SOUTH CENTRAL
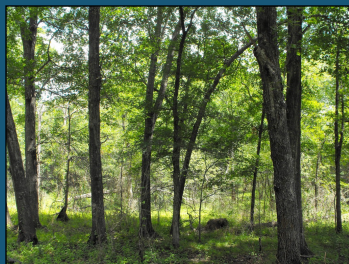## CLIMATE ADAPTATION SCIENCE CENTER

2018 Annual Report
March 1, 2018 - July 31, 2019

This year's highlights for funding from the hosting agreement:

- Completed the third and final downscaling dataset for our regional climate projections
- Conducted five Climate 101 trainings for Tribes and Pueblos across the region
- Launched our new website and rebranded as the "Climate Adaptation Science Center"
- Conducted another round of listening sessions with our stakeholders
- Hosted an undergraduate internship and an early-career workshop

## *Helping to solve real problems in a variable and changing climate*

The South Central Climate Adaptation Science Center (CASC) is one of eight regional Climate Adaptation Science Centers that are managed by the U.S. Geological Survey (USGS). Established in 2012, the South Central CASC is a research collaboration between the USGS, University of Oklahoma, Texas Tech University, Chickasaw Nation, Choctaw Nation of Oklahoma, Louisiana State University, Oklahoma State University, and the Geophysical Fluid Dynamics Laboratory of the National Oceanic and Atmospheric Administration. The South Central CASC collaborates with a wide range of researchers and decision-makers in tribes, state and Federal agencies, universities, and non-governmental organizations.

Our research

The USGS Climate Science Adaptation Centers are working across regions of the United States to develop and bring critical science results to managers and stakeholders concerning impacts of climate variability, trends, and extremes with the goal of developing strategies to minimize economic, sociological, and ecological consequences. Priority science activities include measurement, modeling, and decision support that are related to the impacts of climate on natural and cultural resources.

Our region

Water, energy, agriculture, native peoples, and rapidly growing metropolitan areas intersect with a highly variable and changing climate to frame many of the risks, challenges, and opportunities for natural and cultural resources in the south-central United States. National parks, scenic waterways, tribal and trust lands, and other protected areas are prevalent across the region. Spatial and temporal changes in the south-central's climate are linked to changes in biodiversity; key wildlife habitats; wetlands quality and extent; stream sedimentation and flow; range and density of heritage and invasive species; cultural and natural landscapes; water quality; pathogen outbreaks; and health of ecosystem services. Changes in the region also result from other stressors; hence, responses to climate change must be examined in combination with land cover/use change, habitat fragmentation, increasing population, pollution, invasive species, increasing demand for natural resources, and other stressors.
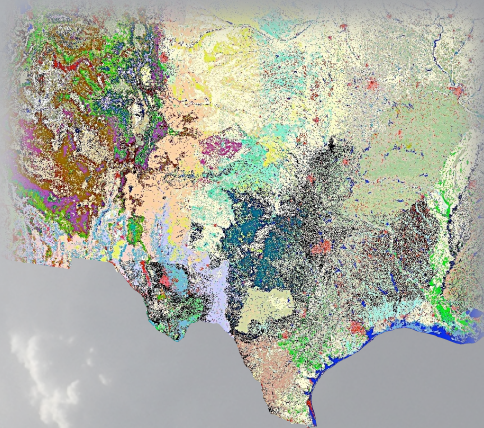
The south-central U.S. encompasses 20 ecoregions, resulting from a significant gradient in annual average precipitation, from 60 inches in coastal areas to 6 inches in the deserts.

Changes in Personnel

The South Central CASC has continued to grow and become more diverse over the past 7 years! The table below highlights the CASC employees at our consortium institutions. In addition, the CASC has over 70 Affiliates across the consortium and at partner institutions. Affiliates of the CASC are people whose professional activity, including research or education, contributes to our mission of collaboratively developing science and tools that address the impacts of climate change on natural and cultural resources.

Consortium Institution	PIs & Associated Faculty	Staff	Post-docs	Grad Students	Undergrad Students
University of Oklahoma	4	7	2	2	8
Texas Tech University	11	1	2	1	0
Louisiana State University	4	0	0	8	4
Chickasaw Nation	2	1	0	1	6
Choctaw Nation of Oklahoma	2	0	0	0	0
Oklahoma State University	5	0	1	2	2
NOAA's GFDL	1	4	—	—	—

USGS Acting Director

Starting in November 2018, Dr. Carolyn Enquist (right) became the Acting USGS Director of the South Central CASC. For a year, she invested her time and expertise tremendously in the CASC. Her background in climate adaptation, coproduction of science, stakeholder engagement, and strategic planning was extremely valuable in fulfilling our mission during 2018-19.

New Mexico Tribal Liaison

We hired Mr. Maurice Cruz (left) to fill the vacant New Mexico Tribal Liaison position after Mr. Atherton Phleger took another opportunity. As the New Mexico Tribal Liaison, Maurice facilitates Tribal planning and decision-making by providing the connection to data and resources in coordination with Indigenous ways of knowing. He is an enrolled member of Ohkay Owingeh with a background in rangeland management and Geographic Information Science. Prior to joining the CASC, he served as a firefighter for the Bureau of Land Management.

Rio Grande Program Coordinator

In 2019, we added Ms. Genevieve Johnson (right) as the new Rio Grande Program Coordinator to assist with stakeholder engagement and research coordination in the Rio Grande Basin. Genevieve came to us with extensive experience in the region having served as the Coordinator for the Desert Landscape Conservation Cooperative from 2012-18. In her role at the CASC, she leads the effort to reach out to new and diverse partners across the basin.

