THE STATE CLIMATOLOGIST

2017 ANNUAL SUMMARY

Volume 36,
Issue 1

AASC
AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

Compiled by the SC State Climate Office

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2017 Annual Summary

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The *State Climatologist* is a publication of the
American Association of State Climatologists

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November 2018

Dear Fellow Climatologists, Partners, and Friends of the AASC,

As I end my term as President, I want to thank the association for allowing me to serve. I'm in awe of the work, passion and dedication of our members. I extend my heartfelt gratitude to the AASC Executive Committee. We have come a long way as a result of your vision and leadership. This publication of The State Climatologist highlights the broad spectrum of work done by our state climatologists, regional climate centers and partners in climate services over the past year. From myself and our Executive Committee, thank you for your membership and support of the AASC.

Over the past two years we have welcomed four new State Climatologists, celebrated the retirement of two legends and unfortunately said good-bye to our good friend Mike Borengasser. Mike passed away on January 24, 2018. He worked for over 30 years as a hydrologist for the Arkansas Natural Resources Commission and was the first State Climatologist for Arkansas. We celebrated the retirement of two legacy builders, Nolan Doesken and Harry Hillaker. Nolan retired in August 2017 after 40 years of service to Colorado State University, 11 of those as Colorado's State Climatologist. He was President of the AASC from 2008-2010. Nolan's legacy includes Founder of CoCoRaHS, the Community Collaborative Rain, Hail and Snow network (20,000 volunteers and growing). Harry retired in March 2018 after an accomplished career as Iowa's State Climatologist. Harry was hired by Paul Waite in 1981 and would eventually succeed Wait in 1988 as only the second Iowa State Climatologist in the State's history. Harry served as the AASC Secretary-Treasurer from 2009 to 2010. We welcomed Russ Schumacher, Colorado State Climatologist, Justin Glisan, Iowa State Climatologist, and Whitney Montague, Arkansas State Climatologist. Luigi Romolo took over as the Minnesota State Climatologist in March 2017 and will begin serving as the AASC Treasurer in January 2019. Finally yet importantly we wish the best to Aaron Simms from North Carolina and Dev Niogi from Indiana as they both move into new positions and will no longer be serving as State Climatologist. Walt Robinson is serving as Interim Director of the North Carolina State Climate Office.

Our membership is growing slowly with 11 new Associate Members joining in 2018 and 8 in 2017. A limitation is the requirement that new Associate Members can only be voted upon at the Annual Meeting. In my opinion this is an issue that we need to address. However, this past year we created a Student Membership level and those members can join anytime. I do want to also remind the membership that 4 years ago we voted to expand the traditional membership structure consisting of full and associate memberships, to include institutional memberships at two levels: Institutional Leaders and Institutional Associates. We continue to depend on this revenue to support the Executive Director position. Many thanks to the eleven states

for their investment in the AASC during 2017 (Institutional Leaders: Alabama, Kentucky, Delaware, New Jersey, Colorado, and South Carolina / Institutional Associates: Washington, Missouri, Pennsylvania, Texas, and Minnesota). I know this is not possible for some states, but for others it may be possible just not easy or comfortable.

As I pass the torch, I want to leave you with seven challenges:

1. **Become an Institutional Member.** Take that step and make the investment this year even if it means having that not so easy talk with your Dean or supervisor.

2. **Invite Someone New to Next Year's Annual Meeting.** We had 103 attendees in Asheville and 95 in Nebraska City. Let's shoot for 119 in 2019.

3. **Encourage Student Memberships.** I know most of you work with or know students. Students can become members at any time during the year they don't have to be voted upon at the Annual Meeting. For the price of four Starbuck's Lattes they can become an AASC Student Member ($20 annually).

4. **Join a Committee / Consider Chairing a Committee.** We have nine Standing Committees http://www.stateclimate.org/node/182 . Most of them need new energy so whether you are already a member of the committee or willing to serve don't sit back waiting on a directive make it happen.

5. **Consider serving as Secretary or President.** We have a Nominating Committee that is tasked with identifying suitable candidates, but it would be terrific if they knew in advance if certain members were interested in serving. So if you are interested or would like to recommend someone please contact *Lesley-Ann Dupigny-Giroux, Tim Brown, Jeff Andresen or Hope Mizzell.*

6. **Corporate Members Needed** We voted in 2018 to add a Corporate Membership Level. Yes we had to build it for them to come, but we can't expect they are going to flock toward the AASC. Glenn can seek out potential members, but the chances of sealing the deal is much greater when a personal or professional connection is already in place.

7. **No News Is Bad News** We tried this past year to get the AASC Monthly Newsletter established and honestly we had limited success. We are going to give it a try again this year, but we need your help!! Please send Glenn at least one item to be included in the newsletter. Consider sharing research results, product development or bragging on your team.

So, whether you've been a member of the AASC for 25+ years, one year, or somewhere in between, I encourage you to maximize the value of your membership by getting involved. Thank you again for your confidence in me and your support over the past two years. I'm excited about what the future holds for our organization. I look forward to seeing you at our 2019 AASC Family Reunion (Annual Meeting) in California!

Sincerely,
Hope Mizzell, Ph.D.
AASC President

About the American Association of State Climatologists

The American Association of State Climatologists (AASC) is a professional scientific organization composed of state climatologists (one per state), directors of the six Regional Climate Centers and associate members who are persons interested in the goals and activities of the Association. State Climatologists are individuals who have been identified by a state entity as the state's climatologist and who are also recognized by the Director of the National Centers for Environmental Information of the National Oceanic and Atmospheric Administration as the state climatologist of a particular state.

State Climatologists currently exist in 48 states and Puerto Rico. They are typically either employees of state agencies or are staff members of state-supported universities. Associate members may be assistant state climatologists or other climatologists under the employment of the state climatologist, representatives of federal climate agencies, retired state climatologists, or others interested in climate services. For more info, see http://lwf.ncdc.noaa.gov/oa/climate/stateclimatologists.html

ARSCO

A state climate office may gain status as the AASC-Recognized State Climate Office (ARSCO) by providing:

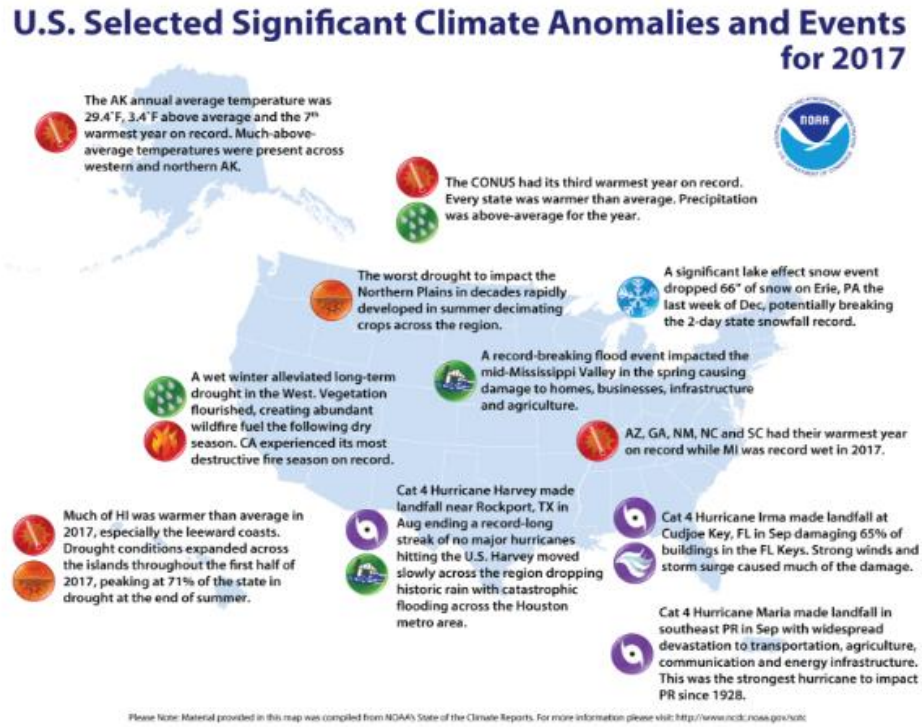
1. A document detailing current and planned activities meeting ARSCO requirements;
2. A letter of support from the state's Regional Climate Center Director;
3. A letter of support from at least one National Weather Service Forecast Office serving the state.

Candidate offices must demonstrate the following capabilities:

- Communication capabilities – the office must be able to communicate with its clientele via multiple media, including telephone, Internet, mail, E- mail, and fax;
- Information services – the office must be capable of providing a range of data and information;
- Research – the office must conduct research on climate and human activities;
- Outreach – the office should design products and services for education, climate information, awareness, and the media;
- Monitoring and assessments – monitoring climate conditions, evaluating future impacts, and providing historical context to events are activities conducted by ARSCOs.

Upon receipt of the materials and approval of the AASC Executive Board, a Memorandum of Agreement (MOA) with the National Centers for Environmental Information shall be issued. Currently, 38 states have received ARSCO status.

2017 United States Climate Summary



2017 National Events Map

Click for more information

Issued January 12 2018: *Unless otherwise noted, temperature and precipitation rankings refer to a 123-year period of record (1895-2017), and long-term average refers to the 20th century (1901-2000) value. Data for 2017 should be considered preliminary. The most up-to-date temperature and precipitation data is available through Climate at a Glance.*

HIGHLIGHTS

66" of snow fell on Erie, PA due to a strong lake effect, potentially breaking the 2-day state snowfall record.

By the end of summer, 71% of HI was in drought. The Northern Plains experienced the worst drought in decades.

Cat 4 hurricanes Harvey, Irma, and Maria all made landfall in the US.

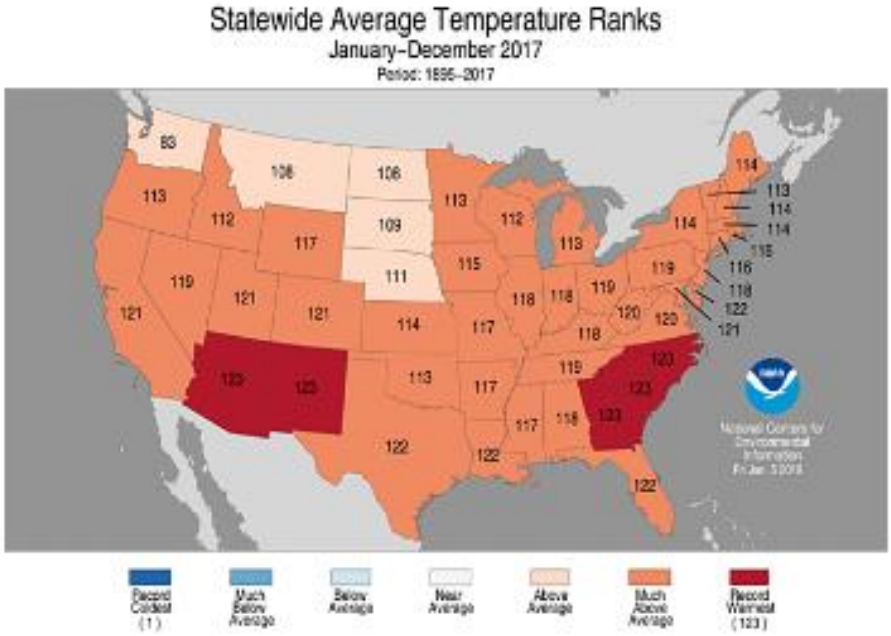
CA experienced its most destructive wildfire season on record.

Catastrophic flooding occurred in the Houston, TX area from Hurricane Harvey. Record-breaking floods impacted the Mississippi Valley.

The CONUS experienced above-average precipitation for the year. The West had a wet winter, relieving drought conditions. MI had its record wetness.

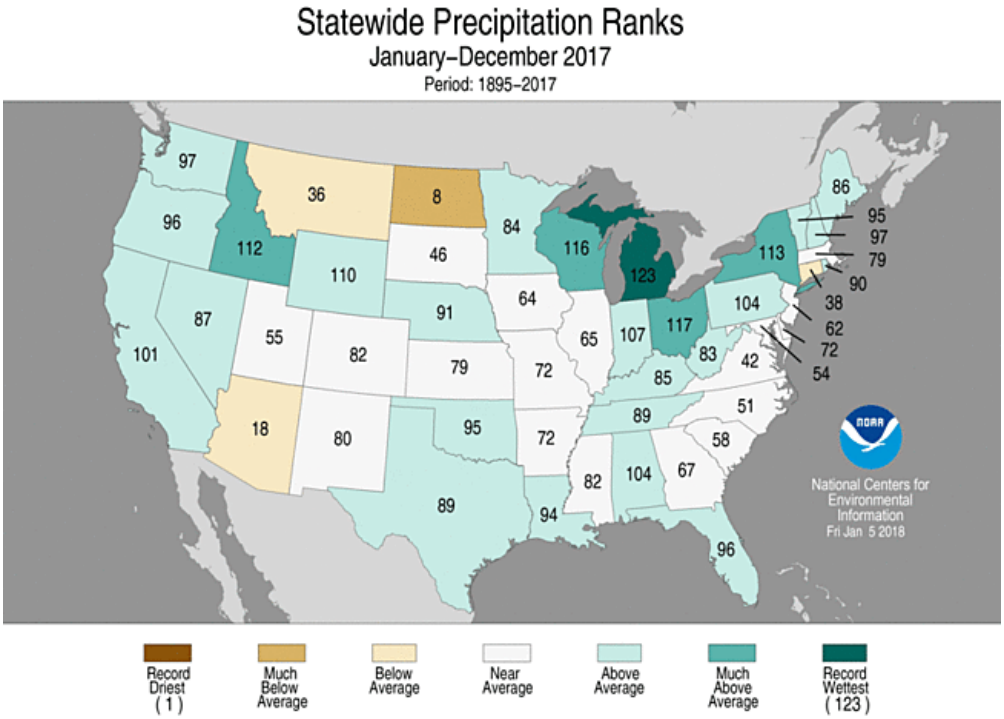
The CONUS had its third warmest year on record. AZ, GA, NM, NC, and SC all had their record warmest year. AK and HI were significantly warmer than average.

ANNUAL TEMPERATURE AND PRECIPITATION ANALYSIS



Based on preliminary analysis, the average annual temperature for the contiguous U.S. was 54.6°F, 2.6°F above the 20th century average. This was the third warmest year since record keeping began in 1895, behind 2012 (55.3°F) and 2016 (54.9°F), and the 21st consecutive warmer-than-average year for the U.S. (1997 through 2017). The five warmest years on record for the contiguous U.S. have all occurred since 2006. Since 1895, the CONUS has observed an average temperature increase of 1.5°F per century. Nationally, the average minimum (low) temperature was 42.8°F, the fourth warmest on record, while the average maximum (high) temperature was 66.4°F, the fifth warmest on record.

For the third consecutive year, every state across the contiguous U.S. and Alaska had an above-average annual temperature. Despite cold seasons in various regions throughout the year, above-average temperatures, often record breaking, during other parts of the year more than offset any seasonal cool conditions. Five states – Arizona, Georgia, New Mexico, North Carolina and South Carolina – had their warmest year on record. Thirty-two additional states, including Alaska, had annual temperatures that ranked among the 10 warmest on record.



The contiguous U.S. average annual precipitation was 32.21 inches, which is 2.27 inches above the long-term average. This made 2017 the 20th wettest year on record for the nation, and the fifth consecutive year with above-average precipitation. Since 1895, precipitation across the CONUS has increased at an average rate of 1.67 inches per century.

Above-average precipitation was observed across the nation with much-wetter-than-average conditions across parts of the West and the Great Lakes region. Michigan had its wettest year on record with 39.23 inches of precipitation, 8.10 inches above average. Below-average precipitation was observed in parts of the Southwest, Northern Rockies and Northern Plains.

Several large-scale flooding events impacted the nation during 2017 including the record-shattering rainfall across Texas and Louisiana associated with Category 4 Hurricane Harvey – the first major hurricane to make landfall in the U.S. since in 2005. Rainfall totals exceeded 60 inches in parts of Texas with devastating floods across the Houston metro area. Another heavy rain event impacted the Mid-Mississippi Valley in April and May. Numerous tributaries of the Mississippi River had record high crests, breaching levees with widespread damage to homes, businesses, infrastructure and agriculture.

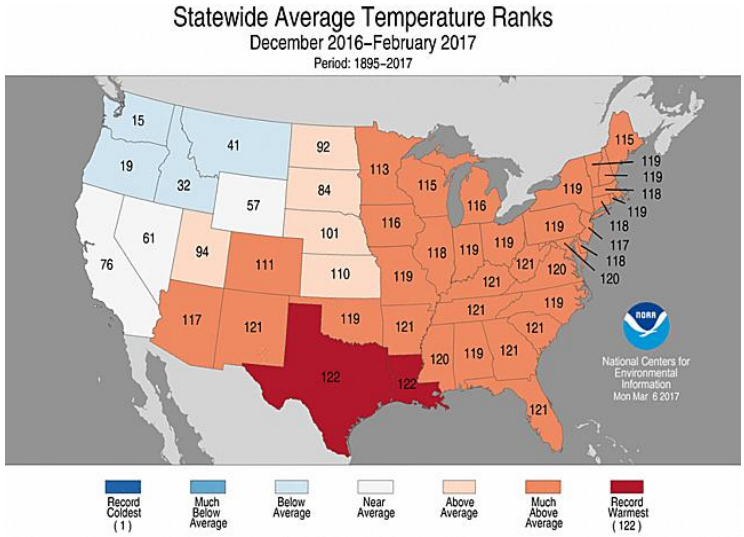
Drought conditions changed dramatically throughout 2017. According to the U.S. Drought Monitor, the year began and ended with about one-quarter of the contiguous U.S. in drought. The drought footprint reached a low of 4.5 percent in late May, the

smallest drought footprint in the 18-year period of record for the U.S. Drought Monitor.

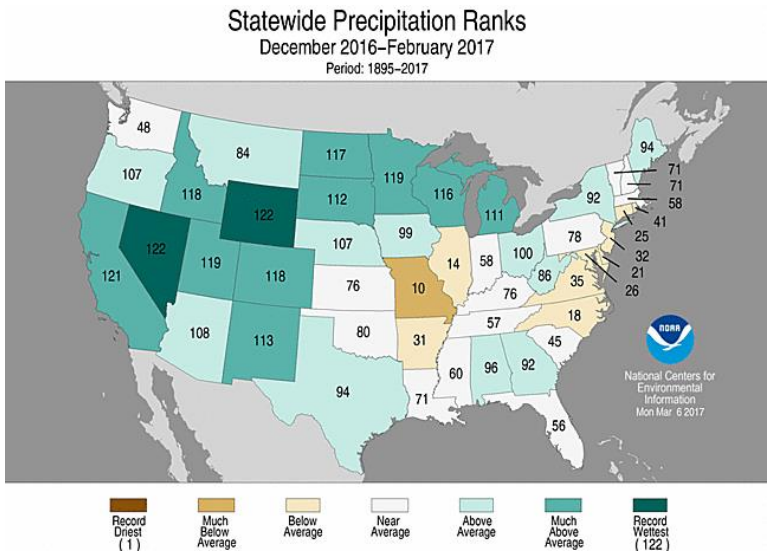
- Heavy precipitation during the winter season caused significant flooding and record high snowpack across the West and helped to end a multiyear drought impacting California and Nevada. However, the wet winter allowed vegetation to flourish creating an abundance of fuels for wildfires during the subsequent dry season.
- A dry spring and summer set the stage for a rapidly expanding and intensifying drought in the Northern Plains, causing widespread agricultural impacts with total losses exceeding $1 billion.
- Lingering drought from 2016 in the Southeast persisted into early 2017, but beneficial precipitation helped eliminate drought conditions by summer. Dryness returned to the South in late 2017 with drought developing and expanding – especially in the Southwest, Southern Plains, Lower Mississippi Valley and Southeast.

SEASONAL ANALYSIS

Winter

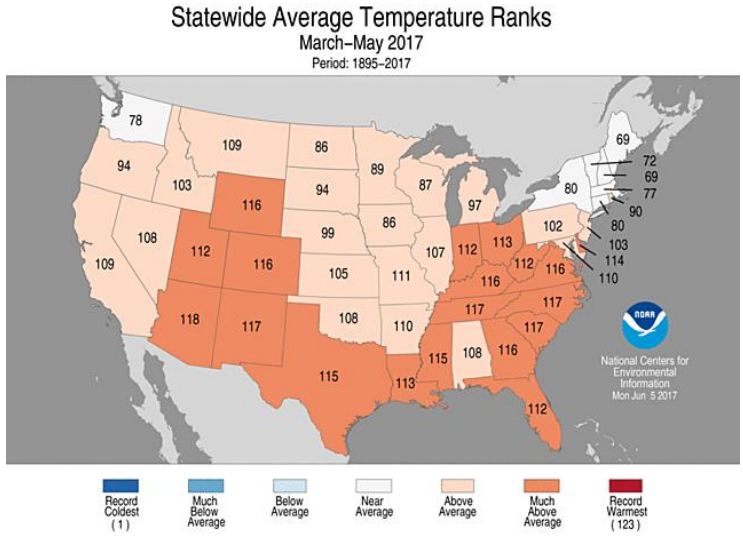


- The average winter temperature for the Lower 48 was 35.9°F, 3.7°F above the 20th century average. This was the seventh warmest winter on record for the CONUS. Thirty-five states across the contiguous U.S. had a winter temperature that was much above average. Texas and Louisiana had their warmest winter on record.
- The December-February average temperature is rising at a rate of 2.2°F per century since records began in 1895.
- Alaska had a near-average December-February temperature and was slightly drier than average.

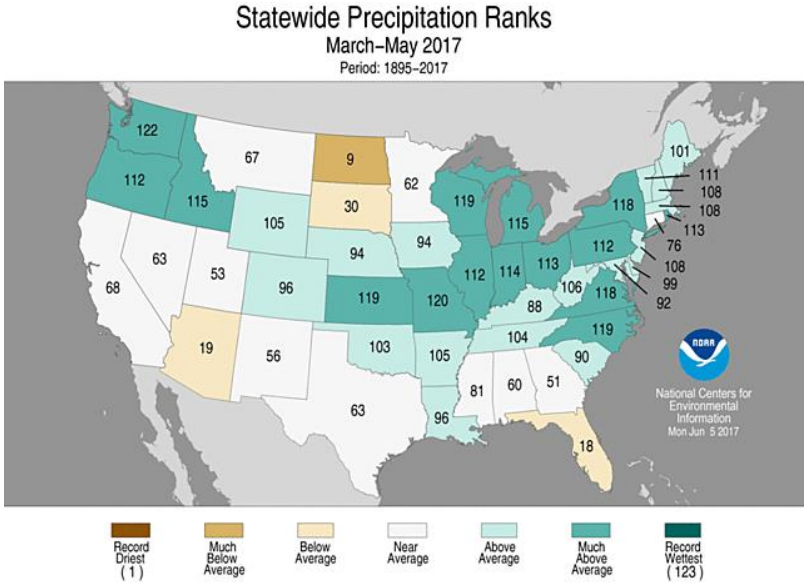


- It was the ninth wettest winter for the CONUS and the wettest since 1997/98.
- Twelve states across the West, Northern Plains and Midwest had winter precipitation totals that were much above average. Nevada and Wyoming were record wet. California had its second wettest winter helping alleviate a multi-year drought.
- Hawaii had a dry winter with nearly all locations across the islands observing below-average precipitation. Parts of the Big Island received above-average precipitation. By the end of February about seven percent of the state was in moderate drought.
- There were three weather and climate disaster during winter that had losses exceeding $1 billion — a January severe weather outbreak in the South, a severe weather outbreak in the central U.S. and Southeast and a flooding event in California.

Spring

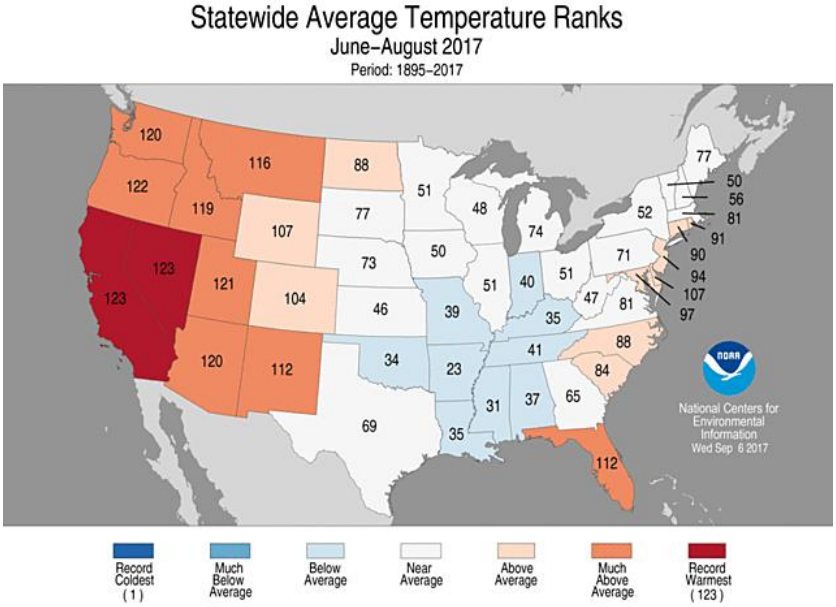


- The average spring temperature for the Lower 48 was 53.5°F, 2.6°F above the 20th century average. This was the eighth warmest spring on record for the CONUS. Above-average temperatures spanned most of the nation with 20 states much warmer than average. No state was record warm or record cold.
- The March-May average temperature is rising at a rate of 1.5°F per century since records began in 1895.

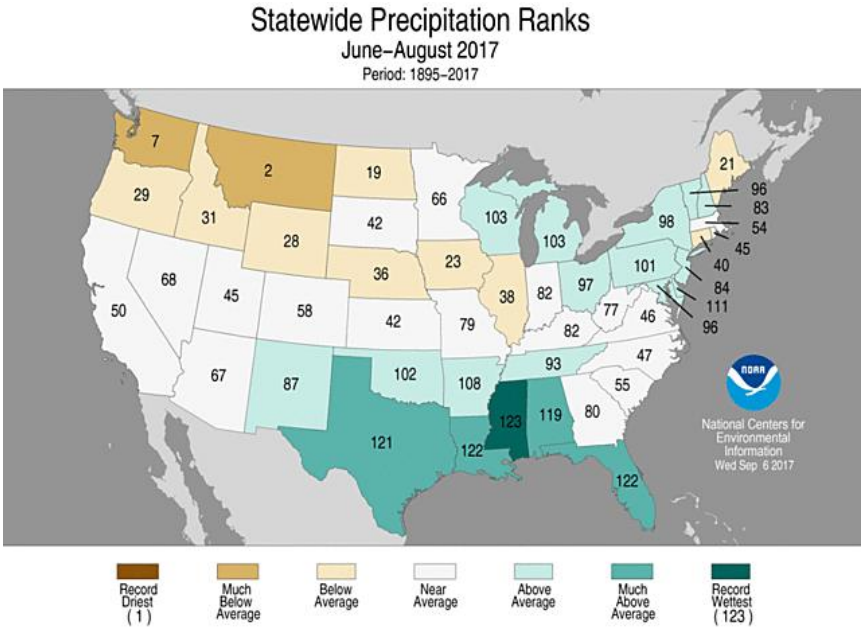


- It was the 10th wettest spring for the CONUS and the wettest since 2011. Three states in the Northwest and twelve states across the Central Plains, Midwest and along the East Coast were much wetter than average. Parts of the Northern Plains, Southwest and Southeast were drier than average. Alaska had its 10th driest March-May on record.
- By the end of May, drought had started to develop in the Northern Plains. Extreme drought was also observed in Florida, where numerous wildfires burned.
- There were six weather and climate disaster during spring that caused losses exceeding $1 billion — three individual severe weather outbreaks, a freeze events in the Southeast, significant flooding in Missouri and Arkansas and the start of a significant drought in the Northern Plains.

Summer

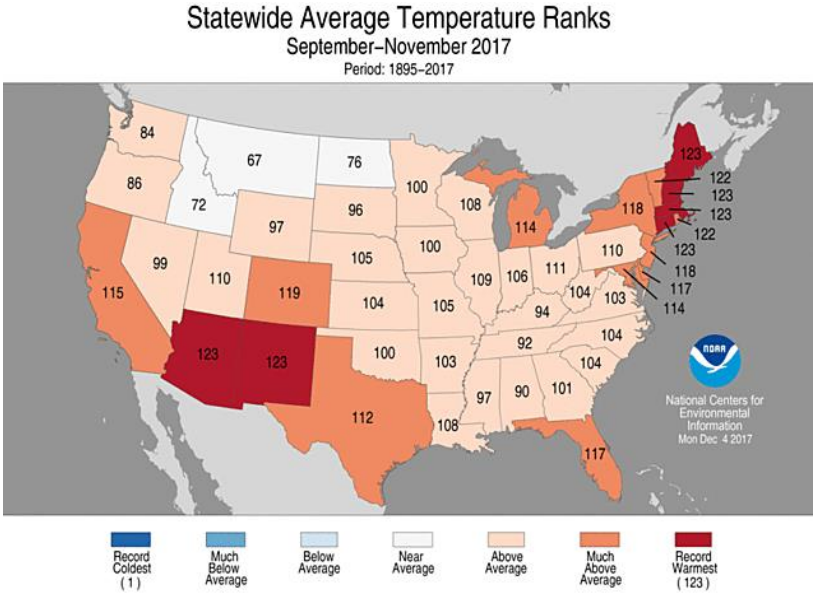


- The average summer temperature for the CONUS was 72.7°F, 1.3°F above the 20th century average. This was the 15th warmest summer on record for the CONUS, but the coolest since 2014. Much of the West was warmer than average with California and Nevada each having their warmest summer on record. Parts of the East Coast were also warmer than average.
- Near- to below-average temperatures were observed across large parts of the central U.S. to Gulf Coast.
- The June-August average temperature is rising at a rate of 1.5°F per century since records began in 1895.

