface temperatures. *International Journal of Climatology*, 37: 1400–1415. DOI: 10.1002/joc.4785

• Hamilton, L.C, J. Hartter, B.D. Keim, A.E. Boag, M.W. Palace, F.R. Stevens, M.J. Ducey, 2016. Wildfire, Climate and Perceptions in Northeast Oregon. *Regional Environmental Change* 16:1819-1832. DOI:10.1007/s10113-015-0914-y.

• Hayes, M., M. López Pérez, J. Andreu, M. Svoboda, B. Fuchs, N. Engle, 2016. Perspectives from the Outside: Contributions to the Drought Paradigm Shift in Brazil from Spain, Mexico, and the United States. In: E. DeNys, N. Engle, A. Magalhães, eds., Drought in Brazil: Proactive Management and Policy, Taylor and Francis Publishers, pp. 81-90.

• Heim, Jr., R.R, M.J. Brewer, R.S. Pulwarty, D.A. Wilhite, M.J. Hayes, and M.V.K. Sivakumar, 2017. Drought Early Warning and Information Systems. Chapter 17 in Vol. 1: S. Eslamian, ed., Principles of Drought and Water Scarcity: Handbook of Drought and Water Scarcity, Taylor and Francis, USA, 303-319.

• Krueger, E. S., Ochsner, T. E., Quiring, S. M., Engle, D. M., Carlson, J.D., Twidwell, D. and S. D. Fuhlendorf, 2017. Measured soil moisture is a better predictor of large growing-season wildfires than Keetch-Byram Drought Index. *Soil Science Society of America Journal*. doi:10.2136/sssaj2017.01.0003

Appendix: Publications

• McRoberts, D. B, Guikema, S. D. and S. M. Quiring (in press). Improving hurricane power outage risk models through the inclusion of environmental factors. *Risk Analysis.* DOI: 10.1111/risa.12728

• Mullens, E., McPherson, R. A., 2016. A Multi-Algorithm Reanalysis-based Freezing Precipitation Dataset for Climate Studies in the South-Central U.S. *Journal of Applied Climatology and Meteorology*. http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-16-0180.1

• Peppler, R. A., 2016. "They could tell what the weather was to be in advance." Native Oklahoma weather and climate insights from the archive. *The Chronicles of Oklahoma*, 94-4, 414-431.

• 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., and R. S. Ware, 2017. Commentary: "We own the land. Why can't we farm it and support our families?" Native American agriculturalists' movements in Oklahoma. *American Indian Culture and Research Journal*.

• Peppler, R. A., K. E., Kehoe, J. W. Monroe, A. K. Theisen, and S. T. Moore, 2016. The ARM Data Quality Program. *The Atmospheric Radiation Measurement (ARM) Program: The First 20 Years. Meteorological Monogr*aphs, No. 57, American Meteorological Society, 12.1-12.14.

• 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, In Press. ISBN 978-11387-72974-2.

• Shankman, D., and B.D. Keim, 2016. Flood Risk Forecast for China's Poyang Lake Region. *Physical Geography* 37(1):88-91.

• Sisterson, D. L., R. A. Peppler, T. S. Cress, P. J. Lamb, and D. D. Turner, 2016. The ARM Southern Great Plains (SGP) Site. *The Atmospheric Radiation Measurement (ARM) Program: The First 20 Years.. Meteorological Monographs*, No. 57, American Meteorological Society, 6.1-6.14.

•Stiles, C. and M. Hayes, 2017. Recommendations for collaborative drought management in transboundary river basins. *Water Resources Impact*, 19(3): 17-19.

• Sun, X., Xue, M., Brotzge, J., McPherson, R. A., Hu, X., Yang, X.-Q., 2016. An evaluation of dynamical downscaling of Central Plains summer precipitation using a WRF-based regional climate model at a convection-permitting 4-km resolution. *J. Geophys. Res. - Atmospheres, 121*, 13801-13826. http://onlinelibrary.wiley.com/wol1/doi/10.1002/2016JD024796/abstract

• Teale, N. G., Quiring, S. M. and T. W. Ford, 2017. Association of synoptic-scale atmospheric patterns with flash flooding in watersheds of the New York City water supply system. *International Journal of Climatology,* 37: 358–370. DOI: 10.1002/joc.4709

• Tian, L., Leasor, Z. and S. M. Quiring (in press). Potential to improve precipitation forecasts in Texas through incorporation of multiple teleconnections. *International Journal of Climatology*. doi:10.1002/joc.4960

Appendix: Publications

•Van Lanen, H., Vogt, J., Andreu, J., Carrao, H., De Stefano, L., Dutra, E., Feyen, L., Forzieri, G., Hayes, M.,Iglesias, A., Lavaysse, C., Naumann, G., Pulwarty, R., Spinoni, J., Stahl, K., Stefanski, R., Stilianakis, N., Svoboda, M., Tallaksen, L., 2017. Climatological risk: droughts. In: Poljanšek, K., Marín Ferrer, M., De Groeve, T., Clark, I. (Eds.). Science for disaster risk management 2017: knowing better and losing less. EUR 28034 EN, Publications Office of the European Union, Luxembourg, Chapter 3.9.

• Yuan, S. and S. M. Quiring, 2017. Evaluation of soil moisture in CMIP5 simulations over contiguous United States using in situ and satellite observations. *Hydrology and Earth System Science,* 21: 2203–2218. doi:10.5194/hess-21-2203-2017

• Yuan, S. and S. M. Quiring, 2017. Comparison of three methods of interpolating soil moisture in Oklahoma. *International Journal of Climatology*, 37: 987–997. DOI: 10.1002/joc.4754

• Yuan, S., Quiring, S. M., and S. Patil, 2016. Spatial and temporal variations in the accuracy of meteorological drought indices. *Cuadernos de Investigación Geográfica*, 42: 167-183. DOI: 10.18172/cig.2916

•Zeng, L., B. D. Wardlow, R. Wang, J. Shan, T. Tadesse, M. J. Hayes, and D. Li, 2016. A hybrid approach for detecting corn and soybean phenology with time-series MODIS data. *Remote Sensing of Environment*, 181: 237-250. http://dx.doi.org/10.1016/j.rse.2016.03.039