Personnel Highlights and Funding

McPherson Awarded Charles E. Anderson Award

Dr. Renee McPherson (right center), University Director of the South Central CASC, was awarded the Charles E. Anderson Award by the American Meteorological Society at their 2019 Annual Meeting in Phoenix, AZ. The award honored her "extraordinary, sustained efforts to broaden participation of traditionally underrepresented individuals in STEM research and education, particularly women and Native Americans." The Charles E. Anderson Award recognizes outstanding contributions an individual for promoting diversity in the scientific community through community service and education.
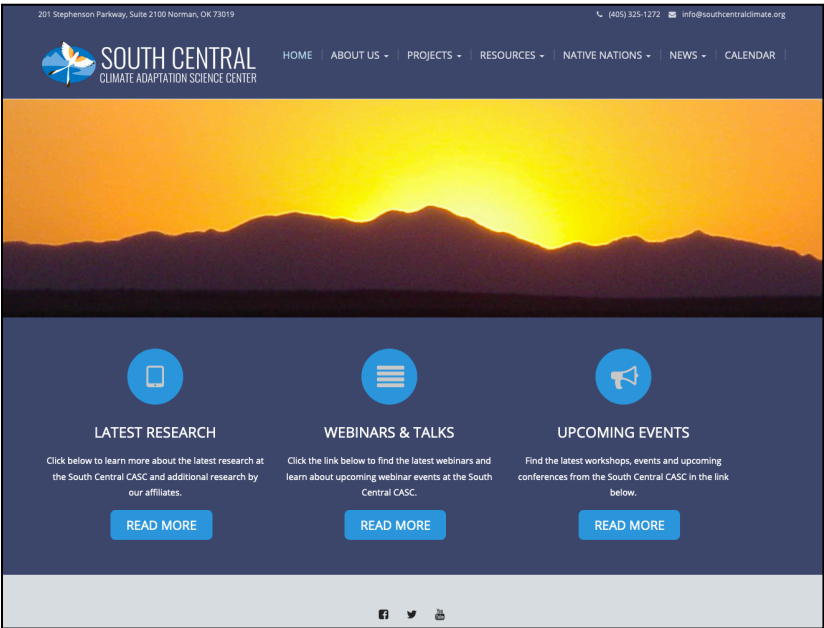
The Role of Students in South Central CASC Communications

Over the past year, we have been updating our communications, including redesigning our website (homepage on left), producing a monthly newsletter, and furthering our social media footprint. To accomplish our goals of effectively sharing our research with natural and cultural resource managers, we have hired students who have communications experience and an interest in climate impacts and adaptation. Since March 2018, we have had four students (two undergraduate, two graduate) work on this effort. The students gain valuable work experience and learn new skills, often bringing us fresh ideas on how to accomplish our goals.

South Central CASC Base Funding

During Year 7 (March 1, 2018 - July 31, 2019), the non-federal members of the South Central CASC expended 100% of our "hosting agreement" budget. The numbers below reflect the balance as of October 22, 2019.

| Budget	Year 7	Bridge Period	Carryover from Year 6	Expended	Percent Expended
University of Oklahoma	$267,234	$131,471	$5,484	$404,606	100.10%
Texas Tech University	$167,670	$27,647	$37,352	$232,308	99.84%
Louisiana State University	$127,116	$76,057	$0	$203,173	100%
Chickasaw Nation	$131,413	$40,333	$4,636	$176,388	100%
Choctaw Nation of Oklahoma	—	—	—	—	—
Oklahoma State University	$104,741	$57,067	$55,544	$176,388	100%

Consortium Research Projects

Downscaling Satellite Soil Moisture Data (Graduate Student - Xu, LSU; Host Agreement)

Having accurate, high resolution soil moisture data is important in planning for droughts and wildfires, as it gives land managers an idea of how vulnerable the land may be in drought conditions. Researchers at Louisiana State University (LSU) are working to improve the accuracy and resolution of soil moisture data from satellites by including ground observations into their analysis. The research team used a spatial statistical analysis (based on geographical information science, GIS) to fuse together the soil moisture product from NASA's Soil Moisture Active and Passive satellite and observations from the West Texas Mesonet.

By building a statistical relationship between several data sets (soil moisture data from satellite and observation, elevation, surface temperature, normalized vegetation index, gross primary productivity, and topographical water index), the researchers developed a model to downscale the satellite's soil moisture product. The model takes the 9-km satellite soil moisture data down to a resolution of 1 km, which is more useful to those managing for drought and wildfires. Validation of the model showed that the downscaled soil moisture data significantly improved the accuracy of the soil moisture product as well as enhanced its spatial resolution.

Evaluation of Sustainable Water Availability in Drought Prone Watersheds in Southeastern Oklahoma (Kellogg, CN; USGS Project)
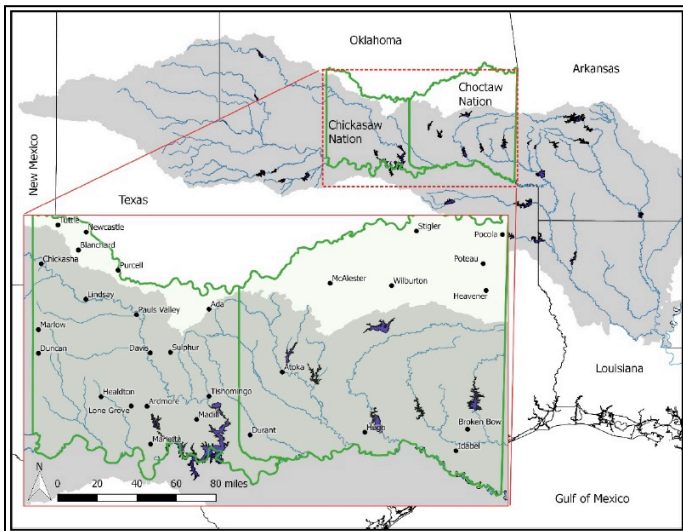
The Chickasaw Nation and Choctaw Nation of Oklahoma are actively investigating the impacts of climate change on stream and river flow in portions of the Red River Basin that are within their Tribal territories (study area to left). This work stems from a previous USGS-funded project that examined flows across the entire basin under a changing climate.

For this project, output from updated downscaled climate projections are used as the input into a Variable Infiltration Capacity (VIC) model to understand rainfall and runoff patterns in the area of interest. The output from the VIC model then is used as the input into a Riverware model (which incorporates reservoir management strategies, permitted withdrawals from surface waters, and discharges to surface waters from treatment plants) to better understand how the flows may change given future shifts in precipitation and runoff. Population growth also will be taken into account as it will increase future demand.

Using a sensitivity analysis, the researchers will identify sub-basins that are most vulnerable to drought. Communities within in these vulnerable watersheds may have a high risk of not being able to meet future water demands under a changing climate. Through this analysis, the researchers will be developing updated projections of future water demand that can be used to perform a detailed supply-demand gap analysis, helping to identify the need and timeline for the development of alternative water management strategies. The research team also is collaborating with the USGS to investigate the impacts of drought on key fish species, determine changes in occupancy, and investigate the potential of ecosystems to repopulate with key species following very dry conditions.

Consortium Research Projects

The Effects of Climate Change Across Soil Boundaries (Graduate Student - Duell, OSU; Host Agreement)

Arbuscular mycorrhizal (AM) fungi form important and widespread beneficial relationships with ~80% of all land-based plants. In fact, the majority of tall grass prairie plants rely on such a relationship to get the nutrients and water they need to grow. Fungal benefits to plants could become even more important in the future as AM fungi can help alleviate some stress caused by climate change.