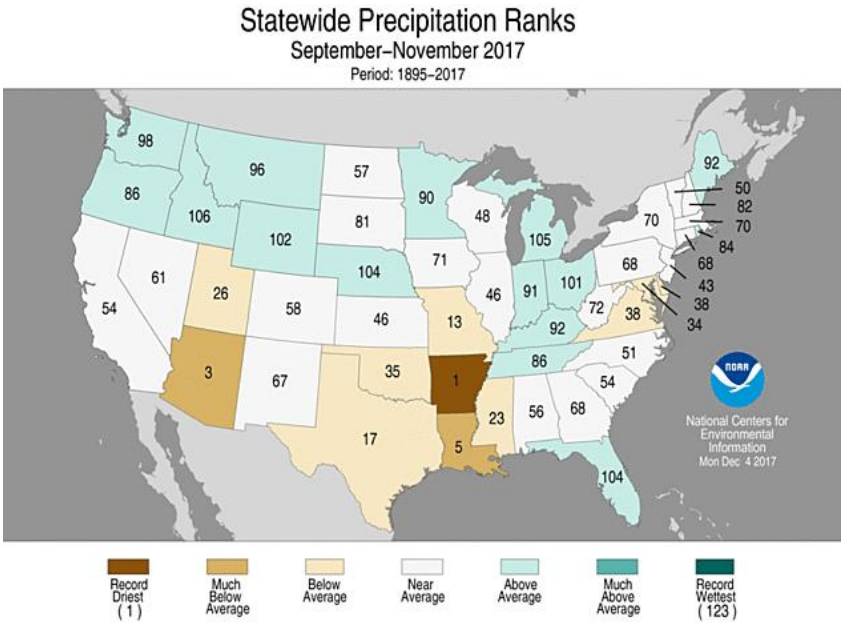


- It was the 13th wettest summer for the CONUS. Above-average precipitation accumulated along the Gulf Coast, Midwest, and Northeast. Louisiana and Mississippi were record wet. Below-average precipitation fell in the Northwest, Northern Rockies, and parts of the Northern Plains and Midwest.
- Hurricane Harvey made landfall in Texas in late August causing record breaking flooding and over $100 billion in damages. Harvey was the second costliest weather and climate disaster on record to impact the United States.
- There were five weather and climate disaster during summer that caused losses exceeding $1 billion — three individual severe weather outbreaks, the start of the wildfire season in the West and Hurricane Harvey.

Autumn



- The average autumn temperature for the CONUS was 55.7°F, 2.1°F above the 20th century average. This was the 10th warmest autumn on record for the CONUS, but the coolest since 2014. It was also the 11th consecutive autumn with temperatures above average for the CONUS.
- The majority of the nation was warmer than average with near-average conditions in the Northern Rockies and Plains. In the Southwest, Arizona and New Mexico were record warm while in the Northeast, Connecticut, Massachusetts, Maine and New Hampshire were record warm.
- The September-November average temperature is rising at a rate of 1.2°F per century since records began in 1895.



- It was a drier than average autumn for the CONUS. Above-average precipitation was observed in parts of the Northwest, Great Plains, Midwest and in Florida and Maine. Below-average precipitation was observed in the Southwest, Southern Plains, Lower Mississippi Valley and Mid-Atlantic. Arkansas had it driest autumn on record. Drought conditions developed rapidly across a large portion of the southern U.S..
- Hurricane Irma made landfall in Florida in September bringing heavy rain to Florida and storm surge to both the Gulf Coast and Atlantic Coast of the state northward into the Carolinas.
- There were two weather and climate disaster during autumn that caused losses exceeding $1 billion — Hurricanes Irma and Maria.

2017 Regional Center Summaries

NORTHEAST REGION

Northeast Regional Climate Center

The Northeast had its seventh warmest year on record. The region's average temperature of 48.8 degrees F (9.3 degrees C) was 1.6 degrees F (0.9 degrees C) above normal. All twelve states ranked 2017 among their eleven warmest years on record: Delaware, second warmest; Maryland, third warmest; West Virginia, fifth warmest; New Jersey, sixth warmest; Pennsylvania, seventh warmest; Connecticut and Rhode Island, eighth warmest; Maine and Massachusetts, 10th warmest; and New Hampshire, New York, and Vermont, 11th warmest. Departures ranged from 1.2 degrees F (0.7 degrees C) above normal in Maine to 2.4 degrees F (1.3 degrees C) above normal in Delaware. It was the warmest January on record for Bridgeport, Connecticut. The Northeast had its warmest February since 1895 with an average temperature of 32.8 degrees F (0.4 degrees C), 6.6 degrees F (3.7 degrees C) above normal. Delaware, Maryland, New Jersey, New York, Pennsylvania, and West Virginia had a record warm February. Nineteen of the Northeast's 35 major climate sites also had their warmest February on record. In addition, seven major climate sites had their warmest February day or winter day on record on February 24 or 25. February's above-normal temperatures contributed to Baltimore, Maryland, and Huntington, West Virginia, receiving only a trace (less than 0.1 inches [0.3 cm]) of snow during the month, with both sites tying their records for least snowy February. Dulles Airport, Virginia, had its warmest winter on record. With an average temperature of 50.6 degrees F (10.3 degrees C), 4.6 degrees F (2.6 degrees C) above normal, April 2017 tied April 2010 as the warmest on record for the Northeast. April 2017 was the warmest on record for Delaware, Maryland, New Jersey, Pennsylvania, and West Virginia. Fourteen of the region's 35 major climate sites also had a record warm April. On May 18, LaGuardia Airport, New York, and Burlington, Vermont, tied their warmest spring temperatures on record. On June 13, LaGuardia Airport, New York, tied its all-time warmest June day on record. The following week, on June 19, Caribou, Maine, tied its all-time warmest June low temperature on record. In September, nine major climate sites experienced a heat wave (three or more consecutive days of at least 90 degrees F [32 degrees C]) sometime between the 23rd and 27th. For some sites, such as Burlington, Vermont, and Albany, New York, it was the latest heat wave in a calendar year. In fact, it was Albany's first recorded heat wave in astronomical autumn. The Northeast had its second warmest October since recordkeeping began with an average temperature of 55.7 degrees F (13.2 degrees C), 6.3 degrees F (3.5 degrees C) above normal. The record warmest October was 55.8 degrees F (13.2 degrees C) in 2007, only 0.1 degrees F (0.1 degrees C) warmer than

October 2017. It was the warmest October on record for the six New England states. In addition, eleven of the region's 35 major climate sites had a record warm October. On October 8 or 9, ten major climate sites had their warmest minimum temperature for October. Later in the month, on the 25th, Caribou, Maine, broke their record for warmest October minimum temperature that was set earlier in the month. In fact, Caribou's top three warmest minimum temperatures for October were all set or tied in 2017. Connecticut, Maine, Massachusetts, and New Hampshire had their warmest autumn since recordkeeping began. Four major climate sites also had their warmest autumn on record: Burlington, Vermont; Concord, New Hampshire; Islip, New York; and Providence, Rhode Island. On November 7, Rochester, New York, had its first 32 degrees F (0 degrees C) freeze, making it the site's second longest frost free season (time between last spring freeze and first fall freeze) since 1872. With its first freeze on November 10, Dulles Airport, Virginia, was one day short of tying its record for latest first freeze (November 11, 2005). It was the first time since 1963 that both Dulles Airport and Washington National, D.C., had their first freeze on the same date.

2017 averaged out to be slightly wetter than normal for the Northeast. The region received 46.30 inches (117.6 cm) of precipitation, 104 percent of normal. Seven states were wetter than normal, with precipitation for all twelve states ranging from 88 percent of normal in Connecticut to 111 percent of normal in New York, its 11th wettest. Also, Pennsylvania had its 20th wettest year. On April 20, Buffalo, New York, had its wettest April day on record, which contributed to the site having its wettest April on record. Buffalo and Rochester, New York, received an entire May's worth of rain in just the first week, which contributed to the sites having their second wettest spring on record. Maryland had its third wettest July since record keeping began. On July 29, Atlantic City, New Jersey, had its second wettest July day on record. On November 5, Erie, Pennsylvania, had its largest one-day precipitation total for November since records began. Erie also had its wettest December on record.

A storm brought up to 24 inches (61 cm) of snow and wind gusts of up to 70 mph (31 m/s) to the region from February 9 to 10. Blizzard conditions occurred for up to seven hours at 38 sites in New Jersey, New York, and New England. The intense system produced snowfall rates of 2 to 3 inches (5 to 8 cm) per hour, as well as thundersnow in several locations. Travel was severely impacted, with hundreds of vehicle crashes and thousands of flight cancellations. A few days later, from February 12 to 13, another storm dropped more than 12 inches (30 cm) of snow on much of northern New England, with the greatest totals of up to 40 inches (102 cm) in Maine. Wind gusts of up to 72 mph (32 m/s) contributed to power outages and led to whiteout conditions in the region. A third storm, from February 15 to 16, dropped up to 21 inches (53 cm) of snow on northern New England. In the 10-day span from February 7 to 16, up to 60 inches (152 cm), or 5 feet (1.5 m), of snow fell in portions of Maine. According to the National Weather Service office in Gray, the second

greatest one-day snow depth on record for Maine occurred on February 16 in Andover, which had 79 inches (201 cm), or 6.6 feet (2 m), of snow on the ground.

From March 14 to 15, a powerful nor'easter impacted the Northeast. Snow totals in the hardest hit areas ranged from 24 to 48 inches (61 to 122 cm). Binghamton, New York set a new all-time 24-hour snowfall record, picking up 31.3 inches (79.5 cm) from 3 am on March 14 to 1 am on March 15. The old record of 23 inches (58 cm) was set in February 1961. By the end of the storm, the site already had its snowiest season (October through May) on record, and by May 31, the site's season snow total sat at a record 135.2 inches (343.41 cm). The previous year, in 2015-16, Binghamton had its least snowy season on record with 32.0 inches (81.3 cm) of snow. Scranton, Pennsylvania, had its all-time snowiest day on record with 22.1 inches (56.1 cm) on March 14, beating its old record of 18.7 inches (47.5 cm) set on March 13, 1993. In addition, the 14th was the snowiest March day on record for four major climate sites. Atlantic City, New Jersey received 3.02 inches (76.71 mm) of precipitation (almost all of which fell as rain) on March 14, making it the site's wettest March day on record. Strong winds, hurricane-force in some areas, accompanied the storm. For instance, preliminary data indicated a gust of 79 mph (35 m/s) in Wellfleet, Massachusetts and blizzard conditions occurred for four hours in Lawrence, Massachusetts. The winds downed trees and power lines, contributed to thousands of power outages, and caused rough seas that led to some erosion and coastal flooding. Travel was hampered by the storm, with several travel bans enacted in the region and thousands of flights cancelled nationwide. In northeastern Pennsylvania, at least two small avalanches blocked roads.

Preliminary data from the U.S. Army Corps of Engineers indicated that the Lake Ontario basin had its wettest May since 1900 and the lake had its all-time highest monthly mean water level since 1918. Above-normal precipitation during spring contributed to record-high water levels on Lake Ontario and the St. Lawrence River, which resulted in flooding and significant erosion along those waterways in New York. Homes and buildings were flooded, roads were closed, and boat launches, docks, and beaches were submerged. The high water washed away land, trees, and breakwalls, and left a few homes and cottages on the verge of falling into the lake. High water levels continued to cause flooding and erosion along the Lake Ontario and St. Lawrence River shorelines during summer. In Sodus Point, New York, boats could not access the lake because docks and ramps were under water, leading to reduced tourism revenue. Flooding damage was estimated to be up to $2 million in Ogdensburg, New York.

During July, there were multiple extreme rainfall events in the region that exceeded the 100-year return period, meaning rainfall of that magnitude has a 1 percent chance of occurring in a given year. A particularly notable event occurred on July 23 when 4.27 inches (108.46 mm) of rain fell in one hour at the Harrisburg International Airport in Pennsylvania. Downpours and wet conditions led to flash flooding in

many parts of the region, with impacts such as numerous washed out or impassable roads, hundreds of flooded basements and damaged buildings, stranded vehicles, water rescues, evacuations, and several mudslides. Agriculture was also affected. USDA crop reports from July indicated the wet conditions led to flooded and muddy fields, delayed harvest and reduced quality of hay, and stunted corn growth in wet fields. Runoff from the heavy rains contributed to high levels of bacteria along the southern New Jersey coastline, causing 15 beaches to close, as well as harmful algal blooms on several waterways including Lake Erie and Cayuga Lake, one of New York's Finger Lakes.

A powerful storm brought heavy rain, high winds, and some snow to the Northeast from October 28 to 30, with the most significant impacts in New England. The highest rainfall total was 6.38 inches (162.05 mm) in southern Vermont. The heavy rain caused flooding but also helped ease drought conditions in the region. Snow totals of up to 8.4 inches (21.3 cm) were reported in higher elevations of northern West Virginia and western Maryland. Wind gusts of up to 93 mph (42 m/s) downed trees and wires. More than 1,400 poles were snapped in Maine. News reports indicated nearly 1.5 million customers lost power in the Northeast, some for almost a week. More than 400,000 Central Maine Power customers lost power, making it the 'largest number of outages in the company's history.' In New Hampshire, more than 350 roads were closed due to flooding and high winds. In addition, hundreds of schools were closed, with some having to extend the school year farther into summer.

There were several notable tornado events in the Northeast during the year. On February 25, an EF-1 touched down in western Massachusetts. According to the Taunton National Weather Service office, 'there has never been a tornado during the month of February since official tornado statistics have been kept, dating back to 1950' in Massachusetts. On May 1, Pennsylvania had eight tornadoes, which is more than double the state's average for May (based on data from the NOAA's Storm Prediction Center from 1989-2013). In Maine, a state that averages only two tornadoes a year, the Gray National Weather Service office issued seven tornado warnings on July 1, their greatest number in recorded history. Five weak (EF-0 or EF-1) tornadoes touched down, the most Maine has had in a single day. Clarion County, Pennsylvania, had six tornadoes from May through July; however, between 1950 and 2016 the county only had eight tornadoes, according to the National Weather Service in Pittsburgh. Two tornadoes touched down in western Pennsylvania in November, one in Erie County and one in Allegheny and Westmoreland counties. Data from the National Centers for Environmental Information's Storm Events Database (records to 1950) indicated that it was the first tornado in November and the latest in a calendar year for Allegheny County and only the second November tornado and the second latest in a calendar year for Erie and Westmoreland counties.

Erie, Pennsylvania, experienced a historic snow event from December 24 to 26 that

shattered numerous records. On the 25th, the site had its all-time snowiest day on record with 34.0 inches (86.4 cm) of snow. The previous record was 20.0 inches (50.8 cm) on November 22, 1956. The following day, on the 26th, the site received 26.5 inches (67.3 cm) of snow, which made it the second all-time snowiest day on record. Preliminary data indicates that the two-day snow total of 60.5 inches (153.7 cm) is the all-time greatest 2-day snowfall for Pennsylvania. The previous record was 46.0 inches (116.8 cm) in Seven Springs from March 13 to 14 in 1993. Erie wrapped up December with 121.3 inches (308.1 cm) of snow, making it the site's all-time snowiest month on record. The previous record was 66.9 inches (169.9 cm) in December 1989. Erie's 121.3 inches (308.1 cm) of snow in December 2017 is the all-time greatest monthly snowfall for Pennsylvania. The previous record was 117.8 inches (299.2 cm) in Laurel Summit in February 2010.

MIDWEST REGION

Annual averaged temperatures in the Midwest were well above normal. The region as a whole averaged 1.8 degrees F (1.0 C) above normal ranking it as the 8th warmest year (records began in 1895). All nine Midwest states ranked among the warmest 10 percent (top-12) of their records with each ranking between 5th and 12th. January (9th), February (2nd), and April (12th) ranked among the warmest 10 percent for the region as a whole, with six, nine, and eight states likewise ranked among the warmest 10 percent in those respective months. New record high average temperatures in April were set at some stations with very long histories in Kentucky (Louisville and Lexington, both with records back to 1872) and Ohio (Akron 1887, Cleveland 1871, and Columbus 1878). The old April records at Columbus, Louisville, and Lexington were from 1896, more than 120 years ago. August was notably cool with three states ranking among the coolest 10 percent of their records — Illinois 10th, Iowa 8th, and Missouri 7th. Warmth in September had Michigan and Wisconsin ranked among the warmest 10 percent. Following a hot and humid spell in mid July, there was a cool 6-week period that extended into early September. Temperatures in the latter half of September were, for many Midwest locations, the hottest of the year. Chicago had a string of seven consecutive record high days, September 20th-26th, each with maximum temperatures above 90 degrees F (32 C). December was generally warm for the first three weeks but then around Christmas temperatures fell to much below normal. The last seven days of the year were the coldest of the season, and for most locations the coldest of 2017. Temperatures dropped to -40 degrees F (-40 C) in northern Minnesota and to zero degrees F (-18 C) as far south as Missouri and Kentucky. The 7-day period had average minimum temperatures below zero degrees F (-18 C) for most of the northern half of the region.

Precipitation was generally on the wet side (ranked 27th wettest since 1895) in 2017 for the Midwest but there was a lot of variability. Michigan had its wettest year, and Ohio (7th) and Wisconsin (8th) also ranked among the wettest years while Illinois, Iowa, and Missouri were below normal. In February, Illinois and Missouri ranked among the driest 10 percent. From April through November, each month except September had at least one state ranked among the wettest 10 percent in their history. There were a total of 15 cases of a state with a monthly value among the wettest 10

percent during these months with all nine states having at least one. Missouri in April and Michigan in October set records for the wettest month. Tecumseh, MO (period of record, 1942-present) received 17.48 inches (444 mm) of precipitation in April, breaking the previous monthly precipitation record of 14.43 inches (367 mm) set in 1957.

In September, the remnants of Hurricane Harvey brought heavy rains to Kentucky in the first few days of the month while three states (Illinois, Michigan, and Missouri) ranked among the driest 10 percent. More dry months were recorded in November (Missouri ranked 11th driest) and December (Iowa 5th and Illinois 7th). Spring ranked as the 6th wettest for the Midwest while the fall saw numerous extremes of both wet and dry.

Drought in the Midwest during 2017 was limited in areal coverage but still intense in a few locations. The year began with moderate drought mostly in Missouri. Drought expanded to a peak at 13 percent of the Midwest in March before spring rains wiped out all Midwest drought. In early May, there was no drought and no abnormally dry areas in the region for the first time since May of 2002. Late summer and fall saw new drought development around the region with southern Iowa having extreme drought from mid-August to early October. Areal coverage peaked at about 12 percent of the region in early October when scattered areas of drought touched every Midwest state except Kentucky. In the last three months of 2017, drought expanded in Missouri and neighboring parts of Iowa and Illinois while ending in other parts of the Midwest except in north central Minnesota.

Seasonal snowfall for the winter of 2016-17 was well below normal for much of the region. The only above-normal areas were in northwestern Minnesota and a swath from north central Iowa to northeastern Wisconsin. The southern half of the Midwest had seasonal totals ranging from 10 to 50 percent of normal.

It was a slow start to the 2017-18 snow season overall. The first significant snow of the season fell in late October in northern Minnesota and the Upper Peninsula of Michigan with totals up to a foot (30 cm). There was little snowfall in November. Lake-effect snows began in earnest in early December as the nearly ice-free and relatively warm Great Lakes provided ideal conditions. Heavy snow fell down wind of the lakes through mid-December and then again in the last week of the year. Away from the Great Lakes, in southern Minnesota through southern Wisconsin, seasonal snowfall deficits topped 10 inches (25 cm).

A number of lakes in southern and central Minnesota froze in November but then melted again. Most Minnesota lakes were frozen over by mid-December.

There was a late freeze in northern and eastern parts of the Midwest in May. Freezing temperatures touched all Midwest states except Missouri. Temperatures fell below 25

degrees F (-4 C) in Minnesota, Wisconsin, and Michigan with reports of damage to fruit trees in Michigan. An early freeze on August 25th in the Arrowhead of Minnesota and the Upper Peninsula of Michigan, brought the growing season to an early end.

The total solar eclipse on August 21st was the first to pass across the Midwest since 1925. The path of totality crossed Missouri, southern Illinois, and western Kentucky and the remainder of the region had a partial eclipse. Viewing in the Midwest was generally good but a frontal boundary limited viewing for parts of Iowa, Minnesota, Wisconsin, and northern Illinois.

Heavy rains in the southern Midwest in late April, brought widespread flooding. Southern Missouri was very hard hit with locations picking up more than 10 inches (254 mm) of rain in just two days. Interstate 44 was closed after parts of the roadway were washed away by floodwaters. Four deaths and more than 100 rescues were related to flooding in southern Missouri. Many Midwest corn and soybean fields had ponding or saturated soils that caused many acres to be replanted.

There were four deadly tornadoes in 2017 with five deaths. Two tornadoes in Illinois killed three on February 28th, another in Missouri the same day killed one, and a Wisconsin tornado on May 16th was responsible for 1 death and 25 injuries. Iowa had a busy day early in the year, with 18 tornadoes on March 6th. On November 5th, 21 Midwest tornadoes included 17 in Ohio alone. The Ohio tornado count for the day was nearly equal to the average annual total of 20 tornadoes.

Non-thunderstorm winds were deadly in three other cases in 2017. On March 8th, two deaths were caused when high winds blew down a tree onto a vehicle. On May 17th, strong winds in Missouri felled a rotten tree killing one person and in central Illinois died in a multiple vehicle accident caused by low visibility in a dust storm.

SOUTHEAST REGION

The top 10 weather and climate extremes that occurred across the region during the year are designated with 'Extreme' in parentheses. The numbers associated with each extreme are used as identifiers rather than rankings.

Temperatures were exceptionally warm across much of the Southeast region during the year, with annual departures ranging from 1 to 4 degrees F (0.6 to 2.2 degrees C) above average (Extreme #1). Annual mean temperatures were at least 2 degrees F (1.1 degrees C) above average for approximately 40 percent of the 169 long-term (i.e., period of record equaling or exceeding 50 years) stations across the region. Over 40 percent (72 of 169) of the long-term stations observed annual mean temperatures that were within their five warmest values on record. At least 6 of these stations were located in every state, including most of the major cities within the region. Twenty-three of the long-term stations observed or tied their warmest annual mean temperature on record, including Tampa, FL (1891-2017), Pensacola, FL (1880-2017), Augusta, GA (1875-2017), Columbia, SC (1888-2017), Asheville, NC (1890-2017), and Norfolk, VA (1874-2017). Collectively, the Southeast region observed its warmest year since records began in 1895, with an annual mean temperature of 65 degrees F (18.3 degrees C). South Carolina (65.1 degrees F, 18.4 degrees C) observed its warmest year on record, while Georgia (65.8 degrees F, 18.8 degrees C) and North Carolina (61.1 degrees F, 16.2 degrees C) tied their warmest year on record. Temperatures were especially warm during January, February, and April, with monthly departures ranging from 3 to as much as 10 degrees F (1.7 to as much as 5.6 degrees C) above average across the region (Extreme #2). Thirty-five, or roughly 15 percent, of the long-term stations within the region observed their warmest February and April mean temperatures on record. It is especially outstanding that multiple stations in every state recorded February mean temperatures that were well above their 30-year (1981-2010) mean temperature for March, including Montgomery, AL (1.9 degrees F above its March mean temperature, 1.1 degrees C above its March mean temperature), Pensacola, FL (+3.2 degrees F, +1.8 degrees C), Atlanta, GA (+1.8 degrees F, +1.0 degrees C), Charlotte, NC (+2.3 degrees F, +1.3 degrees C), and Norfolk, VA (+2.1 degrees F, +1.2 degrees C). While 38 long-term stations observed average daily maximum temperatures that were ranked within their five warmest values on record, more than double the

number of stations (78) observed average daily minimum temperatures that were ranked within their five warmest values on record. However, the persistence of daytime warmth was exceptional for many locations across the region, particularly during winter and spring. At least 17 long-term stations observed or tied their highest annual count of days with a maximum temperature at or above 70 degrees F (21.1 degrees C), including Jacksonville, FL (1872-2017; 324 days, 89 percent of the year), Mobile, AL (1873-2017; 305 days, 84 percent of the year), Atlanta, GA (1879-2017; 248 days, 68 percent of the year), Charlotte, NC (1879-2017; 236 days, 65 percent of the year), and Raleigh, NC (1887-2017; 231 days, 63 percent of the year). In addition, several stations observed or tied their highest annual count of days with a maximum temperature at or above 80 degrees F (26.7 degrees C), including Miami, FL (1896-2017; 323 days, 88 percent of the year), Augusta, GA (214 days, 59 percent of the year), Montgomery, AL (1873-2017; 209 days, 57 percent of the year), Charleston, SC (1939-2017; 199 days, 55 percent of the year), and Columbia, SC (1888-2017; 198 days, 54 percent of the year). Average daily minimum temperatures were extremely warm along the coastlines of Florida and Puerto Rico during the year. Tampa (1891-2017), Melbourne (1941-2017), and Pensacola observed their highest annual count of 138, 130, and 102 days with a minimum temperature at or above 75 degrees F (23.9 degrees C), which surpasses their previous records by 22, 33, and 15 days, respectively. Miami observed its highest annual count of 72 days with a minimum temperature of at least 80 degrees F, surpassing the previous record (45 days in 2010) by 27 days. The coldest temperature observed during the year was -11 degrees F (-23.9 degrees C), which was recorded on a fresh snowpack at Waynesville 1 E, NC on January 8th and 9th. The warmest temperature observed during the year was 102 degrees F (38.9 degrees C), which was recorded at Raleigh-Durham International Airport, NC, Fayetteville Regional Airport, NC, and John H. Kerr Dam, VA on July 23rd.

Annual precipitation totals were near-average to above-average across much of the Southeast region, with pockets of unusual dryness occurring in several areas. The driest locations were found across relatively small portions of central Virginia, central and far western North Carolina, north-central South Carolina, west-central and northwestern Alabama, and southwestern Georgia. Annual precipitation totals were 6 to more than 12 inches (152 to more than 305 mm) below average in these areas. The lowest annual precipitation total for any station (excluding CoCoRaHS) across the region was recorded in Louisa, VA (1917-2017), which observed its fifth driest year on record with only 30.27 inches (769 mm) of precipitation. In contrast, the wettest locations were found across much of Alabama, the Florida Peninsula, the western half of the Florida Panhandle, Puerto Rico, and the U.S. Virgin Islands, as well as portions of northern Georgia, coastal South Carolina, and western North Carolina. Annual precipitation totals ranged from 12 to more than 20 inches (305 to more than 508 mm) above average in these areas. Numerous long-term stations in Alabama and Florida observed annual precipitation totals that were ranked within their five highest values on record, including Naples, FL (1943-2017;

93.44 inches, 2,373 mm), Pensacola, FL (1880-2017; 91.91 inches, 2,335 mm), Atmore, AL (1941-2017; 90.15 inches, 2,290 mm), Miami, FL (1912-2017; 83.12 inches, 2,111 mm), Federal Point, FL (1893-2017; 78.78 inches, 2,001 mm), and Sylacauga 4 NE, AL (1955-2017, 75.58 inches, 1,920 mm). The highest annual precipitation total for any station (excluding CoCoRaHS) across the mainland portion of the region was recorded in Naples, which surpassed its previous wettest year on record (2003) by 18.81 inches (478 mm). An extraordinary number of heavy rainfall events were observed across the region throughout the year, with over 550 reports of flooding during summer (Extreme #3). From May 20th through the 21st, a slow moving system of thunderstorms produced widespread heavy rainfall across Alabama, with flash flooding occurring in the three major cities of Birmingham, Montgomery, and Mobile. Multiple water rescues were performed in the Birmingham metropolitan area, and several submerged vehicles were reported in Montgomery. On the 20th, Montgomery observed its wettest May day and fourth wettest day for any month on record, with 8.15 inches (207 mm) of precipitation. Of this daily total, 7.31 inches (186 mm) was recorded in only 6 hours, which would be expected to occur about once every 200 years on average at this location. On June 10th, a nearly stationary thunderstorm caused flash flooding in Ocala, FL, with a National Weather Service spotter measuring 4.62 inches (117 mm) of rainfall in less than 30 minutes. About 15 vehicles were submerged in several feet of floodwater, and one vehicle was swallowed by a 25-foot-deep sinkhole. Sarasota-Bradenton, FL (1911-2017) observed its highest 1-day and 2-day precipitation totals for August and its third highest 1-day and 2-day precipitation totals for any month on record, with 8.12 inches (206 mm) on August 26th and 12.44 inches (316 mm) from August 26th through the 27th. On the 27th, a resident of Sarasota was killed after driving his vehicle into deep floodwater, while over 60 homes were flooded in a Bradenton neighborhood, requiring at least 26 people to be evacuated. On October 23rd, a slow-moving complex of thunderstorms produced heavy rainfall and flash flooding across Upstate South Carolina, western North Carolina, and southwestern Virginia. Brevard, NC (1902-2017) observed its wettest October day and fourth wettest day for any month on record, with 7.20 inches (183 mm) of precipitation. Boone, NC (1929-2017) observed its wettest October day and third wettest day for any month on record, with 5.95 inches (151 mm) of precipitation. Over 50 apartments in Boone sustained floodwater damage, while more than a dozen people were rescued from partially submerged vehicles. Annual snowfall accumulations were below average across northern Alabama, northern and western Virginia, and Washington, D.C., while above-average snowfall occurred in much of central and southern Alabama, northern and west-central Georgia, Upstate South Carolina, North Carolina, and southeastern Virginia. Charlottesville 2 W, VA (1913-2017), Washington, D.C. (1885-2017), and Washington Dulles International Airport, VA (1963-2017) recorded only 5.1, 5.3, and 11.9 inches (130, 135, and 302 mm) of snowfall during the year, which is 15.6, 13.0, and 10.9 inches (396, 330, and 277 mm) below their long-term averages, respectively. In contrast, Highlands, NC (1893-2017), Caesars Head, SC (1890-2017), and Clayton 1 SSW, GA (1895-2017) recorded 28.6, 18.8,

and 13.4 inches (726, 478, and 340 mm) of snowfall during the year, which is 15.4, 8.8, and 8.0 inches (391, 224, and 203 mm) above their long-term averages, respectively. A large proportion of the annual snowfall across the region was recorded on December 8th and 9th, as an early-season winter storm produced 3 to more than 12 inches (76.2 to more than 305 mm) of snowfall in a continuous swath extending from southwestern Alabama to east-central Virginia (Extreme #4). Measurable snowfall was recorded in every state across the region, but the greatest storm total accumulations occurred in portions of east-central Alabama, northern Georgia, Upstate South Carolina, and western North Carolina. With 1 inch (25.4 mm) of snow recorded on the 8th, Mobile, AL (1895-2017) observed its earliest measurable snowfall on record, surpassing the previous record (1 inch on December 18, 1996) by 10 days. Snowfall totals were exceptionally high in areas located north and west of Atlanta, GA, with seven long-term stations observing their greatest 1-day snowfall on record for December. Three of these stations observed their second greatest 1-day snowfall for any month on record, including Dallas 7 NE (1948-2017; 12.3 inches, 312 mm), Taylorsville (1939-2017; 8.8 inches, 224 mm), and Carrollton (1942-2017; 8.0 inches, 203 mm). Over 325,000 customers lost power in northern Georgia, and more than 800 flights were cancelled at Hartsfield-Jackson International Airport in Atlanta. On the 9th, Mt. Mitchell, NC (1980-2017) observed its highest 1-day snowfall for December and its fourth highest 1-day snowfall for any month on record, with an accumulation of 25.0 inches (635 mm). Highlands, NC (1893-2017) observed its highest 2-day snowfall for December and its second highest 2-day snowfall for any month on record, with an accumulation of 15.3 inches (389 mm).

Seven tropical cyclones (Tropical Storm Cindy, Tropical Storm Emily, Hurricane Harvey, Hurricane Irma, Hurricane Maria, Hurricane Nate, and Tropical Storm Philippe) brought high winds, inland flooding, storm surge, and tornadoes to portions of the Southeast region, including Puerto Rico and the U.S. Virgin Islands. These landfalling tropical cyclones contributed at least 10 percent of the annual precipitation observed in portions of every state within the region, including 20 to 35 percent of annual precipitation totals across much of Florida. After making landfall twice in southern Florida (Cudjoe Key and Marco Island) on September 10th, Hurricane Irma became the first major hurricane to make landfall in Florida since Hurricane Wilma in October 2005 (Extreme #5). Irma produced 5 to more than 15 inches (127 to more than 381 mm) of rainfall across nearly all of the Florida Peninsula, as well as broad portions of southeastern Georgia and the southern half of South Carolina. In Florida, the Fort Pierce COOP station (1901-2017), the Sanford COOP station (1948-2017), and Melbourne (1937-2017) observed their wettest day for any month on record, with 13.85, 11.50, and 10.23 inches (352, 292, and 260 mm) of precipitation, respectively. A combination of torrential rainfall and storm surge caused exceptional flooding in Miami, FL, Jacksonville, FL, and Charleston, SC, with more than 350 water rescues performed in Jacksonville. Some of the highest recorded wind gusts from Irma included 142 mph at Naples Municipal Airport, FL, 137 mph on Buck Island in the U.S. Virgin Islands, 130 mph on Marco Island, FL,

120 mph on Big Pine Key, FL, 101 mph on Virginia Key near Miami, FL, 86 mph at Jacksonville International Airport, FL, and 64 mph at Hartsfield-Jackson International Airport in Atlanta, GA. Approximately 17 million people across the Southeast (including an estimated 15 million residents in Florida) lost power for less than a day to more than one week, which is the greatest number of power outages in the United States caused by any hurricane on record. About one-quarter of over 50,000 homes in the Florida Keys were destroyed, while 65 percent sustained major damage. Catastrophic damage also occurred on St. Thomas and St. John in the U.S. Virgin Islands, where collapsed homes and buildings as well as downed trees and power lines produced uninhabitable conditions across much of these islands. At least 92 fatalities (77 in Florida alone) were attributed to Hurricane Irma, including 14 nursing home residents in Hollywood, FL who died from heat exhaustion due to a lack of air conditioning after the storm. On September 20th, Hurricane Maria made landfall near Yabucoa, Puerto Rico as a Category 4 hurricane with maximum sustained winds of 155 mph (Extreme #6). Maria was the strongest hurricane to strike Puerto Rico since the Category 5 landfall of the San Felipe Segundo hurricane in September 1928, and it was also the tenth most intense hurricane on record in the Atlantic basin, with a minimum central pressure of 908 mb. Several wind gusts exceeding 100 mph were recorded as Maria tracked near St. Croix and over Puerto Rico, including 137 mph at Sandy Point National Wildlife Refuge on St. Croix, 120 mph in Gurabo, PR, 116 mph at Yabucoa Harbor, PR, 113 mph in San Juan, PR, and 112 mph in Arecibo, PR. Ten to more than 25 inches (254 to more than 635 mm) of rainfall was observed across much of the island, with the highest precipitation total of 37.90 inches (963 mm) recorded near G. L. Garcia. Broad portions of eastern and northwestern Puerto Rico observed maximum 12-hour rainfall totals that would be expected to occur once every 1,000 years on average. Widespread river flooding was observed, as 30 of the 65 USGS streamflow gages on the island exceeded major flood stage and 13 reached or exceeded their highest crest on record. Puerto Rico sustained catastrophic infrastructural damage, including a total loss of electricity, drinking water shortages, and damage to countless homes and buildings. The National Weather Service Doppler radar located in southeastern Puerto Rico was destroyed by Maria's strong winds. Over 50 percent of the island was without power for at least 2 months. While the preliminary death toll was 64, Hurricane Maria likely caused hundreds of additional fatalities across the island.

There were 4,059 severe weather reports across the Southeast during the year, which is about 120 percent of the median annual frequency of 3,340 reports during 2000-2016. Over half (2,161 of 4,059) of these reports were observed during April, May, and July. The fewest number of reports occurred in Florida (437; 11 percent of total), while the greatest number was recorded in Georgia (951; 23 percent of total). Strong thunderstorm winds accounted for nearly 80 percent (3,189 of 4,059) of the severe weather reports and caused at least 10 fatalities and 49 injuries across the region. On May 30th, thunderstorm wind gusts estimated at 80 to 90 mph caused trees to fall onto several homes and vehicles across Sampson County, NC, resulting in at least 12

injuries. Approximately 16,000 turkeys were killed, as the strong winds destroyed numerous poultry houses. The highest thunderstorm wind gust recorded during the year was 87 mph, which was measured near Destin, FL as a powerful squall line moved through the Florida Panhandle on February 7th. The highest non-convective wind gust recorded during the year was 101 mph, which was measured on Grandfather Mountain, NC (5,280 feet above sea level) following the passage of a strong extratropical cyclone on April 6th. The largest hailstones observed during the year were grapefruit-sized (i.e., 4-inch diameter), which was reported in Talladega County, AL on April 5th. On September 1st, severe thunderstorms produced hail up to 2.75 inches in diameter (i.e., baseball-sized) across southern Wake and northern Harnett Counties in North Carolina, with dozens of homes in the town of Fuquay-Varina sustaining broken windows and damaged siding. In addition, dozens of vehicles experienced major hail damage, including shattered windshields and large exterior dents. A total of 312 tornadoes (10 unrated, 122 EF-0s, 143 EF-1s, 35 EF-2s, 2 EF-3s) were confirmed across the Southeast during the year, which is the fifth highest annual tornado count for the region since modern records began in 1950 (Extreme #7). About 65 percent (202 of 312) of the tornadoes occurred during January (77), April (70), and May (55). The 77 tornadoes observed during January was more than double the previous monthly record of 29 tornadoes recorded in January 2006. Over one-third of the 312 tornadoes across the region occurred in Georgia, with an annual statewide count of 113 tornadoes surpassing the previous record (63 in 2008) by 50. In January, Georgia also set new state records for the most tornadoes recorded in a single day (27) and a two-day period (41). Of the 17 fatalities and at least 91 injuries caused by tornadoes across the region, sixteen of the fatalities and 62 of the injuries occurred in Georgia. On January 22nd, an EF-3 tornado, with a maximum width of 1.25 miles, tracked over 70 miles across four counties in southwestern Georgia. Dozens of homes and other structures were damaged or destroyed, and 90 to 100 percent of trees were snapped or uprooted in many locations along its path. Five fatalities were reported in the city of Albany, and at least 40 people were injured. On October 8th, an EF-1 tornado spawned by Hurricane Nate crossed the Blue Ridge Parkway at an elevation exceeding 3,000 feet and became the first observed tornado in Ashe County, NC since records began in 1950. Eleven fatalities and at least 51 injuries were caused by lightning strikes across the Southeast. On September 5th, a lightning strike killed a 63-year-old fisherman and injured three others in Juana Diaz, PR, as they were anchoring their boat prior to the arrival of Hurricane Irma. This was the first reported lightning fatality in Puerto Rico since June 2009.

After peaking in intensity during autumn 2016, moderate-to-extreme (D1-D3) drought conditions gradually improved across interior portions of the Southeast region during winter and spring. Well-above-normal precipitation in January ended the drought across the Florida Panhandle and the southern half of Alabama and Georgia. With unseasonable warmth and below-average precipitation observed during February, drought conditions briefly intensified in northern Georgia and the

western Carolinas, while a narrow corridor of moderate-to-severe (D1-D2) drought emerged east of the Shenandoah Valley in northern Virginia and the Washington, D.C. area. In addition, unusual dryness led to the development of moderate drought in parts of central and southern Florida. Well-above-normal precipitation during the spring terminated nearly all of the drought across interior portions of Alabama, Georgia, the Carolinas, and Virginia. Conversely, a persistent lack of spring rainfall produced moderate-to-extreme drought across much of Florida and southern Georgia, covering nearly 72 percent of Florida for the first time since February 2013. Indeed, only 0.10 inches (2.5 mm) of rainfall was observed in Orlando, FL (1892-2017) during March and April, which is its second lowest precipitation total for any two-month period on record. Moultrie 2 ESE, GA (1928-2017) and Tampa, FL (1891-2017) tied their second and fifth highest count of spring days with no measurable precipitation, at 79 and 83 days, respectively. This drought sparked the most active wildfire season since 2011 in Florida, with nearly 1,800 fires observed and over 120,000 acres burned during spring (Extreme #8). A few of the largest wildfires in Florida included a 7,500-acre fire in southwestern Florida, which destroyed 4 rural homes near Naples in early March, and the Cowbell Fire, which burned nearly 22,000 acres of the Big Cypress National Preserve in southern Florida. The West Mims Fire was the largest and most destructive inferno, consuming over 150,000 acres of the Okefenokee National Wildlife Refuge in southeastern Georgia and a small portion of northeastern Florida. Burning for roughly two months (April-May), it caused a significant reduction in tourism in the Okefenokee Swamp and nearby beaches along the Atlantic coast. Beginning on May 6th, southern portions of Charlton County, GA, including about 2,000 residents in the community of St. George, were placed under a week-long mandatory evacuation order due to a rapid spreading of the West Mims Fire. On the same day, heavy smoke and falling ash were reported in downtown Jacksonville, FL, located about 30 miles from the fire perimeter. Following a mostly drought-free summer and early autumn, an area of moderate drought developed in portions of central North Carolina and south-central Virginia during early October. By the end of December, moderate drought covered at least 15 percent of every state in the region, including central Virginia, central North Carolina, north-central South Carolina, southern Georgia, west-central and southeastern Alabama, and the Florida Panhandle. While agricultural and livestock production was satisfactory across much of the Southeast during the year, major devastation from a spring freeze and landfalling hurricanes occurred in southern portions of the region. A hard freeze during mid-March caused over $1 billion in fruit crop losses across the region, including about 90 percent of South Carolina peaches and 80 percent of Georgia peaches and blueberries (Extreme #9). Daily minimum temperatures from March 14th through the 17th fell below 32 degrees F (0 degrees C) as far south as northern Florida, and hard freeze conditions (i.e., air temperature at or below 28 degrees F [-2.2 degrees C] for at least 4 consecutive hours) were observed across much of the region, primarily from central Georgia to northern Virginia. During this four-day period, some of the stations that recorded the most consecutive hours at or below 28 degrees F were Asheville, NC (19 hours), Roanoke,

VA (18 hours), Valdosta, GA (7 hours), Huntsville, AL (6 hours), Charleston, SC (6 hours), and Crestview, FL (5 hours). While the freeze did not occur unusually late in the season, many fruit crops had budded or bloomed prematurely due to an exceptional lack of winter chill hours, which increases their vulnerability to spring freezes. Other fruit crops that were damaged included strawberries and blueberries in South Carolina, peaches and blueberries in North Carolina, and peaches and cherries in Virginia. In September, over $2.5 billion in agricultural losses was caused by Hurricane Irma in Florida, while Hurricane Maria destroyed about 80 percent of the crop production in Puerto Rico, resulting in at least $780 million in agricultural losses (Extreme #10). Following Hurricane Irma, citrus fruit losses ranged from less than 30 percent to nearly 100 percent in groves across central and southern Florida, with the extent of damage varying by the quantity of fruit that dropped from the trees due to high winds. Many citrus trees were uprooted, and some growers were temporarily unable to pump floodwater out of their groves due to a lack of electricity, which could produce long-term tree damage. Dairy farms in Florida were forced to dump milk at a significant cost per day, as power outages prevented consumers from storing it. About 30 percent of the pecan crop in Georgia was lost, as wind gusts from Irma exceeding 50 mph stripped off immature nuts and blew down thousands of pecan trees. Hurricane Maria destroyed dairy barns and plantain, banana, and coffee plantations in Puerto Rico. In addition, about 90 percent of the poultry production on the island was lost, including 2 million of the 2.6 million fowls.

HIGH PLAINS REGION

It was another warm year throughout the High Plains, as 2017 was among the top 10 of warmest years for several locations across the region. Colorado experienced the greatest departures, and Alamosa and Akron had their warmest years on record. The transition seasons were most responsible for this record-breaking warmth, as spring and fall temperatures were approximately 2.0-4.0 degrees F (1.1-2.2 degrees C) above normal. As for precipitation, wet and dry conditions were both present throughout the region. Much of the High Plains experienced a wet winter, and the southern portion of the region had a wet spring as well. Meanwhile, the summer was dry for most, and the fall brought both wet and dry conditions. The major precipitation stories of the year included the high snowpack in the Rockies and the Northern Plains drought. Mountain snowpack was plentiful throughout Wyoming and Colorado, and spring runoff caused streams to flood. However, the Dakotas and Montana experienced drought, which developed during the late spring and peaked during the summer, impacting crops and livestock.

While corn and soybeans did well nationally in 2017, it was a rough year for crops and livestock in the High Plains. In Kansas and Nebraska, winter wheat suffered due to the wet spring, and diseases such as wheat stripe rust, leaf rust, and Wheat Streak Mosaic Virus were reported by producers. In particular, a late-season winter storm dropped a heavy band of snow across the two states that knocked down wheat stands, and it killed thousands of cattle in Colorado. In June, cold temperatures caused frozen corn in South Dakota. In the Northern Plains, spring wheat did not fare well due to summer drought conditions. The drought dried up pastureland and created a hay shortage, forcing ranchers to find alternative feed or sell off livestock. In Nebraska, thousands of acres of corn were damaged during the fall due to a combination of conditions. High temperatures during pollination, followed by cooler temperatures in August led to heavy ears on weakened shanks, which made it easy for high winds in October to snap stalks and knock corn to the ground.

Overall, temperatures were above normal throughout the High Plains in 2017. Temperature departures ranged from approximately 1.0-3.0 degrees F (0.6-1.7 degrees C) above normal in most areas, with the highest departures occurring in Colorado, where several locations had impressive annual temperature records. For instance, Alamosa and Akron had their warmest year on record, while it was the 2nd warmest for Grand Junction and 3rd warmest for Colorado Springs. Breaking it down by month, the greatest above-normal temperature departures occurred in February, March, July, and November, with all four months yielding record-breaking warmth

across parts of the region. As was the case in 2016, average temperatures were influenced more so by warmer minimum temperatures than maximum temperatures. On the other hand, much of the region experienced below-normal temperatures in August, with several locations experiencing a top 10 coolest August on record. The following locations had notable temperature records during 2017:

- Laramie, Wyoming: 5th lowest temperature on record at -40.0 degrees F (-40.0 degrees C), January 6 (period of record 1948-2018)
- Denver, Colorado: earliest and latest 80.0 degrees F (26.7 degrees C) temperature on record, February 10 and November 27, respectively (period of record 1872-2018)
- Liberal, Kansas: earliest 90.0 degrees F (32.2 degrees C) temperature on record, February 11 (period of record 1893-2018)
- Valentine, Nebraska: 3rd highest temperature on record at 112.0 degrees F (44.4 degrees C), July 19 (period of record 1889-2018)
- Chadron, Nebraska: earliest fall freeze on record, September 6 (period of record 1942-2018)
- Cheyenne, Wyoming: latest 70.0 degrees F+ (21.1 degrees C) temperature on record, November 26 (period of record 1872-2018)

The High Plains had a mix of wet and dry conditions in 2017. Above-normal precipitation occurred throughout Wyoming, Nebraska, eastern Colorado, and western Kansas, while it was dry in the Dakotas and western Colorado. Precipitation records were set for both wetness and dryness. For instance, Alamosa, Colorado and Goodland, Kansas had their 6th wettest and 8th wettest years on record, respectively, while it was the 3rd driest year on record for Grand Junction, Colorado and Dickinson, North Dakota, and 8th driest for Rapid City, South Dakota.

Several months were particularly notable in terms of extreme precipitation, or lack thereof. For instance, January was very wet, setting several top 10 records for wettest and snowiest January. September was also quite wet, with heavy precipitation providing drought relief to the Northern Plains. Meanwhile, June, November, and December brought below-normal precipitation to much of the region, causing drought development and expansion. In May and October, the region was starkly divided by extremely wet and extremely dry conditions, setting records on both ends of the precipitation spectrum.

It was a good year for mountain snowpack in Colorado and Wyoming, as the season got off to a favorable start and timely, ample precipitation enabled the snowpack to build. According to the U.S. Army Corps of Engineers, the reach of the Missouri River above Fort Peck Reservoir peaked on April 29th at 99 percent of normal, while the reach between Fort Peck and Garrison Reservoirs peaked on May 2nd at 148 percent of normal. Both reaches peaked about two weeks later than normal. The high snowpack caused spring flooding from runoff in several places, including the Wind River Indian Reservation in Wyoming. As for the current season, mountain

snowpack got off to a good start in the Upper Missouri Basin. In fact, an early October snowstorm in the northern and central Rockies set new snowfall records and caused the greatest impacts in Montana. Wyoming snowpack also started off strong and remained above normal in the northwestern part of the state through December. However, Colorado snowpack got off to a very slow start, as warm and dry fall and early winter conditions inhibited the snowpack from building.

While mountain snowpack was abundant last year, Plains snowpack was scarce in the southern and western portions of the region. This was mostly due to above-normal temperatures causing precipitation to fall as rain instead of snow. The following locations had a top 5 least snowy season on record (defined as the period of July 2016-June 2017): Denver, Colorado (2nd least snowiest), Lincoln, Nebraska (2nd least snowiest), Wichita, Kansas (3rd least snowiest), Concordia, Kansas (3rd least snowiest), Omaha, Nebraska (3rd least snowiest), and Goodland, Kansas (5th least snowiest). However, the Northern Plains snowpack was excessive, causing flooding in North Dakota. This season's Plains snowpack started out below normal for many locations, although there is still plenty of time to catch up.

The following locations had notable precipitation records during 2017:

- Alliance 1WNW, Nebraska: Highest 1-day snowfall total of 17.3 inches (44 cm), February 24 and highest 2-day snowfall total of 22.1 inches (56 cm), February 23-24 (period of record 1894-2018)
- Lander, Wyoming: Highest March 1-day precipitation total of 2.71 inches (69 mm), March 31 and 6th highest 1-day precipitation total on record (period of record 1891-2018)

Contrary to 2016, drought was an issue in the region in 2017, impacting several areas but particularly the Northern Plains. At the beginning of the year, abnormally dry or drought conditions (D0-D4 intensity categories on the U.S. Drought Monitor map) were impacting about half of the High Plains region, including eastern Wyoming, western South Dakota, eastern Colorado, southwestern and central Nebraska, and western Kansas. This depiction changed very little throughout the winter months, and then conditions began to gradually improve throughout the spring, thanks to heavy precipitation in drought-stricken areas. Then, extremely dry conditions caused drought to develop in May in the Dakotas and eastern Montana, expanding and intensifying rapidly in June and July. In August, cooler and wetter weather provided some relief, while heavy rains in September vastly improved conditions. However, dryness returned in October, and with frozen soils and the growing season over, conditions changed very little throughout the rest of the year. Impacts from the drought were mostly agricultural in nature. Read more about the Northern Plains drought in the Noteworthy Events section.

In the southern part of the region, a warm and dry fall caused drought to develop in western Colorado and southern and central Kansas. It was a slow start to the

mountain snowpack season in Colorado, as statewide Snow Water Equivalent was only about 50 percent of median at the end of December. By the end of the year, 80 percent of the High Plains region was experiencing abnormally dry or drought conditions.

Ice Storm in Kansas and Nebraska: An ice storm wreaked havoc on southeastern Nebraska and a large part of Kansas from January 14th-16th. A warm and moist air mass settled over frozen ground, creating a widespread freezing rain event. Ice up to 1.0 inches (3 cm) thick accumulated onto trees and power lines, causing them to snap. While ice storms are not uncommon in the region, this event was rather unusual for January in southeastern Nebraska because snow is the predominant form of precipitation in winter.

Early-Spring Wildfires: A warm, dry end to winter and beginning to spring sparked wildfires across the High Plains in March that spread rapidly due to high winds. The most notable was the Northwest Oklahoma Complex fires, which burned parts of Kansas in early March. Several people and thousands of cattle were killed, and thousands of miles of fencing had to be replaced. It became the largest wildfire in Kansas' history, a record that was just set in 2016 by the Anderson Creek Fire. Fires also occurred in Colorado, South Dakota, and Nebraska.

Late-Season Winter Storm: A powerful storm system impacted Colorado, Wyoming, Kansas, Nebraska, and southeastern South Dakota from April 28th-May 1st. One to two feet (30-61 cm) of snow fell across central Nebraska and western Kansas and damaged crops, particularly winter wheat, corn, and alfalfa. In Colorado, the heavy snow and cold temperatures killed cattle and put calves at risk.

Denver Area Hail Storm: On May 8th, severe thunderstorms produced damaging hail in Denver, Colorado and the surrounding area. Hail of at least 2.0 inches (5 cm) in diameter was reported, damaging homes, businesses, and over 100,000 vehicles. While this event was localized in nature, insured losses exceeded $1.5 billion, and it was officially declared a Billion-Dollar Weather Disaster. It also became the most expensive hail storm in Colorado's history.

Northern Plains Drought: Drought developed across North Dakota, South Dakota, and Montana during the late spring and rapidly intensified throughout the summer. Impacts were primarily agricultural in nature, as field crops were damaged and the lack of feed forced ranchers to sell off their livestock. The drought also contributed to an active wildfire season, particularly in Montana where over 1 million acres were burned.

Legion Lake Fire in South Dakota: Warm, dry, and windy conditions contributed to the spread of the Legion Lake Fire, which ignited in December and burned more than 54,000 acres in the Black Hills, becoming the third largest fire in South Dakota's

history. The fire burned in Custer State Park, which was forced to close temporarily due to damaged trails, roads, and fences. Wildlife was also impacted, as deer, elk, and buffalo perished in the fire.

SOUTHERN REGION

The year 2017 proved to be an extremely warm year for the Southern Region. Five of the six states in the Southern Region ranked in their top ten warmest years on record. The region as a whole had an average annual temperature of 65.55 degrees F (18.64 degrees C), making it the third warmest year on record. Temperatures were generally consistently above normal throughout the year. There were seven months where all six states averaged above normal temperatures. These months included February, March, April, July, October, November, and December. For the year there were areas in Texas, Louisiana, Oklahoma, Arkansas, and Mississippi that averaged between 3 to 4 degrees F (1.11 to 1.67 degrees C) above normal, and the majority of stations averaged at least 1 to 3 degrees F (0.56 to 1.67 degrees C) above normal. A few areas in Texas reported slightly below normal temperatures for the 2017 year. The state-wide average annual temperatures are as follows: Arkansas averaged 62.54 degrees F (16.97 degrees C), Louisiana averaged 68.77 degrees F (20.43 degrees C), Mississippi averaged 65.83 degrees F (18.79 degrees C), Oklahoma averaged 61.79 degrees F (16.55 degrees C), Tennessee averaged 60.05 degrees F (15.58 degrees C), and Texas averaged 67.38 degrees F (19.66 degrees C). The statewide temperature rankings for 2017 were as follows: Arkansas (seventh warmest), Louisiana (third warmest), Mississippi (seventh warmest), Oklahoma (eleventh warmest), Tennessee (fifth warmest), and Texas (second warmest). All state rankings are based on the period spanning 1895-2017.

The 2017 annual precipitation totals indicate that precipitation for the year varied spatially over the Southern Region, but the values do not provide a clear picture of how precipitation varied temporally over the year. This is mostly because many areas within the region experienced periods of wet conditions, which were interrupted with dry spells and in the case of the fall, wide-spread drought. The year started drier than normal for the northern part of the region. March was a dry month for most of the region and abnormally dry conditions expanded into the Southern part of the region. In April, much needed rain came into the region and caused most of the region to return back to normal conditions. This was also the case in May; however, only Texas and Oklahoma experienced a drier than normal month. Conditions in June were slightly wetter than normal with Mississippi recording its fifth wettest June on

record (1895-2017). July brought slightly drier conditions for the southern states (Texas, Louisiana, and Mississippi). In August, Hurricane Harvey made landfall and stalled over Texas, causing historic rainfall amounts throughout the region. All states, except Tennessee, recorded one of their top ten wettest Augusts on record. Texas had its wettest August on record while Louisiana had its second wettest. In fall, drought conditions developed across much of the northern and central part of the Southern Region, and by the end of November, extreme drought conditions were present in Arkansas. Welcomed rainfall in December helped alleviate some of the extreme drought conditions. By the end of the year, the amount of drought increased from approximately 49.54 percent areal coverage in the region to just under 74 percent. The state-wide average annual precipitation totals are as follows: Arkansas received 49.94 inches (1268.48 mm), Louisiana received 63.80 inches (1620.52 mm), Mississippi received 59.19 inches (1503.43 mm), Oklahoma received 38.55 inches (979.17 mm), Tennessee received 55.80 inches (1417.32 mm), and Texas received 30.31 inches (769.87 mm). The state-wide precipitation rankings for the year are as follows: Arkansas (fifty-second wettest), Louisiana (thirtieth wettest), Mississippi (forty-second wettest), Oklahoma (twenty-ninth wettest), Tennessee (thirty-fifth wettest), and Texas (thirty-fifth wettest). All state rankings are based on the period spanning 1895-2017.

The Southern Region had its warmest winter on record in 2016-17. The temperature regime throughout the region in December was variable, with the northern part of the region reporting near normal or slightly below normal temperatures. The southern part of the region reported, on average, 2-4°F above average for the month of December. In January most of the region reported above normal temperatures, with portions of Louisiana, Mississippi, and Tennessee experiencing 6-10°F above normal temperatures. The panhandles of Texas and Oklahoma exhibited near normal temperatures. In February, there were no areas in the Southern Region that were below or near normal. The whole region averaged 2°F above normal, with portions of each state reporting 9-12°F above normal. Louisiana did not have any areas where there were below or near normal temperatures for either winter month. In the entirety of Winter 2016-17, Louisiana and Texas reported their warmest winter, Arkansas and Tennessee reported their second warmest winter, Mississippi reported its third warmest winter and Oklahoma reported its fifth warmest winter. Farmers are concerned about the crops throughout the region, with growing degree days and growing cycles being effected by the warm temperatures. For some farmers in southern Texas, the unseasonable warmth has them anxious to start farming their spring crops earlier than usual according to the Southwest FarmPress in February 2017. Some farmers already have their tractors out in hopes to get an early start on the planting year, which is many farmers optimal outcome.
The western states in the southern region, Texas and Oklahoma, had wildfires burn through their area during March. The combination of dry air, drought, strong winds, and warm temperatures contributed to the wildfires. The March 14, 2017 drought outlook showed the panhandle of Oklahoma in extreme drought conditions along

with most of Oklahoma in moderate and severe drought. The surrounding states were also in drought or abnormally dry conditions which did not help the situation. The wildfires burned more than 2 million acres during their duration. Much of the area burned impacted the large cattle industry in Texas and Oklahoma. The panhandles of Texas and Oklahoma were impacted the most by the wildfires. By late March, at least 7 people and over thousands of livestock died according to Reuters (2017). Damage estimates are over 6 million dollars for acreage that was burned in Texas alone. Kansas, Oklahoma, and Texas declared state of emergencies due to the wildfires. By late March and early April, most of the fires had been distinguished. Throughout the month of April and into May the drought conditions improved over Oklahoma and Texas. Oklahoma went from extreme drought in March to near normal conditions in May. Much needed rain over April and May improved drought conditions and decreased the fires as well as decreased the potential for more wildfires to form.