It is uncertain exactly how AM fungi will respond to increases in temperature and drought conditions, however. Eric Duell, in partnership with his advisors at Oklahoma State University (OSU), are actively investigating the impact that climate change may have on these historic relationships between fungi, plants, herbivores, and parasites. The research team is using AM fungi, milkweed, monarch butterflies, and a parasite of monarchs to model the system.

The research team currently is wrapping up the final steps of an experiment to explore the effects of drought on fungal-plant-herbivore-parasite interactions, and they expect this study will help inform land managers in soil health management. Initial key findings suggest that milkweeds build up reserves when soil moisture is not limited, allowing it to preserve itself during initial drought conditions. However, during extreme drought, a reduction in nectar production occurred, which is expected to negatively impact monarchs and other pollinators. The team is working closely with the Missouri Department of Conservation to ensure this research informs stakeholder-driven questions.

The Influence of Climate on Invasive Pigeons within the Semi-Arid Southern High Plains (Graduate Student - Stukenholtz, TTU; Host Agreement)

Large densities of invasive pigeon populations (e.g., *Columbia livia*) in urban areas can contribute to human health issues and the destruction of infrastructure. Additionally, they can have negative impacts on native bird species and cause local extinction events in critical endemic and migratory bird species. To better understand the impacts of feral pigeons in the Southern High Plains, researchers at Texas Tech University (TTU) studied pigeons using their campus as a roosting and nesting location. They determined what environmental variables were associated with nest success, chick survival, roosting densities, and feeding dynamics.
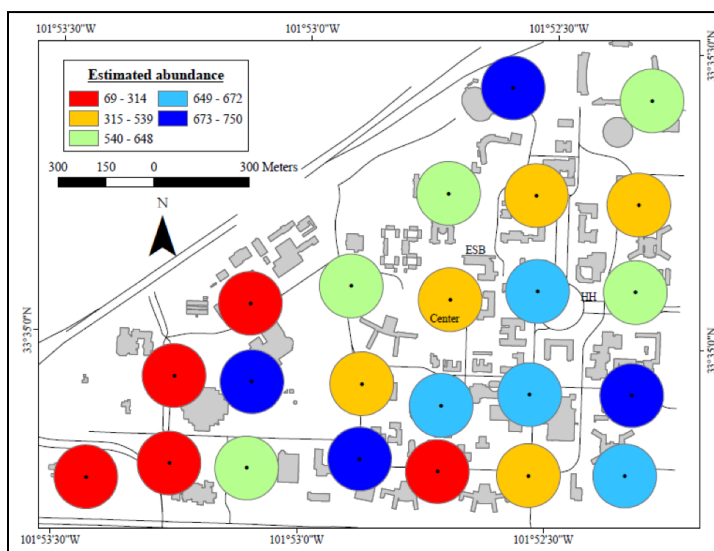
In 2017 and 2018, the average density of pigeons across the TTU campus was estimated at 12,000 (estimated abundance to left). Weather-related variables that influenced pigeon dynamics in 2017 and 2018 were summer and winter temperatures, wind speed, and summer dew points. These variables primarily impacted roosting behavior, which influences density patterns and subsequent building damage, nesting success, and chick recruitment into the population. Cities in the Southern High Plains are an oasis for these birds, as they provide food and water resources and shelter from extreme temperatures and high winds. As the regional climate warms, growing populations of this and similar invasive species may become a larger problem for cities.

Consortium Research Projects

Ecological and Economic Impacts of Kudzu *(Pueraria montana)* Invasion (Graduate Student - Harron, OSU; Host Agreement)

Kudzu (*Pueraria montana*) is a rapidly growing perennial vine that was introduced in the U.S. in 1876 as an ornamental species. Since then, it has become a nuisance plant that can have negative ecological and economic impacts. In the past year, Paulina Harron continued her Master's work on understanding the ecological and economic impacts of expanding Kudzu in Oklahoma.
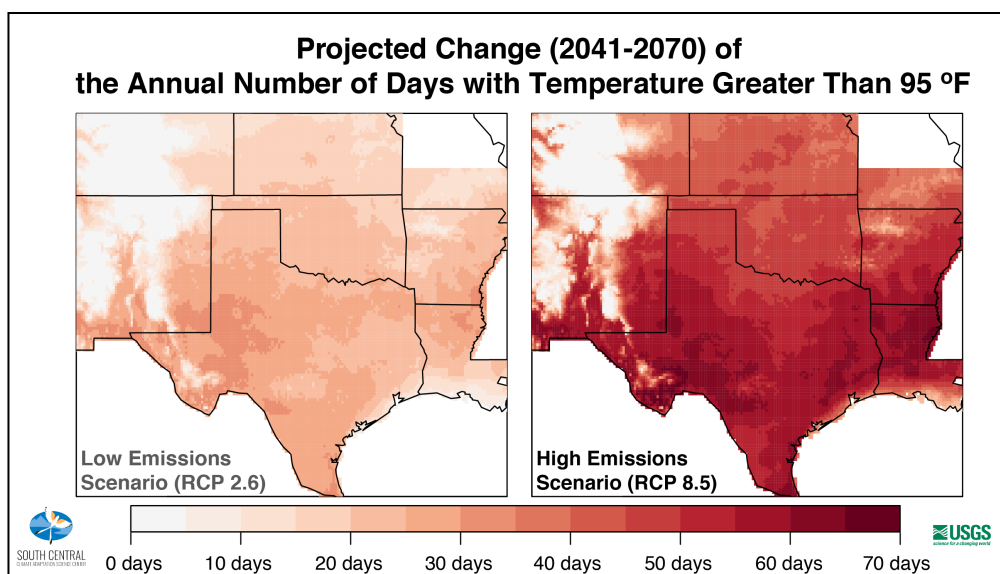
During the last year, the research team accomplished several tasks: (1) identified known populations of kudzu and mapped them using ArcGIS software; (2) paired climate variables and future climate scenarios with the kudzu population data to project future habitat suitability for kudzu in Oklahoma; (3) performed an economic impact analysis for soybean and timber industries, and (4) hosted a brainstorming session at the Oklahoma Natural Resources conference to identify major strengths, weaknesses, opportunities, and threats associated with using best management practices that can help prevent the further spread of kudzu in Oklahoma.

Through this work, the team demonstrated that while kudzu's predicted natural vegetative expansion is fairly slow, the soybean sector could experience total production losses ranging from $226,000 to $1.81 million after five years. Additionally, results for the timber industry showed a potential reduction of $160.4 million in output.

Developing and Analyzing Statistically Downscaled Climate Projections for the South Central U.S. (Wootten & McPherson, OU; Dixon, GFDL; USGS Project)

Global climate models (GCMs) that show us historical climate and project future conditions are tools that resource managers can use to inform their planning decisions. However, GCMs are typically quite coarse in their resolution. Thus, GCMs typically are downscaled to a higher resolution to address more local- and regional-scale questions. For the South Central CASC, Keith Dixon and his team at NOAA's Geophysical Fluid Dynamics Laboratory produced 243 climate projections using three downscaling methods, three global climate models, three observational datasets, three emissions scenarios, and three climate variables (i.e., daily maximum air temperature, daily minimum air temperature, daily precipitation). The ensemble (lovingly called "three-to-the-fifth," or "3^5") is being analyzed by the GFDL team in collaboration with Dr. Adrienne Wootten, a post-doc at the University of Oklahoma. From combinations of these datasets, the research team can identify where climate projections are most sensitive to choices made during the projection-development process. Such insight provides researchers with much needed knowledge to better advise managers in selecting the most appropriate downscaled data for their specific management question. Environmental managers and climate-impacts researchers have begun to use the projections (example product to right) to aid climate adaptation planning.


Projected Change (2041-2070) of the Annual Number of Days with Temperature Greater Than 95 °F

Low Emissions Scenario (RCP 2.6)

High Emissions Scenario (RCP 8.5)

0 days   10 days   20 days   30 days   40 days   50 days   60 days   70 days

Leveraged Research Project Highlight

Climate Impacts on Vegetation in the South-Central Region (Swain, Abeysundara, Hayhoe, & Stoner – TTU)

The inclusion of universities in the Climate Adaptation Science Center network allows for the leveraging of institutional funds to conduct additional climate-related research that is not directly covered by the host agreement or through the annual USGS funding call. For the South Central CASC, one such project focused on the impacts of climate change on vegetation across our region.

Evaluating the response of vegetation to climate change is both relevant and important to managing human and natural systems across the region, including the preservation of potentially sensitive species like the earless lizard. To better understand how vegetation may change due to climate change, TTU researchers studied how the satellite-based MODIS Enhanced Vegetation Index (EVI) responded to temperature, precipitation, and large-scale natural variability during summer months from 2000 to 2013. They found statistically significant relationships (shown below) between climate and EVI that varied across the south-central U.S. and across land cover types, with pastureland showing the strongest relationship and forest showing the weakest. In terms of climate indicators, three-month cumulative precipitation had the strongest influence on summer vegetation, particularly in semi-arid west Texas and eastern New Mexico. Summer monthly maximum temperature played an important role in the eastern half of Texas and Oklahoma, but was moderated by the influence of both Atlantic and Pacific teleconnection indices over inter-annual time scales.
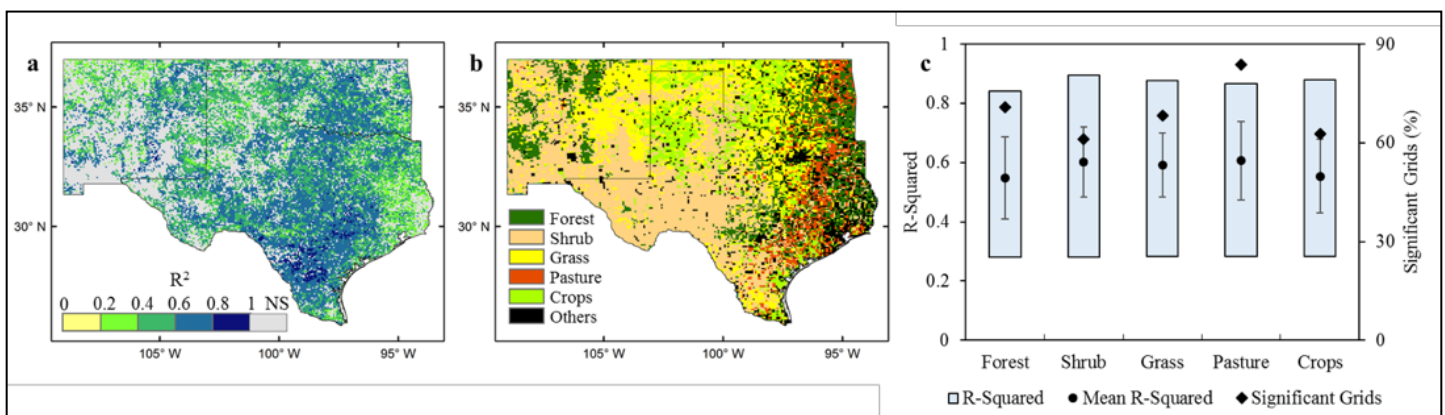
Using these relationships, the research team developed a multivariate predictive model to quantify future changes in EVI based on high-resolution climate projections and remote patterns of natural variability or teleconnections (see below). Through these modeling efforts, the team discovered that as global mean temperature increases, projected EVI decreases. This suggests an increase in stressed and dry vegetation, particularly for grasslands as compared to other land types. Such trends have potentially important implications not only for land management, but also for regional ecosystems and native species that depend on this vegetation as a food source.
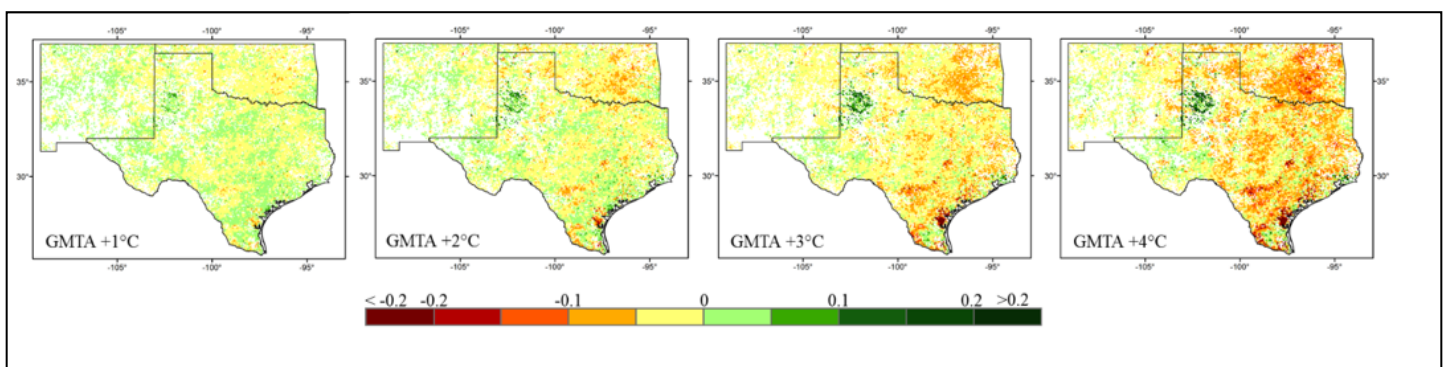
Consortium Grant Funding

In FY18, one proposal was funded for the South Central CASC consortium through USGS Directed Funding:

Improving Resilience for the Rio Grande Coupled Human-Natural System
     Jennifer Koch (OU), PI – 12 months, $67,764

In FY19, the USGS issued a request for proposals that resulted in 5 consortium proposals selected for funding in the South Central CASC region. In addition, 2 other proposals were solicited for Directed Funding.