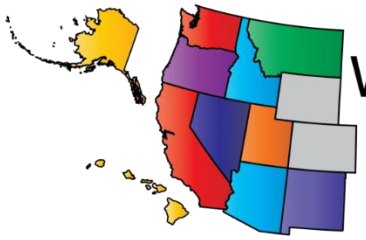
On August 25th, Hurricane Harvey made landfall near Rockport, TX, as a category 4 hurricane with maximum sustained winds of 130 mph. Harvey became the first category 4 hurricane to make landfall in Texas since Carla in 1961. Port Aransas reported sustained winds of 110 mph with a gust to 132 mph. After landfall, Harvey virtually stalled before re-emerging into the Gulf of Mexico on August 28th. Harvey then made its final landfall in the early morning hours of August 30th, near Cameron, Louisiana. The intensity and slow movement of Harvey created a catastrophic combination of flooding, wind damage, and storm surge. Devastating flooding occurred in Houston and the Beaumont/Port Arthur area. Widespread storm totals of 40"+ inundated the Houston area. The highest reported total was 51.88" at Cedar Bayou near Highlands, TX. That total stands as the highest single storm total on record in the US, outside of Hawaii. On August 29th, the Port Arthur SE TX Regional Airport recorded 26.03" of rain. Heavy rainfall then spread into Louisiana with areas receiving over 20", including Bayou Conway, which received 22.25", and Bayou Toro, which received 20.62". Dr. John Nielsen-Gammon, Texas State Climatologist, summed up Harvey: 'Harvey is head and shoulders above all previous multi-day storms ever recorded in the United States. I examined 18 different combinations of storm lengths and area sizes . . . Harvey was the worst in all but one.' According to Dr. Nielsen-Gammon, the most impressive record was the five-day total over 10,000 square miles. 'For Harvey to average 34.72' over five days across that large an area is ridiculous. The previous all-time US record, set in Texas back in 1899, was estimated at 21.39. 'Harvey exceeded that record by 62%.'

The Southern Region experienced a drier than normal autumn during September through November 2017. Autumn 2017 in the Southern Region ranked as the 12th driest, with a regional total of 5.58 inches of precipitation. Arkansas had its driest autumn on record (since 1895) and Louisiana had its fifth driest autumn on record. Three other states had drier than normal autumns as well, Texas (16th driest), Oklahoma (35th driest), and Mississippi (23rd driest). Tennessee was the only state in the Southern Region to report a wetter than normal autumn. Tennessee reported its

38th wettest autumn. Precipitation values for the month of September varied spatially throughout the Southern Region. The central part of the region received below normal precipitation whereas parts of the western and eastern part of the region received above normal precipitation. Central Louisiana, western Arkansas, southern Mississippi, eastern Oklahoma, and northeastern and southeastern Texas received less than 25 percent of normal precipitation. Most of Louisiana and Arkansas received 25 - 50 percent of normal precipitation. Louisiana had its driest September on record and Arkansas had its eighth driest September on record. Precipitation values for the month of October varied spatially throughout the Southern Region. Parts of western Tennessee, northern and central Mississippi, northeastern, central and southern Arkansas, northern, central, and southwestern Louisiana, south central Oklahoma, and central, southern, and western Texas received 50 percent or less of normal precipitation. There were a few areas of 5 percent or less of normal precipitation in central and western Texas and the panhandle of Oklahoma. Precipitation values for the month of November were below normal for most of the Southern Region. All of Arkansas and Oklahoma, most of Louisiana and Mississippi, and parts of Tennessee and Texas received 50 percent or less of normal precipitation. There were a few areas of 5 percent or less of normal precipitation in northern, western, and southern Texas, southeastern Louisiana, and northern and southeastern Oklahoma. In November, four states had one of their top ten driest Novembers ever recorded: Arkansas (fourth), Louisiana (tenth), Mississippi (third), and Oklahoma (fifth).

On December 8th, 2017 snow fell throughout most of the region. Many areas in the southern part of the region accumulated over two inches of snow.

WESTERN REGION



Western Regional Climate Center

The West experienced extreme weather and climate events in 2017. The exceptionally wet winter of 2016/2017 alleviated some of the impacts of one of the worst droughts on record in California and Nevada while producing widespread flooding and landslides. A record hot summer produced hazardous fire conditions and the heat, combined with dry conditions, caused severe drought to develop in Montana. Heat extremes and many large and destructive fires impacted the West throughout summer and well into autumn.

At the start of the year, drought conditions persisted into a sixth year across the southern two-thirds of California and western Nevada. Approximately 63% of California and 34% of Nevada were experiencing moderate to exceptional drought conditions. The first two months of 2017 were much wetter than normal owing to many atmospheric rivers making landfall on the West Coast. The Sierra Nevada region was particularly impacted; Tahoe City reported its second wettest year on record at 59.3 in (1506 mm), 173% of normal. Conditions were favorable in many of these storms for moisture to 'spill over' into the Great Basin. Reno, Nevada, observed its wettest January on record and also its wettest year on record at 13.74 in (349 mm), 186% of normal. Records for Reno began in 1937. Moisture also made it to the Inland Northwest, where Stanley, Idaho, reported its wettest year on record at 25.99 in (660 mm), 212% of normal.

As soils became saturated through the season, mudslides, landslides and flooding began to occur in many areas of the West. These impacts began in January in northern California and the Sierra Nevada, damaging homes and causing prolonged closures of many major roads. Washington and Idaho started observing significant impacts in March; Minidoka and Twin Falls experienced landslides and flooding that damaged over 80 homes. The wet winter contributed to a massive landslide near Big Sur, California, that buried Highway 1 in an estimated 1 million tons of debris. A large snowpack and avalanches also caused many building collapses and road closures around the West, most notably for locations in the Inland Northwest and the Sierra Nevada; Pocatello, Idaho, had its 5th snowiest year since records began in 1939, logging 70.3 in (179 cm). Several storms had very high snow levels, producing rain-on-snow flooding. Such flooding occurred in northern Nevada on the Truckee River in January, and on the Humboldt River in February, causing damage to

structures situated along these rivers. In spite of the negative impacts of this anomalously winter, by March, none of Nevada and only 8% of California were classified as having moderate or worse drought conditions. With an above normal snowpack, most of California's reservoirs filled above historical average by the end of the snow melt season.

April 1 snowpack was more than 175% of normal in the Sierra Nevada, more than 125% of normal in the Cascades and central Rockies, and near normal in the northern Rockies. As temperatures and solar radiation increased into spring and soils remained saturated, snowmelt flooding became a significant hazard for many western locations. Sustained high and near-record flows occurred on many streams and rivers, and minor flooding was reported along the Big Wood River in Hailey, Idaho, on the Truckee River near Tahoe City in California, and in the Mason Valley of western Nevada on the Walker River. Areas of Montana east of the Rockies typically see their wettest months of the year during the spring and summer. However, this year, conditions were much drier than normal. Glasgow reported its driest year in a 70-year record at 6.64 in (169 mm), 57% of normal. A lack of precipitation combined with above normal temperatures produced severe drought conditions. In June, the Montana governor declared a drought emergency in 19 counties in eastern Montana and on two Native American reservations. Range and pasture conditions were poor, and various crops such as oats, spring wheat, and sugar beets were suffering. By mid-August, 90% of the state was categorized as moderate to extreme drought in the US Drought Monitor. The autumn season brought above normal precipitation to the region, providing some relief. At the end of the year, 52% of the state was categorized as moderate or worse drought conditions.

Summer temperatures were well above normal across much of the West. California and Nevada reported their warmest June-August on record, Oregon its second warmest, and Washington, Utah, and Arizona their third warmest such period on record. Death Valley, California, reported its hottest month on record in July at an average of 107.4 F (41.9 C), 5.2 F (2.8 C) above normal. This also sets the record for hottest month anywhere in the United States. Las Vegas, Nevada (72.4 F/22.4 C; 3.1 F/1.7 C above normal), Phoenix, Arizona (77.3 F/25.2 C; 2.3 F/1.3 C above normal) and Albuquerque, New Mexico (60.1 F/15.6 C, 3 F/1.7 C above normal) all reported their warmest years on record. Records for Las Vegas began in 1948, Phoenix in 1933, and Albuquerque in 1891. A late June heat wave caused grounding of regional aircraft in Phoenix, Arizona, and several hundred cattle perished in central California, overwhelming processing facilities.

In many areas of the West, abundant fine fuels (grasses) that grew in response to the wet winter cured rapidly during the hot summer, creating hazardous fire conditions. What ensued was one of the most destructive and costly fire seasons on record. Over 12,000 structures were destroyed in U.S. wildfires this year, primarily in the West. The previous record in a calendar year is approximately 5,000. Over 10 million acres

(4 million hectares) burned across the U.S. this year, compared to the 10-year average of 6.5 million (2.6 million hectares). The US Forest Service spent over $2 billion in fire suppression this year, the highest amount on record. Smoke from fires around the West impacted air quality in major metropolitan areas such as Seattle, Portland, and San Francisco as well as more remote locations. Large wildfires over the summer in Montana strained resources and produced persistent poor air quality. In October, northern California saw some of the state's most destructive fires on record occur during a strong, dry wind event known as a -Diablo wind. Collectively, the fires destroyed 5,643 structures and caused 30 deaths. The fire season continued into December for southern California, with persistent Santa Ana wind conditions and the ignition of several fires in southern California. The largest of these conflagrations, the Thomas Fire, grew to be California's largest fire in modern history by late December, burning over 280,000 acres (113,000 hectares) and destroying over 1,000 structures.

The onset of autumn precipitation favored the Northwest and northern California, leaving the Southwest drier than normal. Additionally, the southern tier of the West did not experience the plentiful precipitation of the preceding wet season, and monsoon rains were lackluster for many locations. Arizona and New Mexico observed their warmest September-November on record, and Arizona reported its third driest such period. Several heat waves impacted the Southwest as well. San Francisco, California, recorded its all-time highest temperature in a 144-year record on September 1, when the temperature reached 106 F (41 C). Several Bay Area cities opened cooling centers for residents during this heat wave. In southern California, Los Angeles Department of Water and Power reported record high electricity demand on August 31. Subsequent significant heat waves impacted southern California and parts of the Southwest in October and November. The hot and dry conditions allowed for moderate to severe drought conditions to persist or expanded across Arizona, southern Utah, the Four Corners Region, and coastal southern California during autumn.

Across the northern half of the West, an active storm track in November produced near to well above normal precipitation. However, for the Sierra Nevada and southern Cascades, the snow level was generally fairly high, so accumulations were confined to higher elevations. During December, a stubborn area of high pressure settled over the West, keeping much of the region drier than normal. December is typically the wettest month of the year at Blue Canyon in California's Sierra Nevada, but this year it only received 0.88 in (22 mm), 8% of normal. This dry start to the wet season raises concerns about a return to drought conditions for California, Nevada, and persistence and expansion of existing drought conditions across the Southwest in 2018.

Average temperatures across the northern half of Alaska were warmer than normal during 2017, while the southern half was generally near normal. Some of the greatest

temperature departures were observed along the North Slope. Utqia'vik (Barrow) observed its second warmest year on record, second to 2016, at 18.5 F (-7.5 C), 6.8 F (3.8 C) above normal. This was also the 3rd wettest year on record at Utqia'vik, with 8.32 in (211 mm), 184% of normal. Kotzebue had its 3rd warmest year on record at 26.9 F (-2.8 C), 4.2 F (2.3 C) above normal. These above normal temperatures and precipitation are related to the lack of sea ice; exposed seas moderate land temperature and allow for greater evaporation. This year featured the 8th lowest Arctic sea ice extent since 1979 and was also one of the lowest on record for the Beaufort and Chukchi seas. Many Interior Alaska locations recorded above normal precipitation, Fairbanks had its 12th wettest year on record at 14.47 in (368 mm), 134% of normal. Precipitation was near to slightly below normal across the southern half of the state.

Precipitation averaged to slightly below normal across the state of Hawaii in 2017. A dry start to the year resulted in drought conditions developing by July. By October, 65% of the state was experiencing moderate or worse drought conditions, mostly on Big Island. A wetter period reduced this to 21% by the end of the year. On Kauai, Lihue observed 23.55 in (598 mm) for the year, 64% of normal and the 7th driest year on record. Temperatures across most of the state were slightly warmer (<1.2 F/0.7C) than normal. Sea levels were much higher than normal throughout much of the year for Hawaii. During king tide events, minor to moderate flooding occurred in low-lying coastal areas. Further west, 2017 precipitation was generally 80-110% of normal across the US-affiliated Pacific Islands. The northern Marshall Islands experienced very dry conditions to start the year; household rain tanks had gone dry by late April prompting the president of the Marshall Islands to declare a State of Emergency. Subsequent summer rainfall helped to alleviate these dry conditions. Temperatures were warmer than normal for many locations in Micronesia. Chuuk experienced its warmest year in a 104-year record at 83.4 F (28.6 C), 1.8 F (1 C) above normal. Kosrae and Pohnpei had their 3rd warmest years on record at 82.5 F/28 C (2.1 F/1.2 C above normal) and 82.1 F/27.8 C (1.2 F/0.7 C above normal), respectively. Records for Kosrae began in 1954 and Pohnpei in 1951.

2017 State Climate Office Annual Summaries

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About the Alabama State Climate Office

It is the role of the Office of the State Climatologist to provide weather and climate information to the public and private interests to improve decision making activities that affect environmental quality and the economic efficiency of the State. Activities include providing specific historical weather data for the State and for the world, developing plans to mitigate the economic impacts of weather and climate variability and providing consultation on the use, interpretation and availability of weather and climate information. The Alabama Office of the State Climatologist also directly engages in important societal debates such as global warming through basic research, hosting workshops, providing congressional testimony and participating in educational activities.

Communication Capabilities

The main communication method is through publications we produce as they are accessed through the internet. Our website is: http://vortex.nsstc.uah.edu/aosc/

A part-time communications expert produces and writes our monthly state information reports and stories related to unusual events, particularly those of the past 150 years. We have yet to see a need to participate in social media outlets given the type of information we provide and the resources available to provide it.

Information Services, Products and Tools

The State Climatologist produces several unique, daily products related to water resources and agriculture.

Lawn and Garden Index: http://vortex.nsstc.uah.edu/aosc/lawn_garden_se.html

We produce several high-resolution, daily antecedent products (average insolation, total precipitation, maximum temperature, minimum temperature) that are utilized to generate the agricultural stress products through the system we call GRIDSSAT. http://gridssat.nsstc.uah.edu/

Each month we generate the Alabama Climate Report which is a summary of the state's climate with historical information about the coming month. http://nsstc.uah.edu/alclimatereport/

Each month our research team generates global grids of satellite-based temperatures for climate monitoring. This is an important product as it is utilized for assessments of climate variability and change at the highest levels. http://nsstc.uah.edu/climate/

Research, Products and Publications

Alabama Climate Report is a monthly summary of the state's climate with historical information about the coming month.

The State Climatologist, with colleagues, publishes research papers that address local, regional and global climate. For example, the following four 2017 papers address several critical aspects of the global climate, including climate sensitivity.

Christy, J.R. and R.T. McNider, **2017**: Satellite bulk tropospheric temperatures as a metric for climate sensitivity. *A-P J. Atmos. Sci.*, 53(4), 1-8, DOI:10.1007/s13143-017-0070-z.

Christy, J.R.: **2017**, Lower tropospheric temperature [Global climate; Temperature; Lower Tropospheric Temperature [in "State of the Climate in 2016"], *Bull. Amer. Meteor. Soc*. 98, (8), S16-S17. DOI:1-.1175/2017BAMSStateoftheClimate.I.

Long, C. and J.R. Christy: **2017**, Lower stratospheric temperature [Global climate; Temperature; Lower Stratospheric Temperature [in "State of the Climate in 2016"], *Bull. Amer. Meteor. Soc*. 98, (8), S17-S19. DOI:1-.1175/2017BAMSStateoftheClimate.I.

Spencer, R.W., J.R. Christy and W.D.Braswell, **2017**: UAH version 6 global satellite temperature products: Methodology and results. Asia-Pac J. Atmos. Sci., 53(1), 121-130, DOI:10.1007/s13143-017-0010-y.

The global climate research is particularly important as federal "global warming" regulations have a particularly negative impact on the economy of our state and its many poor people (see congressional testimony.) The State Climatologist is also the author of the global tropospheric temperature section produced for the Bulletin of the American Meteorological Society's annual State of the Climate report.

Outreach and Education

The State Climatologist has testified before 20 congressional committees on climate variability and change. The 2017 Hearing testimony is below.

House Committee on Science, Space and Technology, 29 Mar 2017

https://science.house.gov/sites/republicans.science.house.gov/files/documents/HHRG-115-SY-WState-JChristy-20170329.pdf

The State Climatologists speaks at numerous venues each year including universities, civic organizations, schools, private industry meetings, state government panels, etc.

Monitoring and Impact Assessment

The State Climatologist is a member of the Monitoring and Assessment Group hosted by the Alabama Office of Water Resources. This group monitors water resources and meets regularly to assess drought designations for the state's regions.

The State Climatologist is a member of the Governor-appointed Alabama Water Agency Working Group which is examining the potential for a statewide water management plan.

The State Climatologist owns and operates a 16-station climate network with instrumentation identical to the NOAA Climate Reference Network (CRN) with satellite-reporting every hour with observations displayed on the NOAA CRN website.

The State Climatologist is the lead for making recommendations to the Drought Monitor each week and is thus in constant contact with water users and water organizations around the state.

ALASKA CLIMATE RESEARCH CENTER

Key Personnel:
Martin Stuefer, Director ACRC, Research Associate Professor
Lea Hartl, Post Doctoral Researcher ACRC
Jason Grimes, Research Technician ACRC
Gerd Wendler, previous Director, ACRC, Professor Emeritus
Blake Moore, Programmer
Telayna Gordon, Research Technician

Housed at: Geophysical Institute, University of Alaska Fairbanks

About the Alaska Climate Research Center

The Alaska Climate Research Center (ACRC) is part of the Geophysical Institute, University of Alaska Fairbanks. It was established by the State of Alaska via Title 14, Chapter 40, Section 085. Specific information can be found about this statute at http://www.legis.state.ak.us/basis/statutes.asp - 14.40.085. Funding support for the ACRC comes from the Geophysical Institute and from the State of Alaska.

The purpose of the center is threefold:

- Dissemination of climatological data.
- Research on climate variability and climate change in Alaska and Polar Regions, and
- Education.

Communication Capabilities

For nearly three decades we have made climatological data available to the public, private, and government agencies, and to researchers around the world. Over the course of a year, winter is the busiest season for public inquiries to the Alaska Climate Research Center, probably due to the very cold temperatures (down to -40°F and colder) and ice fog, which makes driving difficult, if not dangerous. There also exists a high pollution potential locally due to strong surface inversions.

The ACRC website (http://akclimate.org/) contains many summaries, products, meteorological and climatological information. Furthermore, from our home page, users can select a number of links: Alaska weather and climate, our popular webcam and on-campus weather station, climatological data, up-to-date summaries, information for tourists, seasonal and other weather and climate links, and a 'spotlight on climate' section giving a list of the latest features posted. Our research projects involve modeling emissions from wildfires and volcanoes. We disseminate updated Alaska wildfire smoke forecasts via the http://smoke.alaska.edu/ page, which is very

popular during the Alaska wildfire season.

Specific requests for data, normally received online, by telephone, and sometimes by walk-ins, are filled free of charge. It should be noted that we do not make predictions on future climate change, nor assess the socio-economic and biophysical impacts of such predicted climate projections. Our focus is on observations.

We publish monthly and annual reviews both for selected cities (Utqiaġvik, Fairbanks, Anchorage, Nome, King Salmon, Juneau, Ketchikan) as well as for Alaska as the State.

Research, Projects, and Publications

A substantial number of journal and other publications on the climate of Alaska and Polar Regions have been produced over the years including a book on the Climate of Alaska. More recently we wrote papers describing precipitation changes across Alaska, on the climate change of Sitka (the old capital of Alaska under Russia, for which station the records go back to 1827), and on wildfire detection using VIIRS remote sensing data.

Publications:

- G. Wendler, T. Gordon, M. Stuefer: On the Precipitation and Precipitation Change in Alaska, *Atmosphere 8*(12):253, December 2017
- C. F. Waigl, M. Stuefer, A. Prakash, C. Ichoku: Detecting high and low-intensity fires in Alaska using VIIRS I-band data: An improved operational approach for high latitudes. *Remote Sensing of Environment*, vol 199, pp 389-400, September 2017.
- H. Eicken, A. Mahoney, J. Jones, T. Heinrichs, D. Broderson, H. Statscewich, T. Weingartner, M. Stuefer, T. Ravens, M. Ivey, A. Merten, J. Zhang: Sustained observations of changing Arctic coastal and marine environments and their potential contribution to Arctic maritime domain awareness: A case study in northern Alaska. *Arctic*, July 2017.
- G. Wendler, K. Galloway, M. Stuefer 2015: On the Climate and Climate Change of Sitka, Southeast Alaska , *Theor. Appl. Clim*.p.1-8).

Outreach and Education

We have been giving talks and seminars on the climate and observed climate change in Alaska and Polar Regions. We also provided educators and community groups with charts and data for use in educating their classes and communities, as well as answering a variety of queries from the community regarding issues such as the lake effect, Alaska's warming, and abnormal weather events in Alaska.

ARIZONA STATE CLIMATE OFFICE

State Climatologist: Nancy J. Selover, Ph.D.

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About the Arizona State Climate Office

The Arizona State Climate Office (ASCO) is located within the Office of Climatology of the School of Geographical Sciences & Urban Planning (SGSUP) at Arizona State University (ASU) in Tempe, AZ. The office includes the State Climatologist, Dr. Nancy J. Selover and two affiliated faculty in SGSUP (Dr. Anthony Brazel, emeritus professor and former State Climatologist; and Dr. Randall Cerveny – the WMO Rapporteur for the World Climate Extremes). The office is also affiliated with the new Center for Urban Climate Research at ASU and the Global Institute of Sustainability. Our mission is to: (1) manage and disseminate climatological information about the State of Arizona, (2) monitor the climate of Arizona and the Southwest, (3) collaborate with state agencies in need of climate data and advisement, and (4) conduct research aimed at an improved understanding of the spatial and temporal variability of the climate of Arizona. The State Climatologist is appointed by the Governor, but the office is funded through the University. Currently the State Climatologist is funded at a 50% level through the School of Geographical Sciences & Urban Planning and additional funding is grant based, typically on applied climatology projects.

Communication Capabilities

We maintain an ASCO web page (http://azclimate.asu.edu/) to provide real-time weather data with a climate context, and provide climate products online. The website includes general climate and real-time weather information, the monthly Arizona Climate Summary, daily rainfall and evaporation tables for the Phoenix area, daily North American Monsoon updates (in summer), and links to climate education and safety information and other climate data resources.

We maintain a voicemail system to take data and information requests when the office is not physically staffed. Calls are answered or returned typically within 24

hours whenever possible. Most data and information requests come through e-mail, from the State Climatologist contact information available through numerous links on the State Climate and University websites and the State's 211 website. The data are served back through the Internet, phone, e-mail, and the U.S. postal service as we have two weather/climate enthusiasts without computer access.

Information Services, Products and Tools

In 2017 we continued to receive most of our data requests through the e-mail resulting from the State Climate contact information available through the University or re-direct from the webpage. Peak usage is in late spring as we head into the monsoon and again in November as we head into the winter storm season. Data users, other than web downloads, include university researchers; state and local government agencies, particularly law enforcement; the public; private industry; the media; and the legal community. I did 34 media interviews on topics including heat waves, hurricanes, dust storms, drought, climate change, winter storms, daylight savings time, monsoon, flooding and Arizona Climate, urban heat island, and wildfire, we were involved in 3 legal cases as consultants. This year we generated monthly summary products for temperature and precipitation records, and continue updating the Climate of Phoenix with current data. We produced monthly and quarterly reports on drought for the Arizona Department of Water Resources webpage, climate summaries for State Climate Office website, daily climate data for the Kingman, AZ newspaper and daily evaporation and weather data for the local Water/Power Utility Salt River Project.

Research, Projects, and Publications

- Arizona Department of Emergency & Military Affairs – PI on Improving Hazard Mitigation Framework through Content, Infrastructure and Context. $50,000.
- DOC-NOAA – Co-PI on Evaluation of Drought Risks and its Impact on Agricultural Land and Water use to Support Adaptive Decision-making. PI - Soe Myint $300,000
- NASA – co-PI on Using Remote-Sensing to Understand the Impacts of Droughts on Agricultural Land Use and Water Consumption to Support Adaptive Decision-making in Arid Environments. PI - Soe Myint $199,953
- NOAA SARP – Informing Emergency and Risk Management Climate Knowledge in Arid Regions. Co-PI with Nalini Chhetri. $98.443.
- National Park Service – Monitoring Microclimates in Petrified Forest National Park. $20,000.
- National Park Service-- Monitoring Microclimates in Joshua Tree National Park. $20,000.

Proposal Reviewer for one State Climatologist agricultural research proposal, one drought assessment web tool, and one K-12 Science Teacher Education book chapter on Weather and Climate.

Collaborate with CLIMAS – the Southwest RISA at University of Arizona, Sonoran Institute, Central Arizona Project Long-Term Ecological Research (CAP-LTER) project, Decision Center for Desert City, AZ Dept. of Emergency & Military Affairs, AZ Dept. of Water Resources, AZ Dept. of Environmental Quality, AZ Dept. of Health Services, and Phoenix Neighborhood Services Division.

Outreach and Education

- Co-Chair of Technical Monitoring Committee of State Drought Task Force
- Recording Secretary of Arizona Flood Warning Multi-Agency Task Force
- Co-State Coordinator – CoCoRaHS – Community Collaborative Rain, Hail & Snow Network, citizen scientist precipitation observers.
- Member of State Hazard Mitigation Plan Update team helping State and County plan updates to incorporate climate change.
- Executive Committee for Central Arizona Chapter of American Meteorological Society
- Mentoring three K-12 teachers in the Earth Climate System in the AMS Datastreme program
- Chair of WERA1012 – a planning committee within the Western Association of Agricultural Experiment Station Directors, with the task of Managing and Utilizing Precipitation Observations from Volunteer Networks

24 Presentations to Community (6), Education (8), Professionals (3), State Agencies (5), and Conferences (2) on topics including Arizona climate & extreme weather, water, floods, droughts, solar radiation & energy, climate & health, Sclimate resilience, climate change, monsoon, UHI, heat waves, and Hazard Mitigation Planning.

Monitoring and Impact Assessment

- Monitoring temperature and precipitation in the Petrified Forest National Park to inform park archaeologist as to weathering conditions for petroglyphs and other historical cultural assets. Currently have 4 years of data from 12 stations around the park.
- Monitoring temperature and precipitation in Joshua Tree National Park in southern California to provide climate data for research on changes in the vegetation communities across the park. Installed 7 stations in the park.
- Prepare monthly updates of custom SPI and SPEI gridded indices for long-term drought monitoring for the Governor's Drought Task Force.
- Publish monthly newsletter summary of Arizona climate.
- Archive data from the Phoenix first-order weather station, and the AZMet network for Arizona.
- Statewide co-coordinator for CoCoRaHS precipitation monitoring in Arizona (1405 observers).
- Assist new operators with maintenance of the former USRCRN climate stations in Arizona, including National Park Service Inventory & Monitoring Group, Arizona State University Climate Office, Salt River Project, United State Geological Survey, and the White Mountain

Apache Tribe. Data are currently ingested by the Western Region Climate Center and pushed out to MADIS.

- Translating and disseminating climate variability and urban heat island research for policy-makers in the cities and tribes in the Phoenix metropolitan area.
- Monitoring effects of urban forestry on the urban heat island at two locations in central Phoenix, through the City of Phoenix Neighborhood Services Division, and across the Arizona State University Tempe campus.
- Provide climate assessments for numerous Centers and interdisciplinary groups across Arizona State University working on climate change issues including policy and social equity.