Effect of Water Level and Habitat on American Alligator Nesting Efforts in Coastal Louisiana
     John Nyman (LSU), PI – 24 months, $15,680

New Paradigms for Environmental Flow Allocation in the Middle Rio Grande Basin Under a Changing Climate
     Ali Mirchi (OSU), PI – 24 months, $299,135

Regional Graduate Student, Post-Doc, and Early Career Researcher Training IV
     Derek Rosendahl (OU), PI – 12 months, $49,591

Organizing and Synthesizing Ogallala Aquifer Data to Facilitate Research and Resource Management
     Renee McPherson (OU), PI – 24 months, $271,536

Research Symposium: Culturally Significant Plants and Climate Change
     April Taylor (CN), PI – 12 months, $35.000

Assessing Future Changes to Spring Phenology and False Springs in the South Central United States
     Adrienne Wootten (OU), PI – 12 months, $47,029

Hydrometeorological and Hydroclimatological Whiplashes and Boomerangs in Central Texas: Impacts on Freshwater Mussels
     Elinor Martin (OU), PI – 24 months, $170,337

Using the collaborative infrastructure created by the South Central CASC consortium, additional proposals were developed for solicitations from other agencies. Submitted proposals include the following:

Southern Climate Impacts Planning Program (SCIPP) Phase III
        Mark Shafer (OU), PI – 3 years, $770,000 (in year 1); National Oceanic and Atmospheric Administration

Identification of Catalytic Behaviors in Collaborative Environments
        Derek Rosendahl (OU), Co-PI – 1 year, $1,500; National Organization of Research Development Professionals

Tribal Resilience Planning in New Mexico and Beyond
        Renee McPherson (OU), PI – 1 year, $47,880; Bureau of Indian Affairs

Understanding the Benefits of Crop Residues and Bed Designs for Improving Soil Moisture, Reducing Soil Heat Load, and Daily Temperature Variability while Increasing Soil Health in Dryland and Irrigated Cotton Rotation Systems
        John Zak (TTU), PI – 1 year, $40,000; Cotton Inc.

Citizen Science Network - Growers Helping Growers to Farm Sustainability and Improve Soil Health
        Natasha van Gestel (TTU), PI – 1 year, $15,000; Cotton Inc.

Thermal, Evaporative, and Momentum Flux Influences of the Lower Mississippi River on Near Shore Environmental Processes
        Victor Rivera-Monroy (LSU), Co-PI – 2 years, pending review; Bureau of Ocean Energy Management

Tribal Engagement

The South Central CASC's Tribal Engagement Plan was released on September 22, 2014, as USGS Circular 1396. The Plan describes how we will engage and facilitate partnerships with the 68 federally recognized Tribes within our region. The Tribal Engagement Plan emphasizes the collaborative nature of science and outlines concrete steps that the South Central CASC has followed, such as offering trainings for Tribal staff and engaging with Tribal educators. In addition, in partnership with Tribes in Oklahoma, OU is developing a document that details a strategy for ensuring that researchers engage with Tribes in culturally appropriate ways. As this document (*Shifting Landscapes*) evolved, OU hosted several workshops for faculty and staff to learn how to be culturally competent when partnering with Tribes on research and outreach projects. In 2018-19, the South Central CASC continued to fulfill the commitments of our Tribal Engagement Plan, particularly through regional and national inter-agency and inter-Tribal coordination and leveraging of resources.

Tribal Capacity Building

In Year 7, the South Central CASC conducted 13 Tribal Trainings and engaged with ~260 individuals who attended the various events. Of these trainings, five were *Climate 101* trainings (of which three were requested by individual Tribes). *Climate 101* includes an introduction to climate change and climate modeling, an overview of relevant climate impacts, and an introduction to vulnerability assessments. We also worked with two consultants to provide more advanced trainings on vulnerability assessments and adaptation planning for the Oklahoma-Kansas Tribal Coalition. Additionally, we continued to provide trainings on our climate projections for groups such as the Institute for Tribal Environmental Professionals – Climate Adaptation Professionals.

On two occasions the South Central CASC was requested to give a training on a specific topic: (1) with Pueblo of Santa Ana on "Building Resilience to Drought through the Soil," and (2) with the University of New Mexico on "Climate Rezilience – the Power of Corn." In addition to in-person trainings, we conducted a webinar to highlight our online training materials available on our website: https://southcentralclimate.org/tribal-nations-climate/.

Assisting with Tribal Adaptation Planning

As a natural progression toward more advanced climate adaptation needs, the South Central CASC has started to assist with Tribal adaptation planning when asked. To best serve our Tribal partners, CASC staff members have started to learn more about adaptation frameworks and approaches. We work with expert consultants to offer more advanced trainings on vulnerability assessments and adaptation planning, assisting Tribes with identifying potential funding avenues and partnering on grant proposals, reviewing Tribal request for proposals and the received proposals, providing resources for Tribal adaptation on our website, and bringing in Tribal adaptation professionals to speak at training events. The South Central CASC also participated as a reviewer of the new Tribal Climate Adaptation Guidebook that was published in November 2018 (http://www.occri.net/projects/tribal-climate-adaptation-guidebook/). Moving forward, the South Central CASC will continue to work on Tribal climate adaptation with our Tribal partners.

Tribal Engagement

Tribal Climate Health Project

In 2018, the South Central CASC participated on an advisory team to develop a curriculum and contribute to a new resource website (http://tribalclimatehealth.org/) for Tribal health professionals. Prosper Sustainability, U.S. Environmental Protection Agency, and Pala Band of Mission Indians provided the leadership and funding for this project. The new resources were compiled to address a need identified by Tribal health professionals and help them better prepare their communities for the public health impacts of climate change.

In addition to gathering information for the new website, the advisory members offered a series of climate-related trainings and conducted outreach at various conferences in 2019 (including the National Adaptation Forum, National Tribal Public Health Summit, Tribal Public Health Emergency Preparedness Conference, and the first Tribal Climate and Health Adaptation Workshop). Moving forward, our CASC team plans to continue this partnership and offer a *Tribal Health and Climate Change* training in the south-central region.