CALIFORNIA STATE CLIMATE OFFICE

State Climatologist: Michael Anderson
Assistant State Climatologist: N/A
Staff/Service Climatologists:
John Andrew – Executive for Climate Change Programs
Elissa Lynn – Climate Change Program Manager
Peter Coombe – Northern Region Climate Specialist
Jennifer Morales – South Central Region Climate Specialist
Jordi Vasquez – Southern Region Climate Specialist
Nina Oakley – WRCC California Specialist and Volunteer for DWR
Benjamin Hatchett – WRCC/DRI and Volunteer for DWR
Matt Winston – State Meteorologist
Maury Roos – Chief Hydrologist Part Time

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http://cdec.water.ca.gov/
http://ferix.water.ca.gov/webapp/climate.jsp
http://www.cimis.water.ca.gov
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About the California State Climate Office

The California State Climate Office resides in the California Department of Water Resources. The office of the State Climatologist is housed within the Division of Flood Management Hydrology and Flood Operations Office while the climate change program is housed in the Division of Statewide Integrated Water Management. The Office provides technical expertise in weather and climate interfaces with hydrology and water resources management as well as organizes the Department's contributions to the State's climate change program efforts under the Climate Action Team. The State Climatologist coordinates with the Western Region Climate Center, the California Nevada Applications Program RISA and the USDA Climate Hub at the University of California Davis. In addition to working with other State Agencies, the State Climatologist provides funding to federal agencies for designated projects and funds researchers at the University of California campuses through the University of California Office of the President Climate Services Agreement. This includes the Atmospheric Rivers Research Program funded in the 2017 budget which is a $3 million investment with the Center for Western Weather and Water Extremes at Scripps Institution of Oceanography at the University of California San Diego.

Communication Capabilities

The Office of the State Climatologist provides climate data services through a variety of data portals listed above. CDEC alone has an average bandwidth per day of 22.3GB. This corresponds to a total of more than 5 million visitors with almost 800,000 unique IPs. Additional data services are provided via email, phone, and mail.

The State Climatologist has also been involved in the Department's climate change matrix team which is an internal coordination committee regarding climate change and Department of Water Resources program activities. The team meets quarterly. At the state-level Climate Action Team, the State Climatologist participates in the Research Working Group and the Coastal and Oceans Working Group.

As part of the response from the extreme events of 2017, the State Climatologist provided briefings and supplemental information to the Unified Command Group at the State Operations Center of the California Office of Emergency Services. This included providing explanation to General Baldwin of the California National Guard during helicopter flights over flood-impacted areas.

Information Services, Products and Tools

CDEC, FERIX, and CIMIS are DWR outlets providing numerous informational products to support integrated water management for California. The webpage of the

State Climatologist provides a location for the posting of monthly climate summaries for California as well as monthly climate notables. In 2016 a new annual report was launched titled "Hydroclimate Report". The report presents a summary of the water year as well as a number of metrics being used to monitor the impacts of a warming world on California's hydrology. The report has been published for water years 2015 and 2016. Water year 2017 is currently nearing completion.
Work with partners has yielded additional data and decision support products such as the atmospheric river monitoring and forecast information at the Center for Western Weather and Water Extremes (CW3E), the California Climate Tracker at Western Region Climate Center, the Airborne Snow Observatory (ASO) products from NASA's Jet Propulsion Lab, and satellite-based snow products from the Center for Water, Earth Science, and Technology at the University of Colorado Boulder.

Research, Projects and Publications

- The Office of the State Climatologist (OSC) supports multiple research efforts in monitoring, forecasting, and development of decision support tools. A key element of this is work with the University of California managed through the University of California Office of the President Climate Services Agreement. This has been a 10-year contract with a capacity of $13 million supporting work at 6 different campuses. In 2017 work includes $3 million in funding provided by the legislature for the Atmospheric Rivers Research Act which supports advanced observations, modeling, forecasting, and material for decision support developed by CW3E at UC San Diego Scripps Institution of Oceanography.

- An interesting multi-agency collaboration effort funded in part by the OSC has examined the meteorological influences and important thresholds for post-fire debris flows. The effort involved collaboration with Nina Oakley from Western Region Climate Center and CW3E, and Jeremy Lancaster from the California Geological Survey. The effort is part of Nina's doctoral research.

- Collaborative work with the United States Geological Survey is run through an umbrella contract that includes funding for stream gages that are part of the state-federal flood forecasting system. The primary work for the OSC has been developing interpretive maps and products from the Basin Characterization Model.

- Work continues with NOAA's Earth Systems Research Laboratory (ESRL) continuing work started under the Lab's Hydrometeorology Testbed effort begun 10 years ago. This includes support for over 100 observing instruments for atmospheric rivers.

- Work with NOAA ESRL and 10 San Francisco Bay Area Counties has recently begun to install gap-filling radar and other instrumentation to feed into the development of models and decision support for integrated water management ranging from stormwater runoff to reservoir operations and conjunctive use. The work also includes efforts to take the Cosmos sea level planning model and develop a forecast coastal storm surge and river outlet flooding tool. The project is a four-year, $19 million-dollar effort funded through the Integrated Water Management Planning Program at DWR.

- The State Climatologist has been co-author or participated in five publications with the UC Davis Hydrologic Research Laboratory.

Outreach and Education

The State Climatologist provides outreach talks at numerous meetings around the State including partner workshops, professional societies, agricultural groups, and Rotary clubs. Key presentations include the Western States Water Council, the California Extreme Precipitation Symposium, and at the Hydroclimate Symposium at the American Society of Civil Engineers (ASCE) Environmental and Water Resources Institute's World Water Congress.

Using Skype, the State Climatologist has delivered remote lectures on California's climate to an undergraduate class at Humboldt State University and for a graduate class at Columbia University.

The Climate Change team provides two climate literacy classes per year for DWR staff and conducted four external classes in 2017 in Lake, Inyo, Merced, and Santa Barbara Counties.

The State Climatologist sits on the ASCE Hydroclimate Committee, is an associate editor for the ASCE Journal of Hydrologic Engineering, and sits on the Steering Committee of NASA's Western Water Applications Office. The State Climatologist also assists the Bureau of Reclamation with proposal reviews and project reviews including the Seasonal Forecast Rodeo.

The State Climatologist continued participation in the California Nevada US Drought Monitor Coordination calls hosted by the National Weather Service Weather Forecast Offices. He also continued participation in workshops and activities associated with the NIDIS program.

Participation in the Western Extension Research Activity Committee on Hydroclimate Observations was limited due to health issues at the time of the meeting. The State Climatologist is going to host the 2018 meeting at UC Davis with the assistance of the USDA Climate Hub team at UC Davis.

Monitoring and Impact Assessment

Numerous projects noted above contribute to monitoring the characteristics and impacts of atmospheric rivers, California's seasonal snowpack, and water management metrics to track a changing climate. In addition to those efforts, the State Climatologist has participated in the Water Management Indicators Work Group that is part of the National Climate Assessment and reviewed text for the National Climate Assessment.

At the State level, the State Climatologist has provided assistance for the California Indicators of Climate Change Report produced by the California Environmental Protection Agency Office of Environmental Health Hazard Assessment, worked with the Research Working Group of the Climate Action Team on the State's 4th Climate Assessment, and reviewed material for Sea Level Rise Guidance from the Coastal and Oceans Working Group. The State Climatologist and members of the climate change group within the Department of Water Resources developed material and facilitated the updating of the State's Adaptation Report, *Safeguarding California.*

In the area of monitoring, the State Climatologist is participating in a number of activities to rehabilitate and improve California's observation capabilities. Efforts continue with the Hydrometeorological Testbed Legacy Atmospheric River Observing Network made up of coastal wind profilers, GPS-Met stations to observe total integrated water vapor over land, and snow level radar. Complementing this network is a Bay Area project called "Advanced Quantitative Precipitation Information Network which uses smaller radar installations to fill gaps in the larger Doppler radar network due to topographic blocking. These radar installations will augment the data provided by the atmospheric river observing network to help inform choices in integrated water management ranging from stormwater management through reservoir and surface/groundwater coordination operations. The Jet Propulsion Lab in Pasadena is working with the Department through the Western Water Applications Office to explore quantifying the seasonal snowpack volume using airborne remote sensing techniques. Efforts are ongoing to tie these advanced observing systems to existing in-situ weather station networks and satellite data products to achieve an integrated observing system in California.

COLORADO CLIMATE CENTER

State Climatologist: Russ Schumacher
Assistant State Climatologist: Becky Bolinger
Staff/Service Climatologists:
Nolan Doesken, retired state climatologist/Extension
Peter Goble, climatologist/drought specialist
Noah Newman, CoCoRaHS education coordinator
Henry Reges, CoCoRaHS national coordinator
Zach Schwalbe, CoAgMET Manager
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About the Colorado State Climate Office

The Colorado Climate Center (CCC) was established by the State in 1974, through the Colorado State University Agricultural Experiment Station, to provide information and expertise on Colorado's complex climate. Through its threefold program of Climate Monitoring (data acquisition, analysis, and archiving), Climate Research, and Climate Services, the Center responds to many climate-related questions and challenges. The Center monitors climatic conditions on both broad, regional scales and very local scales using data gathered by public sources (National Weather Service, USDA, USDI etc.) but also by monitoring networks deployed by the Center. Data resources are combined to provide higher granularity and as much local detail as possible in a state with great topographic and climatic diversity. By documenting climate variations in time and space, the relationships between climate, water supplies, other natural resources, agriculture and societal responses can be better understood and applied to support appropriate planning and decision making.

Communication Capabilities

The Colorado Climate Center communicates and disseminates climate information via the following platforms:

- Website Services
  - http://climate.colostate.edu - the Colorado Climate Center website serves as a portal to all information about Colorado's climate. Presentations, reports, data, and general climate information can all be accessed on the website. Data requests can be submitted and either provide data from our own servers, or from RCC-ACIS.
  - http://cocorahs.org - CoCoRaHS, an international volunteer precipitation monitoring network, is managed through the Colorado Climate Center. CoCoRaHS has its own website, customer service, and professional outreach including a YouTube channel and an education series of 12-16 webinars per year.
  - http://coagmet.colostate.edu - CoAgMET has its own website and outreach mechanisms including customizable text messaging of recent weather data for individual weather stations. The eRAMS system now provides mapping of near-real-time conditions at many sites across the state. Graphics of recent observations are easily accessible through the map.
  - We currently do not have the capability to give information about the website traffic to these sites.
- Social Media
  - Climate Center on Facebook (***Figure 1***): Number of likes increased from 670 (June 2017) to 862 (June 2018).
  - Climate Center on Twitter: Number of followers increased from 935 (June 2017) to 1,256 (June 2018).
  - CoCoRaHS on Facebook: 7,152 followers (increase of 442 since last report)
  - CoCoRaHS on Twitter: 6,538 followers (increase of 828 since last report)
  - CoCoRaHS YouTube channel: 2,596 subscribers (our educational series video on the water cycle has over half a million views!) – an increase of 488 subscribers since last report.
- Presentations
  - Because of the popularity of weather and climate in our state, we continue to get many invitations to share our expertise with various groups. We typically accept an average of one speaking invitation per week, giving us considerable visibility across the state.
  - Our 36 years of continuous participation in the Colorado Water Availability Task Force is a prime example of how we communicate and disseminate climate information to the state's major water providers, administrators, and utilities.
- Phone and email inquiries – Colorado Climate Center staff regularly receive phone calls and emails with questions about current climate conditions, requests for data, and other climate-related expertise.

Information Services, Products and Tools

- Weekly and Monthly Reports
    - Weekly NIDIS summaries, with periodic webinars, help us communicate current drought, climate, and water conditions. Around 500 people are emailed weekly updates. Webinar attendance typically ranges between 10 and 25 people, however with the development of drought, attendance increased near the end of the year.
    - Fort Collins Campus Weather Station – a monthly report of climate conditions at the climate center maintained campus weather station is distributed to a broad email audience (researchers, educators, businesses, and media) and is also available on our website.
- Popular web services and tools – the bulk of our information services is managed through the Colorado Climate Center website. Following is a list of our most popularly accessed information services.
    - http://climate.colostate.edu/~drought - in addition to the weekly distributed report, visitors can regularly view current conditions across the NIDIS IMW DEWS region.
    - http://climate.colostate.edu/~autowx/fclwx_plot_display.php - Fort Collins Campus Weather Station graphing and data retrieval tool.
    - http://coagmet.colostate.edu/cgi-bin/extended_etr_form.pl - CoAgMET crop specific ET estimation tool. CCC staff uses tool to create unique ET accumulation plots found on the drought webpage.
    - https://cocorahs.org/Maps/conditionmonitoring/ - View current condition monitoring reports from CoCoRaHS observers. (***Figure 2***)

Research, Projects, and Publications

- Ongoing work to serve the mission of the Center and the needs of Colorado include analyzing and interpreting trends in observed climate, placing significant events in historical perspective, and improving our understanding of climate variability.
- A website redesign was completed and went live in spring 2017. The old website emphasized access to raw data, but has since been shifted to focus more on value added products. Old raw data access capabilities are still functional, but new raw data access pulls data from ACIS. Value added products include a climate normals page (***Figure 3***), climate extremes page, seasonal forecasts, and a regularly updated ENSO page.
- With continued support from both state and federal resources, 10 CoAgMET stations were added on the west slopes of Colorado, and maintenance has continued for all 85 stations. The team has been working to add more value-added products to the CoAgMET suite, including climate summaries, water demand information and mapping, and a growing season report for the long-term stations (***Figure 4***).
- In collaboration with the Carolinas Integrated Sciences and Assessments (CISA), Condition Monitoring maps have become available. These maps display the level of dryness or wetness reported by the observers, overlaid on a U.S. Drought Monitor map,

and clicking on a station brings up a detailed report about local conditions. These reports are heavily utilized in drought monitoring, and are referred to by the U.S. Drought Monitor authors.

- An assessment, with support from FEMA's Hazard Mitigation Grant Program, was completed in 2017 that identified gaps in weather and climate monitoring in Colorado. One of the major recommendations from this report is the installation of a radar in southern Colorado (the San Luis Valley).
- As part of the Climate Smart initiative, we teamed with the CSU Water Center and the video production department to develop an online course of modules on Colorado's climate, and climate variability and extremes. Modules include video presentations, slides, suggested reading material, and quizzes. The purpose of these modules is to help train Extension staff on climate issues specific to Colorado.
- Publications
    - Bolinger, B., 2017. A Changing "Climate" at the Colorado Climate Center: Saying Goodbye to Familiar Faces, Hello to What's New. Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 34, 5 (Sept/Oct), pp. 36-40.
    - Doesken, N., 2017. Nolan Doesken, A Man for Our Climate. Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 34, 5 (Sept/Oct), pp. 30-35.
    - Lackstrom, K and Coauthors (Reges), 2017. CoCoRaHS Observers Contribute to "Condition Monitoring" in the Carolinas: A New Initiative Addresses Needs for Drought Impacts Information. Bull. Amer. Meteor. Soc. doi:10.1175/BAMS-D-16-0306.1, in press.
    - Wilhite, D.A., Roger S. Pulwarty and Coauthors, 2017: Drought and Water Crises: Integrating Science, Management, and Policy, 2nd edition. Part III: Advances in Tools for Drought Prediction, Early Warning, Decision Support and Management. ISBN 9781138035645 - CAT# K31741.
    - Bolinger, R. A., A. D. Gronewold, K. Kompoltowicz, and L. M. Fry, 2017: Application of the NMME in the Development of a New Regional Seasonal Climate Forecast Tool. Bull. Amer. Meteor. Soc. doi:10.1175/BAMS-D-15-00107.1
    - Newman, N., and Nolan Doesken, 2017. "Citizen Science" at Work in Colorado. Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 34, 3 (May/Jun), pp. 40-42.
    - Goble, P., and Nolan Doesken, 2017. Colorado's Climate and Forests: An Update on Snowpack's Developing Relationship with Climate Change and the El Niño Oscillation. Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 34, 2 (Mar/Apr), pp. 18-21.

Outreach and Education

- Speaking Engagements
    - Zach spoke about CoAgMET at various events, including at Colorado Water Congress and the Upper Colorado Basin Water Forum.
    - In honor of the 20th anniversary of the Fort Collins Spring Creek Flood, Nolan and Noah attended and presented at a ceremony.
    - Presentations about Colorado's climate and/or the current climate and drought situation were given by all members of the staff at workshops, seminars, and conferences across the state.
- Henry Reges heads up CoCoRaHS national outreach efforts. He gave presentations at 34 offices around the country that included National Weather Service forecast offices and water management districts. He visited other offices, spoke at the AMS Annual Meeting in Seattle, Washington, and his outreach efforts took him to the Bahamas for a WMO-sponsored trip.
- Classrooms/Education
    - On behalf of CoCoRaHS, Noah visited schools to talk with teachers and students about measuring precipitation.
    - Noah has given periodic tours to students and teachers at the historic Campus Weather Station.
    - Becky and Peter have also worked with students at schools to teach them about climate and weather.
    - Noah manned a CoCoRaHS booth at the inaugural Colorado Weatherfest.
- Media Inquiries – Nolan, Russ, Becky, Peter, and Noah have all been interviewed by media outlets to provide information on climate and drought conditions. Media requests have come from radio (NPR, Colorado Public Radio, KOA), printed press, internet news sites, and television stations.

Monitoring and Impact Assessment

The Colorado Climate Center operates and maintains several different weather observing systems:

- Provide comprehensive climate monitoring for the Fort Collins campus weather station. http://climate.colostate.edu/~autowx/ . 2017 was the 129th year of complete and consistent uninterrupted data collection for this station. Detailed monthly summaries of means, extremes and anomalies are distributed at the end of each month.
- The Colorado Climate Center operates and maintains a mesonet called the Colorado Agricultural Meteorological nETwork, CoAgMET (http://coagmet.colostate.edu). It is a network of 85 stations around the state, mainly in rural, irrigated agriculture areas from the plains to the West Slope of the Rocky Mountains. We have been actively involved now for over 20 years and have been the primary caretakers for the past several years. While there are many uses of the data for agriculture, natural resources and environmental protection, a main motivation for this network has been to estimate evapotranspiration needed for irrigation scheduling and more effective water use. Each

station consists of hourly and daily measurements of: air temperature, humidity, solar radiation, soil temperature, precipitation via tipping bucket, wind speed and direction, and soil moisture at select dry land stations. There are now 59 stations with 5-minute reporting. Zach continues to work coordinate with the National Mesonet.

- We currently own and maintain 17 previous National Weather Service RCRN stations that provide high quality observations from many remote locations around the state.
- We continue to host, store, and quality control CoCoRaHS data records. Julian manages the website, including the input of data measurements and condition monitoring reports, data access and display, and condition monitoring mapping. In 2017, 3,862 observers signed up in the U.S., and 2,418 of those submitted at least one daily precipitation report. The following are the number of observations reported in 2017 across the country:
  - 4,185,474 daily precipitation
  - 74,051 multi-day precipitation
  - 5,132 significant weather
  - 2,469 hail
  - 12,905 condition monitoring
  - 23,983 ET
  - 145 soil moisture

Regular drought monitoring continues with the support of the NIDIS program. In addition to the weekly reports, webinars, and drought page, drought monitoring efforts include 1) coordinating with extension, local NWS offices, USDA FSA offices, and NOAA RISAs; 2) communicating current drought conditions to multiple sectors, including media; and 3) participating in the U.S. Drought Monitor weekly procedures.

Figures

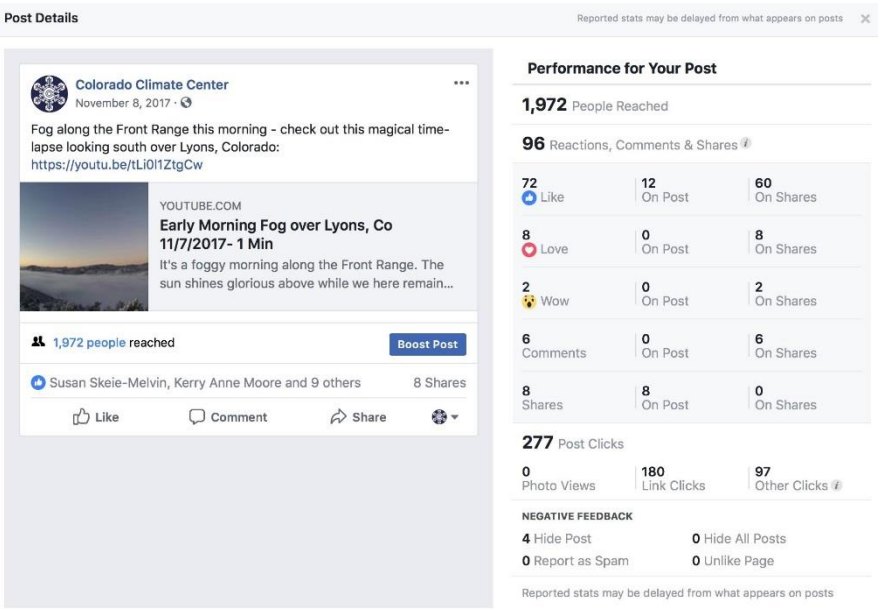

Figure 1: Example of one of our more popular Facebook posts, with analytics included.

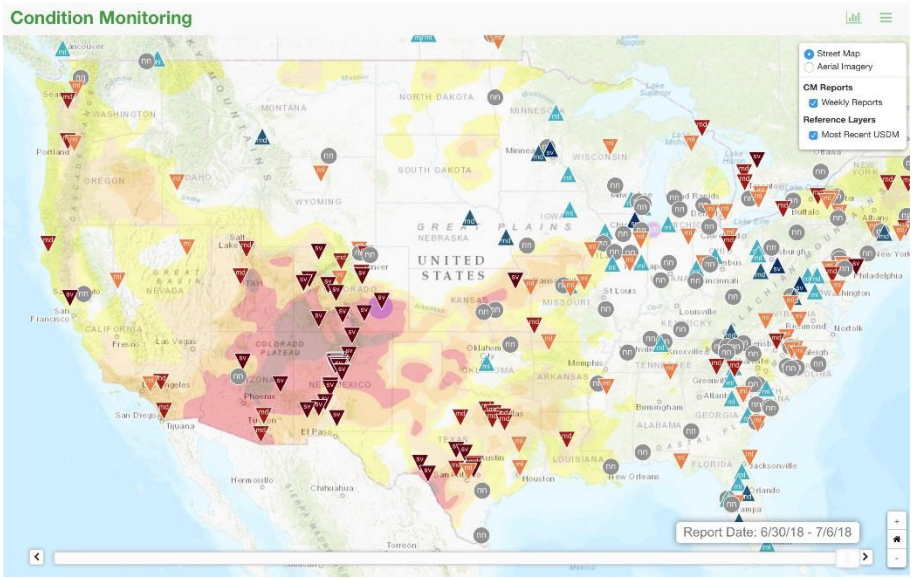

Figure 2: Mapping display feature of CoCoRaHS Condition Monitoring Reports

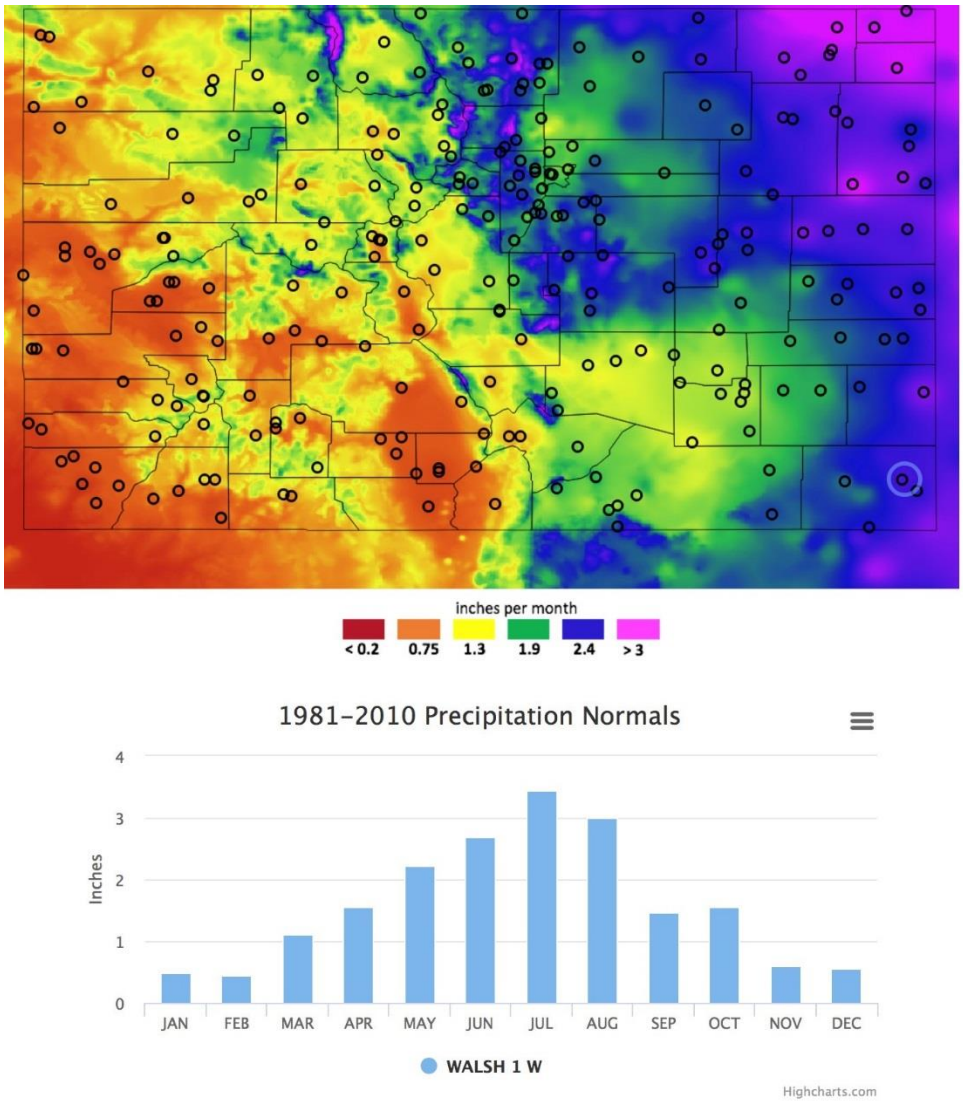

Figure 3: Climate Normals page for June, with a sample station selected and plotted below.

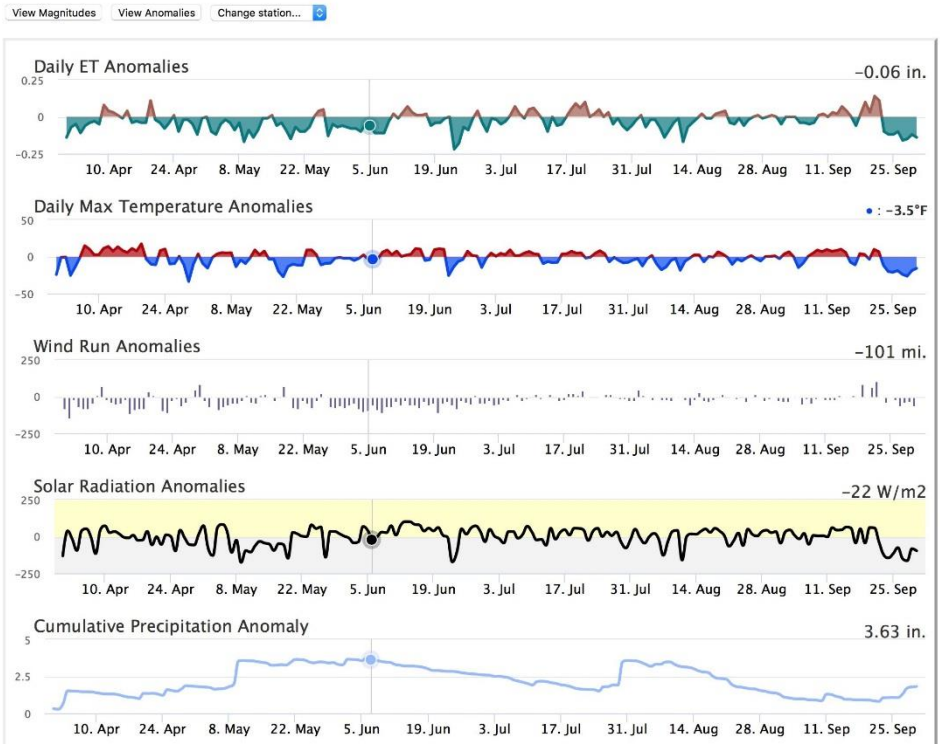

Figure 4: 2017 growing season summary for the Avondale CoAgMET station, showing anomalies for each of the variables. This allows for easier analysis of what led to above or below normal ET throughout the season.

CONNECTICUT STATE CLIMATE CENTER

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Activities

During the past year, CSCC has committed a substantial amount of time and effort in making the Center a valuable asset to the research, education and outreach communities at University of Connecticut, state and local government agencies, and the general public in the State of Connecticut.

The CSCC has been running with support to satisfy the minimum NCDC requirement for the program. Due to budget issues, CSCC was unable to obtain any funds for attending the annual AASC meeting and conducting additional activities.

Research, Projects and Publications

- CSCC has supported 4 researchers (3 from UCONN, 1 from Yale) by providing NCDC quality-insured data, in the fields of climate change, air pollution, environmental engineering, and agriculture.
- CSCC has submitted a proposal to the Connecticut DEEP for analyzing the Connecticut climate data for the past 100 years and rewriting the climate reference book for the State.