Oklahoma-Kansas Tribal Coalition to Develop Climate Resilience (OKTC)

Over the past year, the South Central CASC partnered with three Tribes — Delaware Nation, Delaware Tribe of Indians, and Shawnee Tribe — to build Tribal staff capacity for conducting climate vulnerability and adaptation planning. On March 15-16, 2018, we held the first of four workshops, focusing on an introduction to the climate system and the impacts of climate change. After the first successful workshop, we contracted with Jennie Hoffman from Adaptation/Insight to conduct the second workshop on April 30-May 1, 2018. Jennie introduced the Tribal staff members to the vulnerability assessment process, providing a foundation to eventually conduct their own vulnerability assessments and develop their own climate adaptation plans.

In January 2019, we partnered with Blue Star Integrative Studio to host a third workshop that focused on how the Tribes could conduct their vulnerability assessments based on their own identified needs. Blue Star also worked with us to conduct the fourth and final workshop (on April 30-May 1, 2019) that focused on developing climate adaptation plans. The three Tribes currently are working on their own vulnerability assessments and climate adaptation plans, and we expect to continue working with them moving forward. Given our expertise in climate projections and climate impacts, we were asked to develop a short climate impacts report for each Tribe based on their geography of interest. The reports were delivered to Blue Star Integrative Studios in July 2019 so they could be incorporated into the larger climate adaptation plan for each Tribe.

Building up the Next Generation of Scientists

2018 Undergraduate Summer Internship

Our 2018 summer undergraduate internship for students under-represented in science, technology, engineering, and mathematics fields was held July 8–28, 2018. Ten undergraduate students participated in this internship (6 females, 4 males; 4 African American, 1 Native American, 3 Hispanic).

Our program began in Lubbock, TX, and concluded in Baton Rouge, LA. Interns were involved in hands-on activities related to climate research that allowed them to see the direct impacts of climate variability and change on the Southern High Plains, prairie and forest ecosystems and tribal cultures in Oklahoma, and the bayous, delta, and coastline of Louisiana. Students visited university campuses and field locations, interacting with researchers who were conducting cutting-edge research. Participants had the opportunity to learn how to collect and analyze field data. They also gained an understanding of the breadth of climate science work being done throughout the south-central region. During their three-week internship, student interns conducted research activities related to the science mission of the South Central CASC.

While in the internship, they learned about opportunities to work with the USGS and other Federal partners and how to prepare for graduate school. Many of the graduates of the program originally did not have interest in graduate school, had not conducted any scientific research, and, in some cases, had not left their home state. After the program, many chose to apply to graduate school or sought other undergraduate research opportunities.

2018 Regional Graduate Student, Post-Doc, & Early-Career Researcher Training

On August 5-10, 2018, the South Central CASC held its third researcher training for early-career professionals. Twenty-eight participants were chosen that represented 15 different broad disciplines and various stages in their careers. Held in Baton, Rouge, LA, this one-week program of workforce development introduced the cohort of early-career researchers to the goals, structure, and unique research challenges of the South Central CASC. It also facilitated interdisciplinary interactions among the participants. As part of the program, participants were engaged in a series of instructional presentations that covered many themes (e.g., climate science and impacts, Indigenous knowledge, co-production of actionable science, and science communication, among other

topics), a keynote address that introduced the participants to a broad perspective of stakeholder-based climate science research, small group activities that facilitated interdisciplinary research, and field trips throughout the week that provided stakeholder engagement opportunities and showcased how scientific results are used in the decision-making process. Products generated from the training included specific curricular materials, a "how-to" guide for conducting similar trainings, and a real-world cause study exercise that illustrated science-based policy or management decision making.

Building Collaborations and Partnerships

Wildfire Probability Mapping Workshop

Wildfires took a severe toll on many U.S. communities in 2018, resulting in the destruction of more than 18,000 residences and the deaths of more than 100 people. To reduce wildfire damage, researchers at Oklahoma State University and the University of Georgia, in partnership with the Northern Plains Climate Hub, are investigating the use of integrating soil moisture information as a predictor of wildfire probability.

To begin their exploration, the team organized a one-day workshop in Albuquerque, NM, that was held in conjunction with the 6th International Fire Behavior and Fuels Conference. The workshop brought together more than 30 stakeholders and researchers to identify the needs and interests of the fire management community and to explore how soil moisture information could be incorporated into wildfire modeling, risk assessment, planning, and decision support tools. Invited speakers covered the current trends and status of wildfire occurrence and impacts, fire modeling and danger ratings, soil moisture monitoring, and linkages between soil moisture and wildfire. Small group discussions identified stakeholder needs relevant to local, regional, and national fire management decision making.

Workshop participants identified the need to increase the quantity and quality of available soil moisture information and to determine how soil moisture can be effectively integrated into existing fire danger rating systems. In response, the research team is conducting research to develop a better understanding of the relationships between soil moisture and fuel moisture conditions, and will develop new soil moisture modeling approaches for integration with fire danger rating systems. A follow-up workshop is planned for 2021 to discuss research outcomes and continue community engagement to reduce the loss of property and life.

Listening Sessions across the South-Central U.S.

In 2018-19, the South Central CASC conducted a round listening sessions to gather input from state, Federal, non-governmental, and Tribal organizations that manage natural and cultural resources across the region. We provided our stakeholders background material on the national and regional CASC network, as this was the first time that some of them had interacted with us. During the discussions, we asked the participants to describe their current planning efforts and research needs to add to our understanding of the research priorities across the region. We visited stakeholders Oklahoma, Texas, New Mexico, and Louisiana, and plan to follow-up with them and interact with other stakeholders in the next year.

Building Collaborations and Partnerships

Citizen Science – Engaging Local Growers in Soil Science

In an effort to collaborate with people making real-world decisions, researchers at Texas Tech University worked with growers and others scientists to increase the understanding of soil processes that enhance soil health. They also looked into what management practices or a combination thereof are best suited to achieve a more resilient soil ecosystem. To date, there are 12 cotton grower citizen scientists located near Lubbock that are participating in the Citizen Science Network.

The efforts made by this team, under the direction of Dr. Natasja van Gestel, help producers address and manage the impacts of climate variability and decreasing water availability on soil health and soil conservation. A unique aspect of the project is that the growers feel ownership of it because they help with data collection. Growers are monitoring fields on their farm and are taking measurements and sampling soils as part of the effort. The data are shared with each other and researchers at TTU to better understand how soil health, as assessed by the soil microbiome and nutrient dynamics, is impacted by farming practices. Support for this project comes from the Davidson Foundation and Cotton Incorporated.

This project has helped to shift the paradigm of farming to one that is more nurturing and protective of the soil, which ultimately helps the soil to be more resilient to environmental changes.