Outreach and Education

- CSCC has provided up-to-date climatic data and live images for several courses taught at the University of Connecticut, including NRE 3115 Air Pollution, NRE 3145 Meteorology, NRE 3146 Climatology, and NRE 4170 Climate-Human-Ecosystem Interaction.
- CSCC is working with other faculty members to develop more structured educational and training programs at the University of Connecticut.
- CSCC has updated its website data pages for public to access climatic data for the State of Connecticut. The web site now provides processed climatic data for more stations across the State.
- In addition to the website, CSCC also delivers climate information via the joint web page with Connecticut IWR http://www.ctiwr.uconn.edu, feature articles in various local media, traditional ways through our cooperative extension system, posters and

demonstrations at university and college organized events (such as Connecticut Conference on natural resources), and peer-reviewed publications.

- CSCC has delivered dozens of services in the past year to university research community, governmental agencies and general public by providing processed and certified climatic data sets in various formats through email, telephone, fax, and mail.
- CSCC has provided a few of impact analyses to various media (newspapers, magazines, and radio talks), local governments and schools, and state government agencies on climate change, El Niño, drought, and abnormal wintry weather. Recommended by the Dean of CANR and the NRE Department Head, CSCC also has served on the Governor's working group on climate change. A poster has been displayed at the College's Cornucopia event.

OFFICE OF THE DELAWARE STATE CLIMATOLOGIST

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About the Delaware State Climate Office

The Office of the Delaware State Climatologist (ODSC) is located within the College of Earth, Ocean, and Environment at the University of Delaware. The ODSC is part of the Center for Environmental Monitoring and Analysis (CEMA) and works in conjunction with the Delaware Environmental Observing System (DEOS), the Delaware Environmental Monitoring and Analysis Center (DEMAC) and the University of Delaware Satellite Receiving Station (UDSRS) to provide environmental data services to Delaware and the surrounding region. The ODSC is an AASC Recognized State Climate Office (ARSCO) and partners with the National Center for Environmental Information, the Northeast Regional Climate Center, and the National Weather Service in Mt. Holly, NJ to provide data and climate services to the citizens of the State of Delaware. The ODSC also serves in the Technical Assistance Center of the Delaware Emergency Management Agency during critical weather events. The State Climatologist is also a statutory member of the Water Supply Coordinating Council, and presents water related climate information at quarterly meetings and during drought emergencies.

Communication Capabilities

As with most State Climate Offices, we provide climate data and expertise to the public and private sector via our web page (climate.udel.edu), as well as conduct newspaper, radio, and television interviews and give many public lectures. We also use social media (Facebook and Twitter) to keep the public up-to-date on weather and climate information concerning the State of Delaware.

Information Services, Products, and Tools

The Delaware Coastal Flood Monitoring System (CFMS): Surrounded by the Delaware Bay, the Delaware River, and the Chesapeake Bay, the Delmarva Peninsula is very vulnerable to coastal storms. Much of the damage during tropical and extra-tropical weather events is associated with severe coastal flooding. The Delaware coastline is extremely susceptible to such events, examples being the great March, 1962 storm and post-tropical cyclone Sandy. The Delaware Coastal Flood Monitoring System (CFMS) extends along the Delaware coastline from Lewes, DE to New Castle, DE and is extensively utilized during potential coastal flooding events (www.coastal-flood.udel.edu). The system sends a warning of forecast tidal levels to users via the DEOS Alerts System, directs them to the CFMS web site where all information on the coming event is available. The CFMS website provides the user with a map showing the potential coastal inundation for the upcoming storm for 15 communities along the Delaware Bay shoreline, as well as road elevation profiles of key evacuation routes relative to the predicted inundation level.

The DEOS Snow Monitoring Network: DEOS supports the Delaware Department of Transportation (DelDOT) Snow Removal Reimbursement Program with at least one snow depth measurement in each of the 12 transportation maintenance areas statewide. The three northernmost areas include three snow depth monitoring systems and the southern districts have varying numbers resulting in 26 operational snow monitoring stations across the State. Ten additional snow sensors are operated in Chester County, PA as well as a few research sites, but are not monitored for use in real-time applications. In total 34 snow depth monitoring stations exist within the DEOS network. Sonic ranging depth sensors are installed at each location from October to April. Storm total snowfall is available in real-time and archived on the DEOS snow monitoring website. In recent seasons millions of dollars have been reimbursed to civic associations throughout Delaware by DelDOT based upon the DEOS snow observations. This money helps to defray snow removal costs of neighborhoods and developments and expedites the snow removal process, particularly during major snowstorms. In addition, the snow monitoring network's data are used operationally by DelDOT to deploy snow plows and other snow removal equipment within each maintenance area during an event.

The Delaware Irrigation Management System (DIMS): DIMS serves as an irrigation scheduling tool for the agricultural community of Delaware. It uses daily meteorological data from the DEOS network to obtain reference evapotranspiration and rainfall that are used to calculate crop water requirements for user-defined farm fields. DIMS provides a user interface where growers can enter their field specific information (i.e., crop type, field location, planting date, etc.) and using that information, DIMS automatically determines the NRCS soil texture classification and nearest DEOS meteorological station for each field. Crop water requirements are updated daily and allow users to enter their own irrigation and rainfall data to make the system provide more accurate results. DIMS was launched in Spring 2012 for use

with corn, soybean, and several vegetable crops and is currently used for over 100 irrigation systems statewide.

The DEOS Pond Monitoring Network: Starting in 2015, DEOS began partnering with the Delaware Department of Natural Resources and Environmental Control's (DNREC) Dam Safety Program to install, operate, and maintain a system of water level gauges at high risk ponds around the state. These ponds were studied by the DNREC Dam Safety Program and determined to be high risk because they posed danger to life and property in the 4 event they were to fail. As of September 2017, there are 16 pond monitoring stations in the DEOS network, with 5 more slated to come online later in 2018. An alerts system provides DNREC and DelDOT officals with notifications when the water levels on the ponds reach pond-specific thresholds that could threaten the integrity of the ponds' dams. The notifications are used by state officials to coordinate staff that manage the pond levels using gates and other control structures so as to reduce the risk of dam overtopping or failure.

Research, Projects, and Publications

The ODSC is currently involved in funded research projects to:

- Update and expand a mid-Atlantic coastal storm climatology that includes data for all coastal storms from 1945 through June 2018.
- Develop a Delaware Weather Hazards Index for the Delmarva region.
- Develop for the State of Delaware a "Coastal Dashboard" to integrate realtime, historical, and forecast weather and ocean data concerning coastal storms and coastal flooding.
- Maintain and expand a web portal to disseminate climate change projections and climate data for Delaware.
- Update the Delaware Water Quality Portal (developed by ODSC and DEMAC).
- Develop a downy mildew risk tool for lima beans in Delaware.

Outreach and Education

Delaware joined CoCoRaHS on September 1, 2009. Kevin Brinson, Associate State Climatologist, serves as the CoCoRaHS coordinator for the state. Presently, the state is homogeneously covered by approximately 54 active observers. In addition, the ODSC gives many public presentations on the weather and climate of Delaware each year, and the State Climatologist and Associate State Climatologist serve on a large number of statewide committees concerned with environmental monitoring and environmental data analysis.

The ODSC is highly involved in the educational mission of the College of Earth, Ocean, and Environment at the University of Delaware. Each year graduate students

use data archived within CEMA for thesis work and research support. ODSC/DEOS fund at least two graduate students each year, and generally have 2-4 undergraduate students working with the ODSC on Delaware specific research projects. CEMA also supports the College's new Meteorology/Climatology program with a visualization laboratory, data products and software development.

Monitoring and Assessment

The Delaware Environmental Observing System (DEOS): The ODSC, through the DEOS network, continues to operate a real-time weather, climate and environmental data system to meet the needs of a growing constituency. For over 14 years, the DEOS network has provided real-time environmental observations for Delaware and the surrounding region (http://www.deos.udel.edu). Today, DEOS operates its own environmental monitoring platforms and aggregates and disseminates data from over 184 additional environmental sensing systems throughout our region in real-time. These data are used for a number of purposes including forecast model initialization, emergency management, coastal flood monitoring, and irrigation scheduling to name just a few. DEOS monitoring and data services are utilized across many sectors throughout the Mid-Atlantic Region.

Our core meteorological network has now grown to a total of 57 stations (49 installed and maintained by DEOS) located in the three counties of Delaware, Chester County in Pennsylvania (in cooperation with Chester County (PA) Department of Emergency Services), and Cecil County in Maryland. Data from the core network and approximately 184 additional environmental observing platforms is collected, visualized, disseminated in real-time and archived by DEOS. The data collected by the core meteorological stations include air temperature, relative humidity, wind speed and direction, total solar radiation, atmospheric pressure, precipitation, and in many cases soil temperature and soil moisture. Thirty-four (34) of the core stations also measure snow depth. The additional real-time observing platforms comprise of networks from the U.S. Geological Survey NWIS stream and tide gauge network, National Weather Service ASOS network, National Data Buoy Center buoy network, National Ocean Service NWLON network, as well as the Delaware Department of Transportation RWIS roadway weather monitoring network. Data from these networks augment the real-time data available from DEOS and include meteorological conditions, stream flow, tidal water level, water quality, wave conditions, and groundwater well level.

GEORGIA STATE CLIMATE OFFICE

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Social media: www.facebook.com/georgiaclimate/
www.twitter.com/gaclimateoffice

About the Georgia State Climate Office

The Georgia State Climate Office (SCO), within the Georgia Department of Natural Resources (DNR), functions to collect, disseminate, and interpret climatological and meteorological data. It daily serves the state in responding to public and private entities on issues related to Georgia's climate, as well as offering correspondence with educational institutions as it relates to atmospheric science. An important role of the climate office is to stay apprised of current atmospheric conditions as it relates to (but not limited to) drought, the ENSO (El Nino-Southern Oscillation) forecast, and the short, medium, and long-term seasonal outlooks. In addition, the office internally produces composite maps containing climatological information, such as precipitation and temperature.

Communication Capabilities

The SCO website contains monthly climate summaries, meteorological and climatological data resources, and other useful links for public dissemination of information. Specific requests for climatological information and data are received frequently from media, private and public sources and addressed on an ongoing basis. The SCO monitors climate within the state and provides input on drought conditions and meteorological, hydrological, and agricultural impacts to the U.S. Drought Monitor. The office also seeks to take advantage of the growing influence of social media and thus has established, and maintains, active Facebook and Twitter pages.

Information Services, Products, and Tools

The SCO has increased production of available data products for users. Service Climatologist, Lauren Lindsey, successfully generates and maintains a GIS display tool for viewing of climate information across the state of Georgia and the Southeast U.S. These plots encompass a number of climate-related parameters, including mean temperatures and anomalies, rainfall amounts and departures, stream flows, archived storm reports, and other specialty plots for high impact weather and climate events affecting Georgia. Future goals are to include as many of these plots as possible on the SCO website such that members of the public will have access to this data.

Research, Projects, and Publications

An additional function of the SCO is to provide climate data and analysis for requested use in research and educational projects. The data provided by the SCO has been utilized in academic research for universities across the region. Most recently, the office provided input from Georgia for use in the state summary of the National Climate Assessment report. The National Climate Assessment, generated by a team of more than 300 scientists and guided by a Federal Advisory Committee, provides an in-depth look at climate-related impacts in the U.S. The State Climatologist frequently presents to the Georgia DNR Board of Directors on the state of the climate, drought conditions and outlooks, and issues related to air quality in Georgia.

Outreach and Education

The SCO upholds an outreach focus. Staff participates, to the extent possible within staffing and budget limits, in as many outreach efforts as possible. These outreach efforts range from elementary school presentations, children 4-H programs, guest lectures at various Georgia universities and participation on climate-related discussion panels. The office maintains very open communication with news media outlets across the entire state. Data and analyses are disseminated via the internet, email, telephone, regular mail and in person through interviews and presentations.

Monitoring and Impact Assessment

The SCO, in collaboration with the Air Protection Branch of the Environmental Protection Division and Georgia Institute of Technology, forecasts levels of air pollutants throughout the state of Georgia. Data are used to determine compliance with six compounds and to evaluate the need for any special controls for various other pollutants. Data are used to calculate the Air Quality Index (AQI) and update the information every hour in order to protect public health. A future goal of the office is to enhance automated archived and real-time data on our website to assist in case study analysis and monitoring climate conditions within the state.

Figure

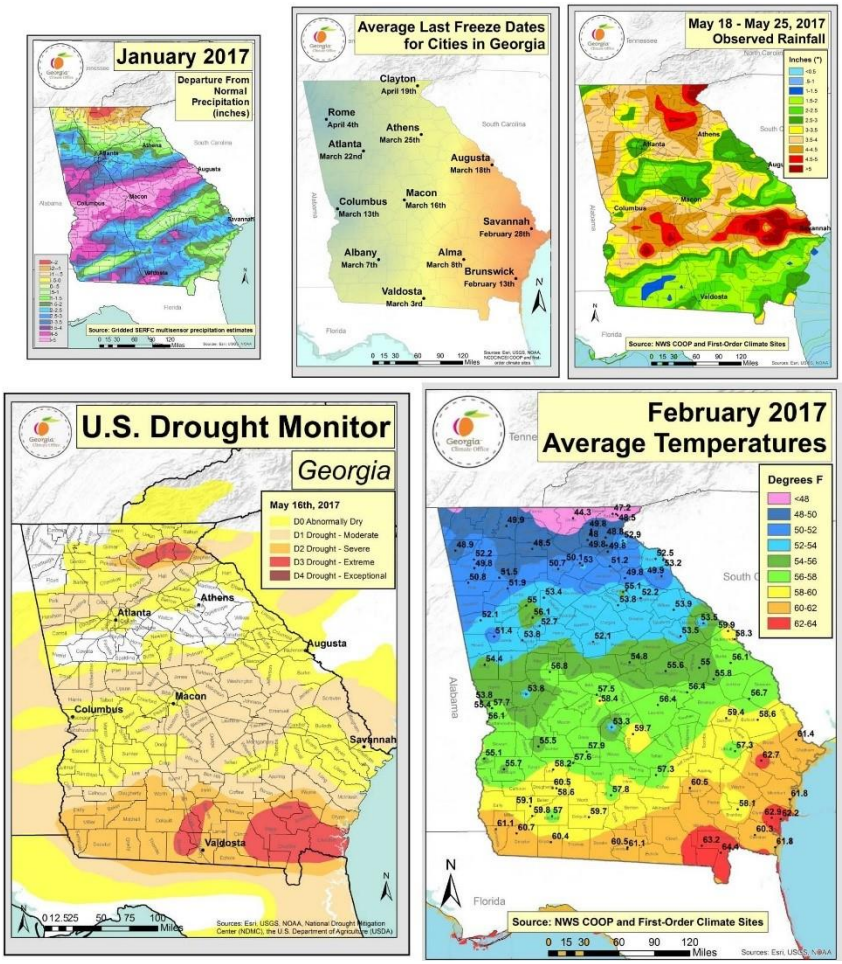

Figure 5: Examples of GIS climate data plots generated within the State Climate Office

HAWAII STATE CLIMATE OFFICE

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About the Hawaii State Climate Office

The Hawaii State Climate Office (HSCO) is a member of the American Association for State Climatologists and a partner of the National Oceanic and Atmospheric Administrations' National Centers for Environmental Information (NOAA/NCEI). It was established in 2000 and located at the University of Hawai'i Manoa in the Department of Atmospheric Sciences. Our primary service is to provide Hawaiian climate and weather related information on a timely basis, such as precipitation and temperature.

Communication Capabilities

Our website is http://www.soest.hawaii.edu/MET/Hsco/site.htm. Through our website, we provide climate reports as well as some important data links, for example, hydrology data and climate change indicators data. We also provide our email address and other contact information for people who are unable to find the data they need on our website.

Information Services, Products, and Tools

This year, the most frequent data request that we handled include precipitation, wind and temperature data from a wide scope of fields: from government agencies to researchers and students. We also help National Weather Services to observe rainfall data. We again assisted the State Department of Business, Economic Development and Tourism (DBEDT) to update their annual Data Book as we did consecutively in the past 13 years.

Research, Projects, and Publications

This year, we conducted the research project on the application of Bayesian model averaging (BMA) to improve the monthly/seasonal forecasts of sea surface temperature (SST) and ENSO. Individual model simulation has strength and weakness which indicates that if only one model simulation is taken into consideration, it can only provide a limited understanding and may ignore and underestimate the uncertainty of the prediction. Thus, it is important to utilize the results

from a variety of different models. It is suggested that the is a useful platform from which to merge the information of different model simulations. BMA is an effective tool not only in describing uncertainties associated with each model simulation but also providing the forecast performance of different models. The BMA method was developed for multi-model ensemble forecasts of SST in Niño 3.4 region from 1982 to 2016. The BMA weights were derived directly from the predictive performance of the combined models. It is shown that the BMA method can be used to assess the performance of the individual models and assign greater weights to better performing models.

The Climate Office is also continuing on our dynamical downscaling project on Oahu to reduce the uncertainty of future projected rainfall simulation. This year, we are also doing the dynamical downscaling on Kauai for the extreme heavy rainfall event that occurred on Kauai and Oahu in April 2018.

The state climatologist, Dr. Chu, in collaboration with Dr. Hui-Ling Chang of the Central Weather Bureau in Taiwan and Barbara Brown of NCAR, published a paper on nowcast guidance of afternoon thunderstorm initiation in Weather and Forecasting, 2017, 32, 1801-1817. Dr. Chu also published another paper with the goal to improve typhoon intensity forecasts with Drs. Kim and Moon of Jeju National University in South Korea. The paper was also published in Weather and Forecasting, 2018, 33, 347-365. A third paper published during July 2017 to June 2018 is with Dr. Hsu of Nanjing University of Information and Science and Technology in Climate Dynamics, 2017, 49, 3175-3192.

Outreach and Education

In 2018, Dr. Chu has been invited to be a member of the Hawaii State Hazard Mitigation team, which consists of government officials from federal, state, county, and city, emergency management, planners, and researchers. A monthly meeting is taking place to discuss various kinds of natural hazards in Hawaii (e.g., volcanic eruptions, flooding) and its vulnerability assessment. Currently, Dr. Chu is assisting the Hazard Mitigation team to update the comprehensive 2018 Plan.

Monitoring and Impact Assessment

We observe and collect daily rainfall data in the Hawai‘i Institute of Geophysics (HIG) Building, a long-term cooperative site used by the National Weather Services.

IDAHO STATE CLIMATE SERVICES

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About Idaho State Climate Services

Climatic information is essential to every citizen of Idaho. To help people obtain the climatic and water data and information necessary to planning and every day work, the State Climatologist Program strives to acquire, archive, process and disseminate, in the most cost effect manner possible, climate and weather information which is or could be of value to policy and decision makers in the state and to provide climatic services which are important to the people of Idaho.

The functions of the State Climatologist and State Climate Services are to:

- Collaborate with state and federal agencies responsible for monitoring and forecasting water availability for Idaho
- Assist Idaho weather information users to obtain historical Idaho weather data from the National Climatic Data Center
- Maintain a data bank of climatological and hydrological research data and information
- Assist data users by formatting climate data into usable forms.
- Perform requested climate analyses or refer requests to other appropriate persons, agencies or consulting firms
- Maintain contact with users of climatic and hydrological data in order to ascertain their needs for data and analyses
- Maintain a bibliography of publication pertinent to Idaho and Pacific Northwest climate

In May, 1978, an agreement was concluded among the National Climatic Data Center, the National Weather Service and the University of Idaho to provide climate services which had been provided by a former National Weather Service program. ISCS became the AASC Recognized State Climate Office (ARSCO) for the State of Idaho in 2001.

Idaho State Climate Services is housed in the Department of Biological Engineering and is directed by the Idaho State Climatologist. It is supported by the Idaho Agricultural Experiment Station and the Idaho Cooperative Extension System in cooperation with the Idaho Water Resources Research Institute.

Communication Capabilities

ISCS maintains internet, email, telephone, and fax communication links.

Information Services, Products, and Tools

- Idaho joined CoCoRaHS in January 2009; the Idaho SC serves as the statewide coordinator of the precipitation network, which now has 265 observers.
- Responded to numerous e-mail/phone requests for climate data/information/services.
- Interviewed by local, state and national newspapers, radio stations, and other media outlets.
- Maintain three automated weather stations, a Cooperative Observer Station with over 110 years of data, a CoCoRaHS non-recording precipitation gage, and a recording precipitation gage, and partially fund a Sno-Tel site.
- ISCS provides numerous reports including Intensity-Duration-Frequency spreadsheets for many cities in Idaho.

Research, Projects, and Publications

- Develop hybrid remote sensing-ground sensor method to quantify watershed snow-covered area.
- Use remote sensing to simulate snowmelt runoff from the Upper Snake River.
- Examine the effect of interannual variability on snowpack and runoff volumes and timing for the eastern Snake River Plain, the principal water supply for southern Idaho.
- Evaluate the impact of current water rights on distribution of irrigation water under changing supplies associated with various climate change scenarios.
- Evaluate the impact of climate change scenarios to evapotranspiration on irrigation water demand and the resulting economic impact on agricultural revenues.
- Analyzing historical temperature trends at climate stations across Idaho
- Developing algorithms and models to assimilate remotely sensed data for use in spatially distributed land surface-atmosphere exchange models
- Maintain a 130 foot tall eddy covariance forest research tower to study water and carbon exchange in complex mountainous, forested topography.
- Conducting studies for the Idaho Transportation Department on the interaction of inclement weather and road slope and curvature on the frequency of accident occurrences.

Publications:

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Outreach and Education

Participation and collaboration of the following outreach activities:

- Interact with federal and state stakeholders regarding annual climate, and water resources conditions.
- Presentations to Idaho State Legislative committees on climate and climate change issues in the state.
- Climate products provided through ISCS, and the printed volume, *Climates of Idaho* (Abramovich, R., M. Molnau, and K. Craine, University of Idaho, College of Agricultural and Life Sciences).
- Climate Presentations to local schools.
- Media Communication

Monitoring and Impact Assessment

- ISCS helps monitor current and historical precipitation through the CoCoRaHS network (http://www.cocorahs.org/) and QA/QC analyses of the Idaho network.
- ISCS is conducting studies of the impact of climate scenarios on state climate, water supply, agricultural water demand, and agricultural revenue for the Snake River Plain of southern Idaho. These are related to historical observations from the Cooperative Observer Network, SnoTel (http://www.wcc.nrcs.usda.gov/snow/), and an agricultural meteorology network (AgriMet, http://www.usbr.gov/pn/agrimet/)

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About the Illinois State Climate Office

The State Climatologist Office (SCO) for Illinois is located at the Illinois State Water Survey (ISWS) in Champaign, Illinois, at the Prairie Research Institute, University of Illinois. The office also operates the NWS coop site for Champaign-Urbana. The office is co-located with the Midwestern Regional Climate Center. Jim Angel has been the State Climatologist (SC) since 1997.

Communication Capabilities

The SC maintains a web site, a blog, and Twitter account devoted to climate data and information on a wide variety of climate topics relevant to Illinois. The web site covers standard products such as climate maps and datasets. Meanwhile, the blog and Twitter accounts provide a means for reporting climate conditions as they develop. In 2017, the blog had 52 posts and 85k views. The Twitter account had just over 1000 followers with about 1 to 5 tweets per week.

Information Service, Products, and Tools

The SC is actively engaged in providing information services within Illinois. In 2017, the media contacted the office over 100 times. Each month the SC prepares a press release on conditions around the state. The SC does a weekly radio recording of current agriculture weather conditions that is distributed around the state. The SC gave 25 public talks in 2017. Social media has been increasingly used to provide climate information.

The SC writes regular contributions to the monthly ISWS Water and Climate Summary. The SC provides both data and information for the following agencies in Illinois: the Water Supply Task Force, the Drought Response Task Force, the

Department of Natural Resources, the Department of Transportation, the Attorney General's office, and the Illinois Emergency Management Agency.

Research, Projects, and Publications

In 2017, the SC was involved in several projects including a US Army Corps of Engineers project to look at incorporating future climate change in the development of extreme rainfall frequencies; a US Army Corps of Engineers project to manage a 25-gage precipitation network in Cook County, Illinois; an NOAA SARP project to develop best practices for communities planning for climate change, and a State of Illinois project to updated the rainfall frequency atlas (Bulletin 70).

Publications:

Markus, Momcilo, James Angel, Kexuan Wang, Gregory Byard, Sally McConkey, Zoe Zaloudek, 2017. Impacts of Potential Future Climate Change on the Expected Frequency of Extreme Rainfall Events in Cook, DuPage, Lake, and Will Counties in Northeastern Illinois. Illinois State Water Survey, Champaign, IL 114 p., ISWS CR 2017-05
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Knapp, Vernon, James Angel, Jennie Atkins, Luke Bard, Elias Getahun, Kenneth Hlinka, Laura Keefer, Walton Kelly, George Roadcap, 2017. The 2012 Drought in Illinois. Illinois State Water Survey, Champaign, IL 99 p.,
http://www.isws.illinois.edu/pubs/pubdetail.asp?CallNumber=ISWS+RI-123

Outreach and Education

The SC has worked closely with University of Illinois Extension on a number of issues that included: a) training of CoCoRaHS weather observers, b) teaching a section on climate to Master Naturalists in Champaign and Madison Counties, c) speaking at University of Illinois Extension Seminars around the state, and d) occasional guest on the Illinois Gardener program on WILL-TV.

Monitoring and Impact Assessment

The State Climatologist monitors climate conditions and their impacts on Illinois throughout the year. When necessary, the magnitude and extent of extreme climate events are communicated to state government for disaster declarations as well as coordination with state and local officials. This is most common during times of drought or extreme rainfall/flooding. This information is disseminated through email, press release, and social media as well as regular contact with state agencies.

STATE CLIMATOLOGIST OFFICE OF IOWA

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About the Iowa State Climate Office

The State Climatologist Office (Iowa SC) is a bureau of the Iowa Dept. of Agriculture & Land Stewardship with duties specified in State Code 159.5.4 and 159.5.5. The State Climatologist is appointed by the Iowa Secretary of Agriculture (an elected state official). The Iowa SC office was founded in Iowa City at the University of Iowa on October 1, 1875 and was initially known as the Iowa Weather Service. In 1890 the Iowa Weather Service operations were moved to Des Moines and came under the supervision of the Iowa Weather & Crop Service. Finally, the Iowa SC was made a division of the newly created Iowa Department of Agriculture in 1923. The Iowa SC was co-located with the National Weather Service from 1890 until 2003 and has worked very closely with that agency since its inception.

Information Services, Products and Tools

The Iowa SC office maintains archives of NWS co-op and first order station data back to the beginning of records. This would include the regular NCEI reports such as *Storm Data, Iowa Climatological Data* and *Local Climatological Data*, as well as the original observations. Access to a multitude of federal and state weather and climate data archives are also maintained. With 142 years of continuous operation the Iowa SC Office has an unusually large archive of original federal and state books, reports and manuscripts from the 19th and early 20th Century. The specialty of the Iowa SC office is the documentation of Iowa's historical climate-monitoring networks, such as station locations, instrumentation and observation procedures.

Research, Projects and Publications

The Iowa SC office primarily is involved with the acquisition, processing, dissemination and archiving of weather and climate data. However, research activities are performed as funding permits and have been conducted in cooperation with agencies such as the National Climatic Data Center (NWS co-op network metadata), the Midwestern Regional Climate Center (pre-1948 data keying project),

the National Science Foundation (crop-hail climatology), U. S. Army Corps of Engineers (evaporation, snow, short-duration precipitation studies) and the Iowa Dept. of Natural Resources (development of more timely temperature data resources).

Work has continued in developing a monthly data base of historical Iowa precipitation records with over 21,000 station-years compiled. Preliminary work in developing statewide averages of various weather statistics beyond average monthly temperature, precipitation and snowfall is also in progress. These new averages include the number of days per year reaching or exceeding maximum temperatures of 90ºF or 100º and minimum temperatures at or below 0ºF, dates of last spring and first fall freeze, as well as extreme annual maximum and minimum temperature and maximum daily precipitation amount.

An ongoing project of the office is the detailed quality-control of daily and monthly NWS automated and co-op data for locations within Iowa. These data are updated monthly and, in cooperation with the Iowa State University Agronomy Department, made available online at: http://mesonet.agron.iastate.edu/request/coop/fe.phtml. The data are also published in a summarized document known as the *Iowa Climate Review* (sample at: http://www.iowaagriculture.gov/climatology/ClimateReview/IowaClimateReview201711.pdf). This data QC effort routinely identifies equipment and/or reporting issues that allow for more timely National Weather Service maintenance and thus minimize the duration of periods of poor data quality.

Another project is underway to develop a complete hourly temperature data base for Des Moines extending back into the 1800's. These hourly data will be used for a variety of uses, such as better documenting the 'time of observation bias' and for providing a means of adjusting the Des Moines historical daily data to a common format (i.e., pre-1906 maximum and minimum temperature data were not based upon calendar day periods).

Outreach and Education

The office maintains very open communication with the news media with several hundred media contacts each year. This, combined with preparation of Public Information Statements issued in cooperation with the National Weather Service, and weekly and monthly crop-weather summaries prepared for the USDA provides very wide dissemination of climate products and information. Over fourteen hundred specific climate data information inquiries are answered in a typical year. Most inquiries are received from government agencies, the news media, attorneys and insurance, in that order. Virtually every major branch of State government utilizes the Iowa SC Office data on a regular basis. Some examples include the Iowa Utilities Board which utilizes heating degree day data as part of its rate-setting policies for energy companies across 18 regions in the state. Data from the Iowa

SCO was used in dozens of investigations of the Iowa Dept. of Inspections and Appeals during 2017 and in 179 cases of potential misapplication of pesticides investigated by the Iowa Dept. of Agriculture & Land Stewardship Pesticide Bureau.

The office also prepares regular monthly climate reports, the *Preliminary Iowa Monthly Weather Summary* and the *Iowa Climate Review*. The Preliminary Monthly Weather Summary is issued within the first few work days of each month and provides a brief summary of Iowa's weather conditions for the previous month. This report is available on-line: http://www.iowaagriculture.gov/climatology/weatherSummaries/2018/pms201802.pdf

The Iowa State Climate Office works closely with the National Weather Service in monitoring the co-op and ASOS data networks so as to improve the quantity, quality and timeliness of Iowa climate observations. The State Climatologist has served on several NWS regional and national committees involved with climate and data issues. In January 2012 the Iowa SC became co-chair of the NOAA Data Stewardship Team and in July 2013 became the co-coordinator for the Community, Collaborative Rain, Hail and Snow Network in Iowa (CoCoRaHS). Considerable effort has been expended in expanding the CoCoRaHS network in the state and in improving the data quality. Record numbers of CoCoRaHS reports have been received in each of the past four years. The Iowa SC makes about one to two dozen public climate presentations per year to various agricultural groups, community service organizations and government agency meetings.

Monitoring and Impact Assessment

The Iowa State Climate Office is a member of the Governor's Drought Task Force and Flood Task Force and the State of Iowa Hydrology Working Group. The office provides regular updates of monthly temperature and precipitation data to the USDA Farm Service Agency for their use in evaluating county-by-county eligibility for disaster relief programs. The office also assists the Iowa Homeland Security and Emergency Management Division in their operations and occasionally provides guidance for county and regional emergency response offices. Special weather summaries and analyses are also prepared for the USDA and U.S. Geological Survey and the office is a regular contributor to the U.S. Drought Monitor. The office also contributed to a regional assessment of the 2012 drought and provided weather summaries for eleven issues of the Iowa DNR's Water Summary Update in 2017. The largest weather/climate impact in Iowa during 2017 was drought with portions of 13 south central and southeast Iowa counties classified as in Extreme Drought in the U.S. Drought Monitor for the late summer/early fall period. Heavy rainfall and flooding events were much less frequent than in recent years. Annual precipitation totals were as much as 13.89 inches below normal at Oskaloosa while on the other extreme Fayette recorded 9.48 inches more than normal precipitation. Above normal annual precipitation was largely confined to northeast and west central Iowa.

For the second consecutive year annual rain deficits of ten inches or more were widespread across portions of south central and southeast Iowa. Overall the year ranked as the ninth warmest and 61st wettest among 145 years of records.

Figure

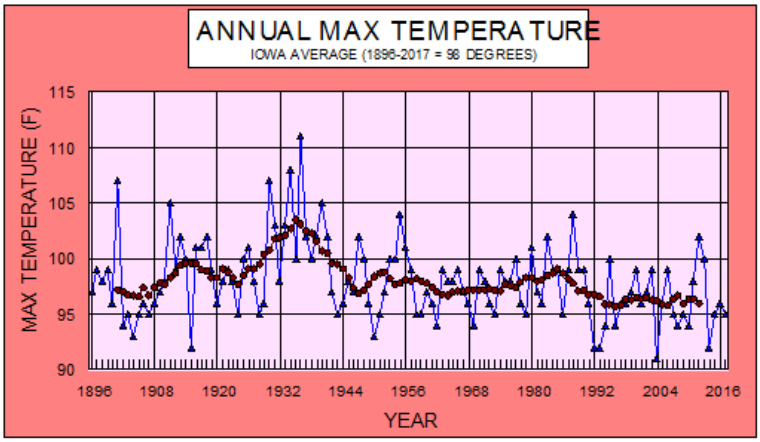

Figure 6: The first version of these historical metrics has been completed with plans for expanding the number of locations used in these statistics continuing in 2018.

STATE CLIMATE OFFICE OF KANSAS

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About the State Climate Office of Kansas

The Kansas Office of the State Climatologist, continues in its 42nd year of operation. As a part of the Department of Agronomy at Kansas State University, the office receives funding from both the College of Agriculture and the Kansas Research and Extension Service to support both undergraduate and graduate students and to provide outreach activities to the state. Dr. Lin, as a tenured faculty, was granted tenure, which recognizes his excellent research and scholarly work.

The office currently supports two Ph.D graduate students, two post-doc fellows, and two visiting scholar/professors in addition to full time positions of assistant State Climatologist, Kansas Mesonet network manager, programmer, and weather station specialist. The Kansas Climate Office has maintained strong relationships with the seven National Weather Service Offices that serve Kansas. These include Pleasant Hill, MO, Topeka, KS, Springfield, Mo, Wichita, KS, Hastings, NE, Goodland, KS, and Dodge City, KS. This collaboration has included coordination with the CoCoRaHS program, support for Cooperative Observer Network awards, and other activities. The office also enjoys a collaborative working relationship with the High Plains Regional Climate Center. That collaboration included participation in regional workshops, submission of monthly climate reports for KS, and transfer of data from our Mesonet for use by the Regional Climate Centers.

In addition, the Kansas Office of the State Climatologist serves as the home of the Kansas Mesonet, a network of automated ag-weather stations. K-State Research & Extension weather stations are at the root of the Kansas Mesonet. These stations were established in 1986 at KSRE research centers and experiment facilities around the

state. Most were co-located with National Weather Service Cooperative Observing Stations. Since that period our network has grown and we now collaborate with the Kansas Water Office, Big Bend Groundwater Management District, the Equus Beds Groundwater Management District, Groundwater Management District 3, the USDA Soil Climate Analysis Network, Highland Community College, Rock Springs 4H Camp, ESA Alcohol, and many others.

Communication Capabilities

The Kansas Office of the State Climatologist provides weather and climate information through a variety of means. Communication by way of telephone, and email are common, but our primary delivery of information is by way of the web. There were over 350 requests for information received by email, phone or office visits. Some of those requests were referred to our website for the information needed. Our main website (http://mesonet.k-state.edu) continues to provide links to near real-time data, as well as historical summaries, and various products for various end users. The climate website (http://climate.k-state.edu) continues development, and is a primary focus of efforts in 2017. It provides information on historical climate data, general climate patterns in the state as well as updates on recent events. For 2017, the Mesonet website had 261,396 views by 36m 724individuals. This is up from 2014 (when monitoring began), where the site had 27, 578 views by 4,043 individuals. The climate website saw 9,797 views by 2,160 individuals in 2017.

Information Services, Products, and Tools

The office provides information services in a variety of ways. Media outlets are a major component. In addition to frequent interviews for radio, TV and newspapers on various weather and climate topics, we produce 3 weekly audio clips on weather and climate phenomena. These are broadcast on the local radio station, are distributed to 75 other stations, and are accessible on the website at http://www.ksre.ksu.edu/News/. Another regular feature is participation in a weekly agricultural weather program which is broadcast across the state and which covers current conditions and developing situations of interest to the agricultural community. Weekly and monthly climate/weather updates are produced, as are special reports as needed. On our website, we feature tools that monitor freeze conditions, hours below various thresholds, peak winds, and evapotranspiration, among other items. The latest has been an interactive degree day page that allows users to select the method and time period for a variety of uses, including energy management.

Research, Projects, and Publications

Faculty and students associated with the Kansas Climate Office are involved in various applied research projects. The office is leading a climate modeling team to conduct dynamic downscaling climate information for Ogallala Aquifer region by using WFO, which was funded by USDA NIFA. Applied climate change research

continues to assess impacts of climate changes on crop yields, irrigation, and cropping system. In addition, our research also includes studies on the impact of climate on native prairies, historical drought patterns, and Kansas drought assessment. Faculty, stuff, and students affiliated with the Kansas Climate Office presented research papers at annual meetings of American Society of Agronomy and the Ogallala Aquifer Research Workshop. We also presented papers at number of state and regional professional meetings and workshops. In addition, faculty also made invited presentations nationally and internationally.

Publications at the Kansas State Climatologist Office (2017 to 2018):

- Sun. S. X. Yang, X. Lin, G. F. Sassenrath and K. Li, 2018: Climate-smart management can further improve winter wheat yield in China. *Agricultural Systems,* **162(2018)**:10-18.
- Liu, Z. X. Yang, X. Lin, P. Gowda, S. Lv, and J Wang, 2018: Climate zones determine where substantial increases in maize production can be attained in Northeast China. *Climatic Change* (accepted).
- Sun, S. X. Yang, X. Lin, G. F. Sassenrath, and K. Li, 2018: Winer wheat yield gaps and patterns in China. *Agronomy J*. **110(1)**:319. doi:10.2134/agronj2017.07.0417.
- Lamm, F.R. D. H. Roger, A. J. Schlegel, X. Lin, R. M. Aiken, N. L. Klocke, L. R. Stone, and L. K. Shaw, 2017: Trends in plant available soil water on producer fields of western Kansas. *Applied Engineering in Agriculture*, **33(6)**, 859-868.
- Lin, X, J. Harrington, Jr., I. Ciampitti, P. Gowda, D. Brown, and I. Kisekka, 2017: Kansas trends and changes in temperature, precipitation, drought, and frost-free days from the 1890s to 2015. *J. Contemporary Water Research & Education, **162, 1**8-30. DOI: 10.1111/j.1936-704X.2017.03257.x.*
- Moberly, J. T., R. M. Aiken, X. Lin, A. J. Schlegel, R. L. Baumhardt, and R. C. Schwartz, 2017: Crop water production functions of grain sorghum and winter wheat. *J. Contemporary Water Research & Education*, ***162,** 42-60. DOI: 10.1111/j.1936-704X.2017.03259.x.*
- Araya, A. I. Kisekka, X. Lin, V. Prasad, P. Gowda, C. Rice, and A. Andales, 2017: Evaluating impact of future climate change on irrigated corn production in Kansas. *Climate Risk Management, http://dx.doi.org/101016/j.crm.2017.08.001*. ***17***, *139-154.*
- Smith AB, Alsdurf J, Knapp M, Baer SG, Johnson LC, 2017: Phenotypic distribution models corroborate species distribution models: A shift in the role and prevalence of a dominant prairie grass in response to climate change. *By*. Global Change Biology. 2017*;*00*:*1–11.
- Zhang, T. R. Mahmood, X. Lin, and R. A. Pielke Sr. 2018: Irrigation impacts on surface air moist enthalpy in the Central Great Plains of the USA. *Agriculture, Ecosystems, and Environment*. (submitted)

- Dhungel, R. R. Aiken, P.D. Colaizzi, X. Lin, D. Brauer, G. Marek, and S. Evett, 2018: Evapotranspiration model test without calibration in a semiarid, advective climate. *Hydrological Processing*. (submitted).
- Zhang, Y., X. Lin, P. Gowda, and D. Brown, 2018: Terrestrial water storage variations in U.S. Ogallala Aquifer region. *J. of American Water Resources Association*. (submitted).
- Sun, S. X. Lin, G. F. Sassenrath, 2018: Yield gap: Rainfield maize in western Kansas. *Ag. & Environ. Letters* (submitted).

Outreach and Education

Outreach activities include presenting at various workshops, and events including the Governor's Water Conference, Regional Drought Conferences, Farm Profit Seminars, and historical society events. Outreach to K-12 has included teacher workshops, participation in the STEM (Science Technology Engineering & Math) program; GROW (Girls Researching Our World) programs, Water Matters Days, and several Kids Field Days. Attendance at the three field days included classes of 2nd, 3rd and 4th graders totaling over 1500 students in addition to the teachers.

Monitoring and Impact Assessment

Expansion of the Kansas Mesonet continues. The latest stations added included collaborations with the KSU Wheat Breeding program, the Southwest Groundwater Management district and McPherson Energy. A station was added in McPherson County, and several stations were upgraded to 10-meter towers. We have completed the installation 10-meter temperature/RH sensors at all 10-meter towers to aid in the detection of temperature inversions. A new temperature inversion page was also created.

Increased focus is being put into the future growth of the Mesonet, as well as enhanced data analysis for quality control. Special reports have been prepared to highlight impacts of weather conditions on crops, livestock, and fire potential.

We also actively participate in the Drought Monitor discussions, and provided information for the NWS Central Regional Headquarters climate assessment products.

The Kansas Climate Office has also provided monthly climate summaries to the High Plains Regional Climate Center for inclusion in their regional reports.

KENTUCKY CLIMATE CENTER

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About the Kentucky Climate Center

The Kentucky Climate Center (KCC) observed its 40th year of operation in 2017-18. Housed within the Department of Geography and Geology, the center is a charter member of the Applied Research and Technology Program created in 1998. The KCC supports both undergraduate and graduate students, providing opportunities for them to participate in a variety of research and service activities. The KCC currently supports students from programs in geography, geoscience, meteorology, and computer science.

The KCC is recognized by the AASC as the State Climate Office for Kentucky and has developed working relationships with the five National Weather Service forecast offices that serve portions of Kentucky, which include Jackson, KY, Louisville, KY, Paducah, KY, Wilmington, OH, and Charleston, WV. The KCC also enjoys supportive relationships with the Midwestern Regional Climate Center and the National Centers for Environmental Information.

In addition to housing the Office of the State Climatologist, the Kentucky Climate Center is home to the Kentucky Mesonet and the Climate Research Laboratory. The Kentucky Mesonet is a research-grade statewide network of automated weather and climate stations that is recognized as the official source of climatological observations for the Commonwealth of Kentucky. The Climate Research Laboratory supports the WRF and WRF-Chem models for atmospheric and atmospheric chemistry modeling focusing on impacts of land use and land cover change and air quality.

Information Services, Products, and Tools

The KCC provides weather and climate data and information through a variety of channels. These include communication via telephone, fax, and e-mail. Our primary sources of service delivery are via the Kentucky Climate Center website, (http://www.kyclimate.org/), which includes a variety of narratives, tables, maps, and

graphs summarizing Kentucky's historical climate, and the Kentucky Mesonet website (http://www.kymesonet.org/). In early 2018, the KCC released the Kentucky Mesonet phone app for both the Android and iOS platforms.

Research, Projects, and Publications

Faculty and students associated with the KCC are involved in a variety of applied research projects. Efforts focus on the analysis of meso-scale land-atmosphere interactions. Papers on this topic were published in the Bulletin of the American Meteorological Society, Boundary-Layer Meteorology, International Journal of Climatology, Theoretical and Applied Climatology, and Earth Interactions. Faculty also continued to attract external grants including from the NSF, USDA-ARS, and NOAA. Over the past year, the KCC has developed a collaboration through the Kentucky Department of Public Health to explore relationships between climate and health with a current focus on developing case studies highlighting the impacts of extreme heat on health.

Outreach and Education

Representatives of the KCC engaged in a broad range of outreach events. These included speaking at a meeting of the Kentucky Soybean Association and at two workshops regarding a regional temperature inversion monitoring project funded by the USDA Midwest Climate Hub. These workshops provided training for private and commercial applicators of dicamba herbicide to soybeans. Other selected speaking engagements included events held by the Kentucky Farm Bureau, the University of Kentucky Cooperative Extension Service, the Kentucky Wildlife Society, the Mammoth Cave Chapter of the Sierra Club, the Kentucky County Judge Executive Association, the Kentucky Rural Water Association, and the Kentucky Public Health Association.

The KCC provided interviews through the television, radio, and newspaper media addressing significant weather and climate events and the Kentucky Mesonet.

The state climatologist plays an active role on the Kentucky Drought Mitigation Team organized through the Kentucky Division of Water. Following the drought conditions that led to an active fire season during the fall of 2016, precipitation was well distributed throughout the year, with only short periods of dry weather.

Monitoring and Impact Assessment

The Kentucky Mesonet has grown to include 69 stations that are currently operational throughout the state, reflecting the addition of a new station in Monroe County. Currently, 25 stations include probes for monitoring soil moisture and temperature. Agreements were reached that will fund new mesonet stations in Pulaski County and Shelby County. Negotiations are underway for additional stations. The KCC reached station sponsorship agreements with local partners in three counties.

The KCC participated in a project funded through the USDA Midwest Climate Hub to acquire and install instrumentation for temperature inversion monitoring at six mesonet sites across the western half of the state.

LOUISIANA OFFICE OF STATE CLIMATOLOGY

State Climatologist: Barry Keim

LOSC Staff: Kyle Brehe, User Services Coordinator

Vincent Brown, Research Associate

Nick Grondin, Graduate Student

Rudy Bartles, Graduate Student

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About the Louisiana Office of State Climatology

The mission of the Louisiana Office of State Climatology (LOSC) and the Louisiana State Climatologist is to serve as the State focal point for activities pertaining to the climate of Louisiana. Responsibilities include:

- to collect, archive, and make available climate data for the state of Louisiana
- to provide climate education and information to the citizens of the region through various outreach programs including the media
- to maintain an active research program pertaining to the climate of Louisiana and the region.

To achieve these goals, the LOSC cooperates with LSU, the National Weather Service (NWS), Southern Regional Headquarters of the NWS, the Southern Regional Climate Center (SRCC), and the National Climatic Data Center (NCDC).

Information Services, Products and Tools

A primary role of the LOSC is to collect and archive high quality climate data for Louisiana and then make these data available to the general public, often with some interpretation or forensic application. Users of these data include researchers, attorneys, construction companies, federal and state planning agencies, private consultants, power companies, insurance companies, teachers and students, among others. Hundreds of requests are still handled annually. We also collaborate with the Louisiana Office of USDA's National Agricultural Statistics Service, where data are shared.

The LOSC has taken on the responsibility of producing a weekly summary of the State's weather and climate in the form of the *Louisiana Weekly Weather Highlights* available on the LOSC website at the following URL: <www.losc.lsu.edu>. The Office also provides a weekly summary of Louisiana Climate Data to the National Agricultural Statistics Service (NASS) that is published weekly in the *Louisiana Crop Weather Summary.* In addition to these weekly products, the LOSC also produces monthly summaries of the State's Climate data, which is also available on the LOSC website. The office also produces event-based summaries for significant weather events that impact Louisiana. The LOSC is also active on the ad hoc committee of the *U.S. Drought Monitor*. We cooperate and coordinate efforts closely with the NWS Offices in the region. We also remain primed and ready to work with Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) when needed.

Research, Projects and Publications

Shao, W., Xian, S., Keim, B. D., Goidel, K., Lin, N. (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.

Outreach and Education

The LOSC conducts frequent interviews with radio, newspaper, and magazine media.

The Louisiana Office of State Climatology (LOSC) handles hundreds of data requests annually from the public, including researchers, lawyers, students, insurance adjusters, construction companies, local/state/federal offices, and more. In 2017 alone, the LOSC has had 30,516 Facebook Post Views; 72,055 Twitter Views, and 466,971 LOSC Website hits demonstrating an effectiveness in reaching the public through multiple means.
The LOSC provides a weekly summary of Louisiana Climate Data to the National Agricultural Statistics Service that is published weekly in the *Louisiana Crop Weather Summary*.

Serve on the U.S. Drought Monitor - Weekly Ad Hoc Advisory Committee.

I am a contributing writer to the *St. Bernard Parish Post*. I contributed 45 articles (weekly) in 2017. Stories and Multiple stories in each of the following Television

Stations, Newspapers and Magazines in 2017: Weather Channel -1, CNN – 2,WBRZ-TV (Baton Rouge), AM Best TV, Climate Central – 1, *Palm Beach Post* – 2, *The Advocate* – 5 (Baton Rouge), *Times-Picayune* - 7, *Ruston Daily Leader* – 1, *Farm News, La Nacion* (Argentina), *Bloomberg Report* – 1, *Gizmodo* – 1, Portuguese National Radio, WWL Radio (New Orleans), Sinclair Broadcasting Group, KATC TV (Lafayette, LA), WWL-TV (New Orleans), . I have given at least 58 radio interviews to *Louisiana Network* on a variety of weather topics involving Louisiana. LA Network has 75 radio station affiliates in Louisiana, and was a Guest on *Sunday Journal* with John Pastorek WBRZ, Channel 2.

Presentations and Speaking Engagements:

- Keim, B. D., American Geophysical Union Annual Meeting, "Hurricane Katrina Field Trip Leader." (December 13, 2017).
- Keim, B. D., The Louisiana Agricultural Industries Association Annual Meeting, "Hurricane Climatology," Louisiana Agricultural Industries Association, Marksville, LA, United States. (October 25, 2017).
- Keim, B. D., "Extreme Events in a Changing Climate," Baton Rouge-Sunrise Rotary Club, Baton Rouge, LA, United States. (October 19, 2017).
- Keim, B. D., The Inland Marine Underwriters Association Annual Meeting, "Weather Trends – Flooding and Inland Marine Exposures," Inland Marine Underwriters Association, Braselton, GA, United States. (May 23, 2017).
- Thompson, D. T. (Author & Presenter), Keim, B. D., Association of American Geographers Annual Meeting, "Spatiotemporal Patterns and Recurrence Intervals of Tropical Cyclone Strikes for the Caribbean Islands," Association of American Geographers, George Sabol, Boston, MA. (April 2017).
- Keim, B. D., "August 2016 Louisiana Rainstorm," Ascension Parish Council, Gonzalez, LA, United States. (February 23, 2017).
- Keim, B. D., Thompson, D., "Extreme Weather," LSU Lab School, Baton Rouge, LA, United States. (February 22, 2017).
- Keim, B. D., Black, A. W., The U.S. Department of Homeland Security Coastal Resilience Center of Excellence Annual Workshop, "Disaster Science and Management at Louisiana State University," U.S. Department of Homeland Security, Chapel Hill, NC, United States. (February 2, 2017).
- Collins, C., Keim, B. D., Black, A. W., Robinson-Cook, A., Wang, L., American Meteorological Society Student Conference, "Impacts of ENSO on Tornado Frequency and Geographical Distribution in the Eastern United States," American Meteorological Society, Seattle, WA, United States. (January 2017).
- Thompson, D., Keim, B. D., American Meteorological Society Student Conference, "Introducing a Comprehensive U.S. Landfalling Tropical Cyclone Size Dataset: 1900-2015," American Meteorological Society, Seattle, WA, United States. (January 2017).

- Edwards, R., Ryu, J. H., Hayhoe, K., Keim, B. D., American Meteorological Society Annual Meeting, "Long-Range Seasonal Precipitation Projections: A Survey of Stakeholder Needs and Comprehension of Information in Different Formats," American Meteorological Society, Seattle, WA, United States. (January 2017).

MICHIGAN STATE CLIMATOLOGICAL RESOURCES PROGRAM

State Climatologist: Jeff Andresen
Staff/Service Climatologists: Aaron Pollyea, Mike Kiefer, and B.J. Baule

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About the Michigan State Climate Office

The Michigan Climatological Resources Program (MRCP), home of the Office of the Michigan State Climatologist within MSU's Dept. of Geography, is the archival and service center for climatological data and related information for Michigan. Leadership of MCRP is the responsibility of the State Climatologist, who supervises operational and research activities under the direction of the Chair of the Geography Department. Operational and research support in the program are provided by Aaron Pollyea and Mike Kiefer. Additional technical support was provided in 2017 by William (B.J.) Baule, a Ph.D. Candidate who works with MCRP on occasion in association with his assigned duties with the Great Lakes Integrated Sciences and Assessment (GLISA) project of which MSU is a partner. MRCP receives the majority of its funding support from the Michigan AgBioRearch Program (formerly the Michigan Agricultural Experiment Station) and Michigan State University Extension.

Communication Capabilities

The majority of public requests for climate data and information are placed via telephone and email exchanges. While a fraction of requests are still filled through conventional mail service, a growing proportion of responses are through email. MCRP also provides information through dedicated worldwide web sites (see below). Climate data are collected operationally in the program via internet (Unidata's Internet Data Distribution system) and dedicated satellite receiver connections, and via internet and telephone through the program's Enviro-Weather information access system.

Information Services, Products and Tools

The total number of requests for climate information, interviews, and speaking engagements decreased slightly in 2017. The total number of formal public requests

for climate-related data and information during the year was 88, which was down from 91 in 2016 and below the five year average. Most of the requests were received via phone or email. The majority of the requests were from law firms, the insurance industry, and other researchers. The average amount of payment received per billable request was $62.21, which was up slightly from $60.68 in 2016. These numbers a consistent with the past several years and suggest a long term decline in the number of formal data requests.

Research, Projects, and Publications

MCRP maintains an active research program addressing climate-related issues in the state and region. Current projects involve investigation of past and projected future climate changes in the region and potential impacts of weather and climate on regional agriculture. We also continued work on the Enviro-Weather project, the primary objective of which is the development and implementation of www-based techniques and tools that address weather- and climate-related processes in agricultural and natural resource management in Michigan. During 2017, staff at MCRP authored or co-authored 2 refereed articles and 3 non-refereed articles and technical reports. MCRP was associated with 2 new external grants totaling $354,453, 13 grants in force from previous years, and 5 new grant proposals submitted.

Outreach and Education

The MCRP in conjunction with MSUE (through the SC's formal appointment) also maintains an active outreach program through traditional venues, providing climate-related information in formats ranging from public speaking engagements to regular columns in the popular press. During 2017, the MCRP staff provided 9 ad hoc interviews to print, radio, and television media (including 5 radio appearances) and 26 talks or seminars to the public. In 2017, the SC began regularly scheduled weekly weather/climate radio updates with Michigan Agriculture Information Network (51 total). The SC and some MCRP staff also write weather- and climate-related columns on a daily (MSUE Crop Advisory Team, see http://msue.anr.msu.edu/news/) and bimonthly (Michigan Farm Bureau) basis. During 2017, 22 columns were written. MCRP continues to serve as state-level coordinator of Michigan's Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network.

Monitoring and Impact Assessment

One of the major efforts of MRCP is the Enviro-weather Project. The overarching mission of the Enviro-weather Project is the provision of relevant, dependable, and sustainable weather and climate information to support the Michigan's agriculture and natural resource industries. The major elements and functions of the Enviro-weather system are environmental monitoring, model application, and integrated delivery of products and education in their usage. Given its mission, Enviro-weather maintains an active research program focusing on the development and application of

weather- and climate-related information. Enviro-weather also supports the research efforts of other scientists and projects requiring detailed environmental data and information. The primary source of environmental information for the system is an automated weather meso-network (formerly the Michigan Automated Weather Network), which has grown considerably from 6 sites at its formation in 1997 to 88 in 2017. Geographical coverage of the network has also grown to additional areas of the state and to nearby sections of eastern Wisconsin. Enviro-weather stations are designed with a variety of sensors required for diverse applications in agriculture and natural resources and include: air temperature and relative humidity (5-foot level), rainfall, wind speed and direction (10-foot level), solar radiation, soil temperature (at 2" and 4" depths), volumetric soil moisture (at 0-12" and 12"-24" levels), and leaf wetness (at a 39" high reference location and in a specified crop canopy). Additional vertical air temperature and wind data are available at two new sites (Sparta and Williamsburg) with 20m towers installed in 2017 to assist fruit and vegetable growers with frost protection.

Observations at each station are taken automatically every 3-60 seconds (depending on sensor) and downloaded to a central computer via cellular-IP phone telemetry for dissemination to the public at *www.enviroweather.msu.edu*. Data are updated on a real-time basis throughout the growing season at 30-minute intervals and every 3 hours November through February. Data quality control procedures include automated data scans, visual data inspection by a project team member, and regularly scheduled preventative maintenance site visits. Raw station data can be accessed at: *www.agweather.geo.msu.edu/mawn*.

MINNESOTA STATE CLIMATOLOGY OFFICE

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Assistant State Climatologist: Peter Boulay
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About the Minnesota State Climatology Office

The Minnesota State Climatology Office (MN_SCO) exists to manage, analyze, and disseminate climate information in service to the citizens of Minnesota. The MN_SCO is funded by the State of Minnesota Department of Natural Resources - Division of Ecological and Water Resources, and housed at the University of Minnesota - Department of Soil, Water, and Climate. This partnership was formed in 1973.

The MN_SCO assists its customers in their investigations of the climate's impact on various components of the natural environment, and on socioeconomic activities. The MN_SCO uses its climate monitoring resources to quantify weather conditions and to place these conditions within historical and geographical context. The MN_SCO also provides quantitative summaries of historical climate conditions, allowing users to make informed decisions about future activities.

In order to provide its services, the MN_SCO requires an extensive historical climate data set. The climate database managed by the MN_SCO consists of millions of data points. The database features data collected by Minnesota's high spatial density precipitation monitoring program, formed in the early 1970s. This "network of networks" utilizes the efforts of water-oriented state and local agencies to assemble precipitation data from approximately 1500 observers each year. Additionally, the National Weather Service (formerly the U.S. Weather Bureau) has maintained a large scale, volunteer-based climate monitoring network in Minnesota since 1890. Other, smaller scale climate monitoring efforts extend the historical record earlier into the

19th century. The MN_SCO also archives multi-element hourly weather data gathered at Minnesota's airports.

The MN_SCO provides customers with free access to a comprehensive electronic climate database. The MN_SCO also serves its customers by offering a variety of value-added analyses of climate data in the form of narratives, maps, graphs, and tables. Customers access MN_SCO products and services via a Web site, email, telephone, office visits, meetings, and public appearances.