The grower-focused citizen science project has received nationwide attention. It was featured as a short video clip at the Smithsonian Institution in the Deep Time exhibit (above). The Texas Tech Public Media also highlighted the project on May 31, 2019, on KTTZ-FM 89.1.

2018 Fall Working Group Meeting

The South Central CASC held a Science Working Group Meeting in Ft. Worth, TX, in October 2018, timed to be just after the CASC/USDA Joint Stakeholder Committee Meeting. At the meeting, we established six working groups, built primarily on our science themes of our five-year rebid proposal. Teams of 8-10 researchers developed initial goals and discussed their desired outcomes and logistics. The working groups are designed to promote cross-consortium interactions and identify projects that address stakeholder needs across our region.

Communicating Science

Southern Plains Climate Science Seminar Series

In Spring 2019, the South Central CASC, in partnership with the Southern Plains Climate Hub and the Southern Climate Impacts Planning Program, hosted their first webinar in the Southern Plains Climate Science Seminar series. The series features prominent scientists and researchers who are addressing key climate challenges facing the Southern Great Plains. Our first two webinars featured Dr. Katharine Hayhoe of Texas Tech University and Dr. Ali Mirchi of Oklahoma State University. Moving forward, we expect to host a webinar every other month focused on topics that are of interest to our researchers and stakeholders. Previous and upcoming webinars are located on our website: https://southcentralclimate.org/products/webinars-talks/.

Seventy-five people tuned into Katharine's talk on April 3, 2019. She spoke about the history of the National Climate Assessment and then focused on the key messages of the *4th National Climate Assessment* for the Southern Great Plains. She talked about how quality of life will be affected by multiple stressors that impact our food, energy, and water resources, our infrastructure, and our ecosystems. Adaptation strategies that include improved climate services are needed to help manage the complex issues our region faces.

On June 5, 2019, our second webinar featured Dr. Ali Mirchi. He discussed the implications of future climate scenarios on water availability in the Middle Rio Grande Basin. In his research, Ali works with decision makers to identify efficient water resource planning and management efforts that ultimately help derive policy insights that promote water sustainability. As part of his webinar, he shared results of ongoing research that demonstrated the vulnerability of agricultural production to water shortages in the Middle Rio Grande Basin. Moving forward, he plans to look into additional future challenges and adaptation opportunities.

Climate Cinema

In partnership with Alamo Draft House, TTU hosted a monthly movie night and discussion during Spring 2019. Their highest attended events had over 100 people, including high school students, college students, and local residents of the region. The film series explored the impacts of climate on our lives through film media, with the goal of spurring discussions on the impacts and consequences of climate on our everyday lives. So often, public conversations on climate focus on difficult statistics, myths, or politically motivated statements. In contrast, these films provided entertaining opportunities to explore different aspects of the connections between daily life and our climate. Through a mixture of popular films and engaging documentaries, scientists and other experts directed conversations beyond politics by focusing on people. After each film, experts gave a brief commentary and engaged with the audience with questions and answers. TTU plans to continue hosting the Climate Cinema events as outreach to potential stakeholders and the general public.

Communicating Science

Open Online Course: Managing for a Changing Climate

In Fall 2018, OU staff and faculty from the South Central CASC once again offered an online, interactive course designed to provide an integrative understanding of the components of the climate system. This year, however, the full *Managing for a Changing Climate* course was divided into four short courses that focused on specific themes (see table below). By dividing the course into themes that were less time-intensive, we were able to improve our enrollment and completion numbers. While the number of individuals who completed the courses decreased as we went further into the semester, we were pleased to see a relatively large number of individuals who completed at least one of the four short courses. Moving forward, we expect to continue offering the *Managing for a Changing Climate* course as four short courses. Feedback from last year's participants suggested that the short courses were easier to manage and did not overwhelm the participants.

| Short Course	Approximate # of Registrants	Number Completed (Rate)
Intro to the climate system	100	33 (33%)
Climate models & assessments	100	18 (18%)
Societal impacts	130	14 (11%)
Physical impacts	120	9 (7.5%)

In 2018, we also added videos to cover climate adaptation planning, the impacts of climate change on ocean circulations, and energy economics. Throughout the short courses, participants are introduced to the physical climate system, downscaling techniques and the use of projections, the known impacts of climate change, and climate adaptation strategies.

Of the participants who enrolled in the online courses, we had 41 Tribal enrollees from 24 different Tribes, including 17 in our region (of which 13 were Tribes that have never attended a previous South Central CASC training). These numbers clearly show there is a need for online training options for Tribal staff, especially for those in remote areas or who are unable to travel long distances.

The Underwater Forest

Communicating science comes in many forms, including scientific publications, fact sheets, meeting presentations, or webinars. But some of our scientists are using film to communicate the importance of their work. In 2017, "The Underwater Forest," featuring Dr. Kristine DeLong of Louisiana State University, was officially released to the public (http://theunderwaterforest.com/). Since then, she has taken part of numerous outreach and education events to share the film and engage with different audiences. Last year, she gave research talks related to "The Underwater Forest" to scientists at NASA and the Office of Naval Research, high school and college students, and the general public. In total, she spoke to over 250 individuals about this particular project.

On April 30, 2019, Dr. DeLong presented her talk to the general public and students at LSU through LSU's Science Cafe presentation series that highlights an LSU professor each month. In that event alone, there were over 100 attendees!
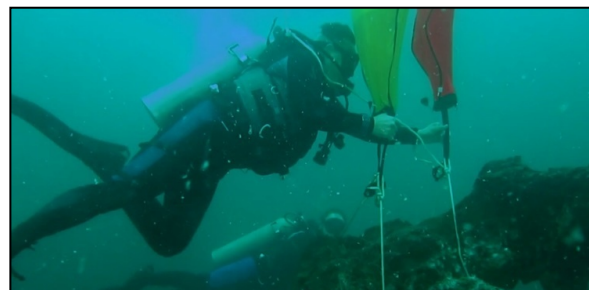
Selected publications

Bertrand, D., and **R. A. McPherson**, 2019: Development of downscaled climate projections: A case study of the Red River Basin, South-Central U.S. *Advances in Meteorology*, Volume 2019, Article ID 4702139, 14pp. https://doi.org/10.1155/2019/4702139

Bertrand, D., and **R. A. McPherson**, 2018: Future hydrologic extremes of the Red River Basin. *J. Appl. Meteor. Climatol*., 57, 1321–1336.

Duell, E.B., K. Baum, and G.W.T. Wilson, 2019: Effects of drought on tallgrass prairie forb biomass, floral resources, and herbivore defenses. *In preparation for American Journal of Botany.*

Hu, X., M. Xue, **R. A. McPherson, E. R. Martin, D. H. Rosendahl,** and L. Qiao, 2018: Precipitation dynamical downscaling over the Great Plains. *Journal of Advances in Modeling Earth Systems*, 10, 421-447. https://doi.org/10.1002/2017MS001154

Klemm, T., and **R. A. McPherson**, 2018: Assessing decision timing and seasonal climate forecast needs of winter wheat producers in the south-central U.S.. *J. Appl. Meteor. Climatol*., 57, 2129–2140.

Klockow-McClain, K. E., **R. A. McPherson,** and R. Thomas, 2019: Cartographic design for improved decision-making: Trade-offs in uncertainty visualization for tornado threats. *Annuals of the AAG*, published online at https://tandfonline.com/doi/full/10.1080/24694452.2019.1602467

Konecky, B., L. Comas-Bru, E. Dassié, **K. DeLong,** J. Partin, 2018. Piecing together the big picture on water and climate. *EOS* 99, DOI: 10.1029/2018EO095283.

Osland, M., L. Feher, J. López-Portillo, R. Day, D. Suman, J. Menéndez, and **V. Rivera-Monroy,** 2018. Mangrove forests in a rapidly changing world: Global change impacts and conservation opportunities along the Gulf of Mexico coast. *Estuarine, Coastal and Shelf Science*, 214: 120-140, DOI: 10.1016/j.ecss.2018.09.006.

Nelson, N.G., L. Montefiore, C. Anthony, L. Merriman, **E. Kuster,** and G.A. and Fox, 2019: Undergraduate perceptions of climate education exposure in natural resources management. *Trans. ASABE*, 62(3): 831-839. https://doi.org/10.13031/trans.13361

Martin, E., 2018: Future projections of global pluvial and drought event characteristics. *Geo. Res. Letters,* 45(11), 913-920. https://doi.org/10.1029/2018GL079807

Mullens, E., and **R. A. McPherson,** 2019: Quantitative scenarios for future hydrologic extremes in the U.S. Southern Great Plains. *Intl J. Clim.,* published online at https://rmets.onlinelibrary.wiley.com/doi/10.1002/joc.5979.

Rosendahl, D., R. A. McPherson, A. Wootten, Esther Mullens, J. Blackband, and A. Bryan, 2019: Building Practitioner Confidence in Working with Uncertainties in Future Climate Projections. *Eos*, in press.

Van Gestel, N., S. Zheng, K.J. van Groenigen, C.W. Osenberg., L.C. Andresen, J.S. Dukes, M.J. Hovendem, Y. Luo, A. Michelsen, E. Pendall, P. Reich, E. Schuur, and B. Hungate, 2018. Predicting soil carbon loss with warming. *Nature*, 554: 104-108.

Selected conference presentations

Berry, Q., **A. Wootten, D. R. Rosendahl,** and **R. McPherson**, December 2018: "The Effects of Climate Change on Tick Habitat Suitability and Potential Transmission of Lyme Disease in the South Central U.S." – *American Geophysical Union Fall Meeting – GeoHealth*, Washington, DC

Celis, J., **A. Wootten, D. H. Rosendahl, R. A. McPherson,** and T. Pham, December 2018: "Process-based modeling of soil moisture, soil temperature, and surface energy fluxes in the U.S. southern plains" – *American Geophysical Union Fall Meeting*, Washington, DC

Ćwik, P., H. Lazrus, **E. Martin, R. A. McPherson,** E, Mullens, C. Kuster, and M. Wagner, December 2018: "Improving the sub-seasonal to seasonal prediction of extreme precipitation events via coproduction of knowledge" – *American Geophysical Union Fall Meeting*, Washington, DC

DeLong, K., G. Ouellette, N. Goodkin, E. Martin, D. Rosenthal, F. Taylor, and C. Shen, January 2019: "Last Interglacial Sea Surface Temperature Variability in the Tropical Atlantic Warm Pool: A Comparison of Model and Coral-Based Reconstructions" – *American Meteorological Society Annual Meeting*, Phoenix, AZ

Duell, E., K. Baum, and G. Wilson, August 2018: "The effects of climate change across soil boundaries: Linking mycorrhizal-plant-herbivore-parasite interactions" – *103rd Annual Ecological Societal of America Meeting*, New Orleans, LA

Haron, P., **O. Joshi**, S. Paudel, **S. Loss**, and K. Hickman, February 2019: "Predicting potential range expansion of invasive *Pueraria Montana* in the South-Central United States under future climate scenarios" – *Oklahoma Natural Resource Conference*, Tulsa, OK

Rosendahl, D. H., A. Wooten, R. A. McPherson, E. Mullens, A. Bryan, **E. Kuster**, and J. Blackband, December 2018: "Helping decision makers incorporate climate model projections into their future planning" – *American Geophysical Union Fall Meeting*, Washington, DC

Taylor, A., and J. Shelhas, May 2018: "Effect of Climate Change on Forests: Opportunities for Collaboration" – *To Bridge a Gap History*, Tulsa, OK

Tucker, C., and J. Trepanier, February 2018: "Communicating the Expected Frequency of Extreme Floods to the Public: Insights from Recent Events in the Gulf of Mexico Region" – *Gulf of Mexico Oil Spill and Ecosystem Conference*, New Orleans, LA

Wootten, A., K. Dixon, D. Adams-Smith, **R. A. McPherson,** December 2018: "Downscaled precipitation sensitivity to gridded observation data and downscaling technique" – *American Geophysical Union Fall Meeting*, Washington, DC

Wootten, A., January 2019: "Projecting Future Rainfall: Sensitivity to Observations and Downscaling" – *USDA Southern Plains Hub Seminar Series*, El Reno, OK

Zak, J., March 2018: "The Importance of Keeping Soils Healthy" – High-Plains Association of Crop Consultants, Lubbock, TX

Activities Planned for New Host Agreement

- Establish working groups to synthesize and identify gaps in stakeholder-driven science priorities;

- Develop best practices for impacts researchers and resource managers on how to apply the output from our downscaled climate model projections;

- Continue taking our new projections to DOI agencies to infuse climate planning information into existing adaptation planning processes;

- Engage stakeholders directly to provide scientific expertise, climate projections, and other information for climate adaptation planning;

- Educate and train management partners and support Tribal engagement across the region, including hosting Tribal workshops and pursuing funding opportunities in collaboration with Tribal partners;

- Establish new collaborations with researchers at the University of New Mexico, the newest addition of our consortium;

- Further enhance partnerships with Tribes and Tribal organizations across our region;

- Strategically develop large-scale inter-institutional and inter-disciplinary regional proposals to establish a broader funding base; and,

- Promote cross-consortium interactions by engaging with CASC funded students at all institutions.

Visit our website at https://southcentralclimate.org/

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