The customers of the MN_SCO are many and varied. Customers can be grouped in the following categories:

- Minnesota Department of Natural Resources (sponsoring agency)
- State, Federal, and Local Governmental Agencies
- Private Sector Professionals (including the media)
- Academic Community
- General Public

Communication Capabilities

- Full-feature Web Page
- New Web page in Development
- Facebook page
- fully staffed information line
- near-immediate response to email and media inquiries

Information Services, Products, and Tools

- Web site – the MN_SCO Web site hosts approximately 3000 users per day. The Web site offers free access to nearly all of Minnesota's digitized climate data, as well as a number of value-added products such as narratives, maps, and tabular summaries.
- The Web site offers on-line daily data entry and data maintenance capability to volunteer precipitation observers. These near real-time data are automatically transferred to the National Weather Service North Central River Forecast Center.
- Phone and email – the MN_SCO answers dozens of phone calls and emails per week from customers with climate questions.

Research, Projects, and Publications

- This year the MN_SCO was called upon to provide data sets and counsel to numerous researchers investigating topics involving atmospheric science.
- The MN_SCO participates in three advisory committees tasked to provide guidance concerning climate change adaptation research and outreach.

Outreach and Education

- Staff give frequent interviews to electronic and print media.
- Staff are commonly requested to attend multi-agency, multi-disciplinary meetings where a climatological perspective is required.
- Staff make public appearances addressing matters of weather and climate.
- Staff make climate science outreach efforts.

Monitoring and Impact Assessments

- The MN_SCO works with the National Weather Service to coordinate Minnesota's role in the *CoCoRaHS* program.
- Web site offers a variety of routinely prepared summaries of weekly and monthly temperature, degree day, precipitation, and snow depth data.
- Web site offers a chronological journal of significant weather events, providing a description of the event, impacts, and historical context.
- The MN_SCO utilizes a list server to deliver a monthly electronic newsletter summarizing climate conditions observed during the previous month and the resulting impact on water resources.
- The MN_SCO is in frequent communication with authors of the U.S. Drought Monitor to ensure accurate drought depiction in Minnesota.
- Development and maintenance of a mesonet to support agriculture and long term climate monitoring.
- The MN_SCO has begun working on updating the State Drought Plan for Minnesota. This will be a collaborative effort amongst the various divisions of the Minnesota Department of Natural Resources and other relevant State agencies.

MISSISSIPPI STATE CLIMATE OFFICE

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About the Mississippi State Climate Office

The Mississippi Office is a small office (with no real physical space) with university support for a service assistant. As a result the majority of data requests and data analysis are left to the two professors within the office. Through the use of the service assistant the office has developed a social media presence and a better web presence.

Communication Capabilities

We try to reach our potential customers through our social media and web presence. We still take data and analysis requests using email and phone.

Information Services, Products and Tools

We provide climate summaries through our various social media platforms. We also provide Drought Impacts from our developed app for MS to the Drought Monitor.

Research, Projects and Publications

Grants:

This year the MS state climate office personnel were awarded two grants. The first is with VORTEX-SE (2017-2018) through NOAA ($82,000), the second is a NOAA-NSSL upsonde project looking at mesoscale severe local storm environments, (95,000).

Ongoing:

The SCO is involved with PBL measurements and analysis using high-resolution radiosondes during periods of severe local storms. The sub-project of the SCO is to better understand the role of vegetation discontinuities in the formation and maintenance of the severe local storm PBL. The SCO just concluded a two year study on NCAA stadium heat threat. This work has shown a clear micro-climate with MSU's football stadium. However, it also appears that the presence of spectators enhanced the heat related threat through the addition of human-induced moisture. A

publication is currently being constructed from this project.
The SCO is involved with a project that monitors corn health and related moisture usage. Observations will be used to assess how efficiently the corn is using available moisture, the effect that the crop is having on the local climate, and to validate thermal imagery from our (MSU) UAVs (drones).
This past year the SCO developed (in conjunction with MSU Extension) a drought reporting and monitoring app. This mobile app allows for trained extension agents to assess and report conditions of drought in Mississippi. These data are then provided to the National Drought Monitor for consideration and inclusion.

Publications:
Sherman- Morris, K., Clary, R., McNeal, K.S., Diaz-Ramirez, J., and **Brown, M.E.** (2017) An Earth Hazards Camp to Encourage Minority Participation in the Geosciences, Journal of Geoscience Education. 65 (1).
Sugg, J.W., **C.M. Fuhrmann** , L.B. Perry, D.K. Hall, and C.E. Konrad II, 2017: Sub-regional snow cover distribution across the Southern Appalachian Mountains. *Physical Geography*, **38** , 105-123.
Gutter, B, K. Sherman-Morris and **M. E. Brown,** 2017 Impacts of Severe Weather Watches on Daily Activities. Weather, Climate, and Society: accepted
Sherman-Morris, K., Clary, R., McNeal, K.S., Diaz-Ramirez, J., and **Brown, M.E.** 2017 An Earth
Hazards Camp to Encourage Minority Participation in the Geosciences, Journal of Geoscience Education. 65 (1).
M. E. Brown, K. Alexander, 2017 Using emerging mobile technologies to better mitigate drought conditions in Mississippi. J. Geogr and Nat Disast: submitted

Outreach and Education

The State Climate Office provided presentations to a number of civic / school / and professional groups. While not a comprehensive list, these included: Boy Scouts of America; Girl Scouts of America; Rotary (2); MSU Athletics; Master Gardeners; MS Historical Society; Seed Producers; Various Schools (8). The SCO is also worked with members of the MSU Geosciences Program to host the 2017 Southeast Association of American Geographers conference, Nov. 2017.

The SC is the state coordinator for the CoCoRaHS program in Mississippi.

The SC is a member of the MSU Crisis Action Team and coordinates with MEMA during episodes of threatening weather. Additionally, the SC is responsible for monitor athletic events at MSU.

Again this year the SCO travelled to Jackson, MS to meet with as many legislature members as possible. This was designed to educate members of our state House and Senate on the expertise of the SCO and discuss current environmental concerns. It is anticipated that this will be an annual trip.

The SCO has been the driving force behind the development of the Drought Reporting and Information (DRI) mobile application. This app will allow extension agents to more accurately and timely report drought conditions in their counties. It is hoped that the app can be adapted to a national application within 18 months.

Monitoring and Impact Assessment

This past year the SCO has worked on the update of the MSU All Hazards Mitigation Plan. The SC has also delivered video lectures to other colleges and universities in order to help them develop or modify their mitigation documents.

This SCO has also provided climate summaries and weather threat analysis to the cities of Madison, MS and Laurel, MS as part of an effort to attract new industry to the state.

MISSOURI CLIMATE CENTER

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About the Missouri Climate Center

The Missouri Climate Center is designated by the AASC as the official state climate office for Missouri. As State Climatologist for Missouri and Director of the Missouri Climate Center, I serve as resource for weather and climate information. The State Climatologist collects and maintains an extensive historical climate database of Missouri weather records for monitoring and dissemination to the citizens of the state and beyond. This includes performing and assisting in the primary functions of the center whose mission is to advance the use of climate information for the economic and environmental benefit of Missouri and the public safety of its citizens through climate monitoring, research, education, and extension and information services. In 2017 we fulfilled hundreds of climate data requests and gave educational presentations in dozens of venues around Missouri. The following information provides information over the past year of how the Missouri Climate Center addressed each of its ARSCO qualifications.

Communication Capabilities

- The MCC web site provides easy access to weather and climate information including links to specialized web sites for real-time and historical weather in Missouri. The Missouri Climate Center posts timely monthly weather and climate impact reports for the state of Missouri;
- Over 4000 lines of data arrays are collected daily from a network of 36 automated weather stations associated with the Missouri Mesonet. The daily and hourly arrays are posted on a server for free unlimited access.
- The Meteorological Assimilation Data Ingest System (MADIS) incorporates 5-minute weather conditions from the Missouri Mesonet (26 real-time stations).

- Continued development and recruitment for an e-mail delivery agricultural weather product called Horizon Point. Horizon Point is a custom weather analysis system for farmers and provides an opportunity to have specific weather reports sent directly to their e-mail address. Over 600 Missouri clients are enrolled.
- Mobile links with forecasts continue to be provided for all the real-time web sites.

Information Services, Products and Tools

- Submitted 5 press releases in 2017 to the Extension news service related to weather, climate and the environment
- Serve as an information source for the media including national, state, and local mediums
- Fulfilled hundreds of requests for climate information and provided climatological expertise to numerous individuals, groups and agencies;
- Submit soil temperature information published in a national bulletin *Weekly Weather and Crop Bulletin*: www.usda.gov/oce/weather/pubs/Weekly/Wwcb/
- Submit soil temperature data to the Midwestern Regional Climate Center for generating daily and weekly 2" and 4" soil temperature maps: mrcc.isws.illinois.edu/cliwatch/mesonets/soilTemp.html
- Submit daily air temperature, soil temperature and solar radiation data to the Midwestern Regional Climate Center for assimilation into their cli-MATE system and ACIS
- Run the rice model program to predict rice growth stages: agebb.missouri.edu/weather/reports/ricedds.asp
- Provide weather data from the automated network to be used in a risk assessment tool for wheat scab prediction: www.wheatscab.psu.edu
- Provide a weekly climate summary table for the *Integrated Pest and Crop Management* Newsletter: ipm.missouri.edu/ipcm
- Provide a 2-inch and 6-inch soil temperature table for the Agricultural Electronic Bulletin Board (AgEBB): agebb.missouri.edu/weather/reports/soilTemp2.asp,
- agebb.missouri.edu/weather/reports/soysoil6.asp
- Campus weather station and forecast linked to College of Agriculture web site: cafnr.missouri.edu/
- The real-time mesonet stations are providing 5-minute weather conditions to the Meteorological Assimilation Data Ingest System (MADIS)
- Installed real-time automated weather stations at:
    - Moscow Mills, MO: agebb.missouri.edu/weather/realtime/moscowmills.asp
    - Unionville, MO: agebb.missouri.edu/weather/realtime/unionville.asp
    - Butler, MO: agebb.missouri.edu/weather/realtime/butler.asp

Research, Projects and Publications

- The Missouri Mesonet has provided opportunities for educational programs, teaching, research, innovation, discovery and service to communities. It has led to the development of state-of- the-art information delivery systems, including transitioning 26 weather stations to wireless telecommunication and real-time weather data dissemination for local, state, and national outlets as well as public, private and federal entities. In 2017, the average number of actual internet visits made to our 26 real-time weather web sites was over 337,000 per station, or, over 8,000,000 visits.
- Providing real-time weather status to 26 weather stations in the Missouri Mesonet for Integrated Pest Management;
- Provide climate data for graduate students and faculty research projects
- In 2014, the National Science Foundation awarded a 5-year collaborative grant involving several universities and others in Missouri. Specifically, it is an Experimental Program to Stimulate Competitive Research grant (EPSCoR). The title of the grant is "Missouri Transect: Climate, Plants and Community". Strong components of the grant are science education, research, technology and community outreach. In 2017, the EPSCoR weather stations continue to provide opportunities to share this new science technology with educational institutions, students, teachers, administrators and others. I am a co-PI on the EPSCoR Climate team.
- In 2015, the directors of the Missouri Mesonet, Pat Guinan and John Travlos, collaborated with University of Missouri weed scientists, Dr. Kevin Bradley and Dr. Mandy Bish, to accessorize three Missouri Mesonet stations with temperature monitoring at two heights, 1.5 ft and 10 ft. The aim of the research was to investigate surface temperature inversions in order to mitigate crop damage from herbicide applications. The project was the first of its kind in the region and gained much interest among researchers and agricultural stakeholders. The Missouri Soybean Merchandising Council provided initial funds to purchase the sensors to monitor for inversions. In 2017, Travlos and Guinan accessorized eight additional stations with inversion monitoring equipment and collaborated with Drs. Bish and Bradley to develop the "Temperature Inversion Potential" tool, http://agebb.missouri.edu/weather/realTime/maps/index.php#temp_inversion
- The Design Storm Alert System (DSAS) tool remained active in 2017, http://agebb.missouri.edu/weather/designstorm. The tool identifies extreme precipitation events that meet specific design storm criteria in Missouri. Extreme weather can produce precipitation events that exceed design criteria for open manure storages and other water impoundments and control structures. The DSAS creates an automated system to track precipitation accumulations across Missouri and notify interested parties when and where precipitation totals have exceeded design criteria and wet weather or emergency management may be warranted. The new MU tool uses specific

NOAA databases, i.e. NWS Precipitation Analysis and Climate Atlas 14, Volume 8, to identify counties that meet specific design storm criteria as established by the Missouri Department of Natural Resources. In 2017, the tool documented 9 extreme rainfall events that met or exceeded a 25-year/24-hour design storm event.

- On August 21, 2017, the Missouri Mesonet was in a unique position to observe several environmental variables before, during and after a total solar eclipse. These variables include solar radiation, air temperature, relative humidity, dew point, wind speed, wind direction, barometric pressure and soil temperature. The Missouri Mesonet managers embraced the opportunity to monitor a once in a lifetime event and reprogrammed 21 Mesonet stations, in and near the path of totality, for extensive monitoring and data sampling at 3-second intervals. These data are currently available and have been used for educational and research projects.
- Easton, Zach, P. Kleinman, J. A. Peter, A. Buda, D. Goering, N. Emberston, S. Reed, P. Drohan, T. Walter, **P. Guinan**, J. Lory, A. Sommerlot, A. Sharpley, 2017. Short-Term Forecasting Tools for Agricultural Nutrient Management. Journal of Environmental Quality, doi:10.2134/jeq2016.09.0377,
- https://dl.sciencesocieties.org/publications/jeq/articles/0/0/jeq2016.09.0377.
- Henson, Chasity, P. Market, A. Lupo, **P. Guinan**, 2017. ENSO and PDO-related climate variability impacts on Midwestern United States crop yields. International Journal of Biometeorology, 61: 857-867. doi: 10.1007/s00484-016-1263-3, http://link.springer.com/article/10.1007/s00484-016-1263-3
- P. Westhoff, S. Gerit, S. Brown, D. Madison, P. Zimmel, R. Milhollin, P. Green, D. Day, **P. Guinan**, R. Massey, G. Carriker, J. Moreland, J. Parcell, J. White, and J. Horner. 2017. Missouri Farm Financial Outlook 2017. MU Extension and Dept. of Ag & Applied Economics bulletin.

Outreach and Education

- Presented at field trip to Sanborn Field for Dr. Allen Thompson's ASM-4460 class, Irrigation and Drainage. Topic: Weather instrumentation and application.
- Presented at field trip to Sanborn Field for Dr. Peter Motavalli's Environmental Science class. Topic: Weather instrumentation, observation and application.
- Gave numerous weather presentations at Extension field day events across the state;
- Gave several presentations to various groups across the state on several climate topics including "Automated Weather Monitoring", "Drought", "Historical Climate Trends in Missouri", and "Climate Change"
- Weekly growing season weather updates for MU's IPM Agronomy and Horticulture Teleconferences (April-August)
- State Co-Coordinator of the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) in Missouri
- Member of the Missouri Drought Assessment Committee

- Member of the North Central 1179 Regional Climate Committee: Food, Feed, Fuel and Fiber: Security Under a Changing Climate
- Member of the WERA 1012 Regional Coordinating Committee: Managing and Utilizing Precipitation Observations from Volunteer Networks
- Information resource for media outlets including Missouri Net, Brownfield Network, Cooperative Media Group, and local TV, radio, and newspaper outlets.

NEBRASKA STATE CLIMATE OFFICE

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Agricultural Extension Climatologist: Allen Dutcher
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About the Nebraska State Climate Office

The year 2016 marked the first official year of the newly formed Nebraska State Climate Office (NSCO). The office is currently in its third year of operation. Staffing the office are the Director and State Climatologist, an Agricultural Extension Climatologist, the Nebraska Mesonet Manager, and a Mesonet Technician. The office has a part-time Communications Associate and Extension Educator. The NSCO manages and maintains a statewide weather network, the Nebraska Mesonet, which has 68 data-gathering stations across the state. The focus of our office is on monitoring, climate services, and stakeholder engagement.

Communication Capabilities

Two websites were released in 2016, the State Climate Office (https://nsco.unl.edu) and the Nebraska Mesonet (https://mesonet.unl.edu). These are undergoing revision and updated websites are set to be released in late 2018 and early 2019. The NSCO performs weekly communications on television and radio broadcasts in which the current conditions and short-term outlook is discussed. The office updates University of Nebraska Extension personnel on pertinent agricultural weather and climate conditions through bi-weekly phone calls from March through October. Community users are regularly engaged via telephone, email and walk-ins. The office has an active Twitter account with regular tweets on weather and climate topics. A monthly summary is developed that summarizes the most recent conditions for the previous month, including impacts and a climate outlook. Furthermore, a quarterly newsletter featuring services, research, mesonet news, and office highlights has been developed, called Climate Crossroads. These publications are distributed to a broad subscriber group. In 2018, the office was pleased to host the annual AASC meeting in Nebraska City, NE.

Information Services, Products, and Tools

The NSCO is active in providing climate services to the community; the office fulfilled 694 data requests in 2018. The primary data requests for the office come from three main sectors – media, education, and agriculture. Numerous climate news articles to the University of Nebraska Extension portal CropWatch were published. There were 52 tapings discussing the short term and seasonal climate outlook for a Nebraska-based radio station (KRVN). A weekly television taping also was performed for Market Journal, an agricultural-focused news organization. These services inform decisions for crop and livestock producers, state and federal agencies, researchers, emergency management, public power districts, and the public. Historical climate trends tools are being developed in order for stakeholders to understand long term and recent variability and change across Nebraska.

Research, Projects, and Publications

The NSCO's ongoing areas of interest include meteorology, climatology and data gathering; data interpretation; assessment of current conditions and data for the agriculture community; and outreach services. The office also collaborates with a number of outside organizations, including the High Plains Regional Climate Center, UNL Extension, the Climate Assessment and Response Committee, USDA Northern Plains Regional Climate Hub; and the U.S. Drought Monitor, to which the NSCO provides weekly input. Shulski serves as an author for the Northern Great Plains chapter of the 4th National Climate Assessment, set to be released in late 2018. In 2016, the office received a grant from the Nebraska Center for Energy Science Research at UNL to investigate improvements in wind forecasts by assimilating Nebraska Mesonet data into WRF simulations. This project is in its second year and improvements are documented for WRF forecasts through the inclusion of the 68 Nebraska Mesonet station data. Shulski is involved in a NOAA SARP project to increase resiliency to climate change impacts for municipalities in the lower Missouri River Basin states. Localized climate reports have been developed with this project and a web tool to assist with planning for municipal staff is being finalized and will be housed at the HPRCC. A one-year NSF project is ongoing for 2018 in which climate resilience in the context of a rapidly changing Arctic is being investigated. In this project, the NSCO is teaming up with the Nebraska Cooperative Fish and Wildlife Research Unit at UNL and The Nature Conservancy office in Nebraska. A series of three workshops are undertaken in 2018.

Outreach and Education

In 2018 NSCO staff delivered 73 talks that reached approximately 4,300 individuals. Talks primarily focused on topics such as emerging weather and climate issues and upcoming seasonal climate outlooks. The office was involved in the planning and implementation of three climate decision support workshops. Individuals impacted included the general public, growers associations, crop advisors, University Extension, local Chambers of Commerce, public agencies and businesses. The office also conducts a standing monthly meeting with Nebraska Public Power District to discuss climate outlooks and load generation. The office has active participation in Extension 'Issue Teams', a local organizational structure within the University of Nebraska. The focus is on developing usable climate information for beef systems and weather-ready farms. Nebraska Emergency Management Agency is working with the office on their State Hazard

Mitigation Plan, a two-year project aimed at reducing the risk profile of communities in Nebraska. In addition to these activities, State Climatologist Martha Shulski teaches Climate in Crisis, a 100-level course at UNL that serves as an introduction to climate change, and she serves as an advisor to two doctoral students and one masters student.

Monitoring and Impact Assessment

The Nebraska Mesonet is the statewide weather network and operates under the auspices of the NSCO. This network began in 1981 with five observing locations and grew to 68 stations currently spread throughout the state. The automated network observes wind speed and direction, air temperature, humidity, liquid precipitation, incoming solar radiation, barometric pressure, soil temperature and soil moisture. Data and products from the network help inform decisions on water resources, drought assessments, agricultural management, energy production, etc. The network is supported through individual cooperators, the State of Nebraska and the University of Nebraska Institute of Agriculture and Natural Resources. The State Climate Office provides briefings to the State of Nebraska's Climate Assessment and Response Committee and the Water Outlook and Availability Board therein.

THE NEVADA STATE CLIMATE OFFICE

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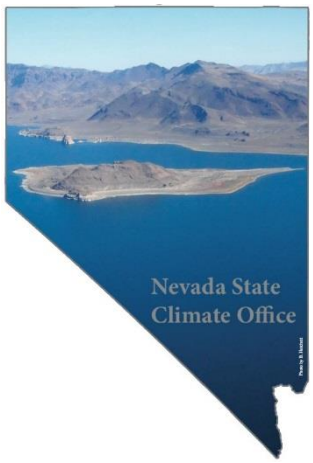

About the Nevada State Climate Office

The Nevada State Climate Office (NSCO) was established under Nevada Revised Statute 396.595. The NSCO serves the people of Nevada by maintaining descriptions of, reporting on, and providing access to information on the climate of the state, including atmospheric conditions and precipitation amounts. The NSCO collaborates with, advises, and promotes climate data collection, interpretation, and research in conjunction with local, state, and federal agencies and the governor's office and is responsible for drought planning in the state. The NSCO participates within and serves as a member of the national and regional network of state climatologists.

Douglas P. Boyle, Professor and Chair, Department of Geography at the University of Nevada, serves at a level of 0.2 FTE (~1.6 months/year) as the Nevada State Climatologist. Stephanie A. McAfee, Assistant professor, Department of Geography at the University of Nevada, serves at a level of 0.1 FTE (~0.8 months/year) as the Deputy Nevada State Climatologist. Chelsea Canon, a Ph.D. student in the Department of Geography at the University of Nevada, has been supported by the NSCO since June 2015.

Communication Capabilities

During 2017, the NSCO continued to maintain a website (https://www.unr.edu/climate) that provides basic information related to the current drought conditions, seasonal forecast information, weather conditions and the activities of the NSCO. The NSCO also continued to utilize a 65" monitor and video software system in the Departmental "glass case" outside the NSCO to present a wide range of different climate and weather related information to students, faculty, and the general public.

The NSCO continues to explore ways to expand climate science communication opportunities and establish sustained collaborations for climate science communication in Nevada. The goal of this work is to (1) maximize communication success per engagement and (2) identify regional partners for coproduction. Coproduction is a strategy for fostering science communication through collaboration with decision makers and stakeholders during the research process, but doing it successfully requires a detailed understanding of the network of scientists, agencies, decision makers, and stakeholders acting in the region. By using network analysis techniques to map and analyze existing collaborations on climate science communication projects, this research contributes to the science communication literature while providing actionable information for the Climate Office's communication efforts.

Information Services, Products and Tools

The NSCO continues its state mandated responsibility of providing a quarterly state climate summary. The reports provide a timely overview of the current climate conditions and are available on the office website. With the help of Chelsea Canon, a Spanish edition of each report is also available. Ultimately, we would like to move from quarterly to monthly reporting in the future with improved coverage of eastern and southern Nevada.

Research, Projects and Publications

Research within the NSCO has been focused on improving our understanding of significant climate changes that occurred within the Great Basin from the end of the Last Glacial Maximum (LGM), through the Mega Droughts of the Medieval Climatic Anomaly (MCA), to the end of the Little Ice Age (LIA). Specifically, we are focused on identifying the mechanisms that caused these events and further constraining the sensitivity of atmospheric temperature and snowpack to CO2 levels to provide a better understanding of the uncertainties related to how our water supply will respond to the current buildup of industrial fossil CO2. Our research program includes a highly collaborative field and modeling effort with research scientists from the University of Maine, Columbia University, the University of Arizona, and the University of California, Berkeley. Together, we are developing a state-of-the-art chronology of the response of glacial moraines and terminal lakes to climate changes over these periods using a wide range of dating methods (e.g., 10Be surface exposure dating of glacial moraines, 14C dating of plant matter obtained from lake–bottom sediments, 14C and U-Th series dating of shoreline tufas) and a complex set of integrated atmospheric, glacial, watershed, and lake modeling tools that, together, will be used to improve our understanding of the sensitivity of mountain snow and ice in dryland regions to the effects of atmospheric warming and consequent impacts on regional water availability.

The NSCO has a number of research projects aimed at developing a better understanding of the frequency and magnitude of previous short- and long-term droughts, why they occurred, and how our modern water resource infrastructure would respond to some of the longer-term mega-drought conditions that we know happened in the past. We conduct high-caliber research that can be used to help answer practical and relevant questions related to our current water resources and climate change related issues in the state.

Another project, in collaboration with the state Cooperative Extension, the Desert Farming Initiative and several local farmers, is exploring microclimate alteration within high-tunnels. Focusing primarily on temperature and humidity, the project is aimed at characterizing the differences in microclimate within and outside high-tunnels of differing construction, identifying how those changes alter yield, and understanding how high-tunnels influence the economics of small-scale agriculture in the high desert.

Peer-reviewed Publications in 2017 (*indicates supervised student advisee):

Hudson, A., Hatchett, B., Quade, J., **Boyle, D.P**, Bassett, S., Ali, G., De los Santos, M. A north-south winter hydroclimate dipole in western North America during the last deglaciation, In Review, *Nature Scientific Reports*.

McAfee, S. A., DeLaFrance, A. Non-stationarity in estimated climate model bias related to natural variability: Implications for bias correction. In Review, *Climatic Change*.

McAfee, S. A., McCabe, G. J., Gray, S. T., Pederson, G. T. Changing station coverage impacts temperature trends in the Upper Colorado River Basin. In Review, *International Journal of Climatology*.

*Hatchett, B., **Boyle, D.P.**, Garner, C., Kaplan, M., Bassett, S., Putnam, A. (in press). The sensitivity of a western Great Basin terminal lake to winter Northeast pacific storm track activity and moisture transport. *Geological Society of America Special Papers: From Saline to Freshwater: The Diversity of Western Lakes in Space and Time*.

Hudson, A., Quade, J., Ali, G., **Boyle, D.P.**, Bassett, S., Huntington, K., De los Santos, M., Cohen, A., Lin, K., Wang, X. (2017). Stable C, O and clumped isotope systematics and 14C geochronology of carbonates from the Quaternary Chewaucan closed-basin lake system, Great Basin, USA: implications for paleoenvironmental reconstructions using carbonates. *Geochimica et Cosmochimica Acta*.

McAfee, S. A., Pederson, G. T., Woodhouse, C. A., McCabe, G. J. (2017). Application of synthetic scenarios to address water resource concerns: A manager-guided case study from the Upper Colorado River Basin. *Climate Services*, 8, 26-35, https://doi.org/10.1016/j.cliser.2017.10.003.

McCabe, G. J., Wolock, D. M., Woodhouse, C. A., Pederson, G. T., **McAfee, S. A.** (2017). Evidence that recent warming is reducing Upper Colorado River flows. *Earth Interactions*, 21, No. 10, DOI: 10.1175/EI-D-17-0007.1

Ormerod, K. J., **McAfee, S. A.** (2017). *Nevada's Weather and Climate* UNCE Fact Sheet 17-04. https://www.unce.unr.edu/publications/files/nr/2017/fs1704.pdf

Outreach and Education

Outreach activities include numerous presentations aimed at a wide range of audiences (e.g., general public, service organizations, professional scientific organizations, governmental agencies, and political organizations), and other direct interactions, numerous media inquiries, and direct interactions with UNR students, faculty, and administrators. In 2017, D. Boyle and S. McAfee participated in the following outreach and educational activities as representatives of the NSCO:

USDA Program Update Workshops - Impacts of Climate on Nevada Farms and Ranches. This workshop provided discussion and expertise on United States Department of Agriculture (USDA) federal assistance programs available to crop and livestock producers in Nevada. Workshops focused on Natural Resources Conservation Programs for water conservation and emergency programs; Farm Service Agency for crop insurance, emergency loans and livestock feed programs; and Risk Management Agency for crop and livestock insurance production and cost insurance options for the 2017 agricultural year. D. Boyle attended and made presentations at each of the following locations:

- 28 August 2017 Pyramid Lake Paiute Tribal Chambers, Nixon, NV
- 28 August 2017 Lyon County Cooperative Extension, Yerington, NV
- 29 August 2017 Churchill County Cooperative Extension, Fallon, NV
- 30 August 2017 Pershing County Cooperative Extension, Lovelock, NV
- 4 September 2017 Duck Valley Reservation, Owyhee, NV
- 5 September 2017 Elko Convention Center, Elko, NV
- 6 September 2017 Humboldt County Cooperative Extension, Winnemucca, NV

As part of the 2017 Cattlemen's Update Workshop D. Boyle prepared materials titled "Nevada Climate and Drought Monitoring" for members of the Cattlemen's Association at the following meeting locations:

- 9 January 2017 Washoe County Cooperative Extension, Reno, NV
- 9 January 2017 Sierra Valley Grange, Vinton, CA
- 10 January 2017 Smith Valley Community Hall, Wellington, NV
- 10 January 2017 Fallon Convention Center, Fallon, NV
- 11 January 2017 Old St. Lawrence Hall, Ely, NV
- 12 January 2017 Great Basin College Solarium, Elko, NV
- 13 January 2017 Humboldt County Cooperative Extension, Winnemucca, NV

As the Nevada State Climatologist, D. Boyle made professional presentations at and/or attended the following meetings in CY2017:

- Presentation at UNR Earth Day sustainability event on UNR campus, 18 April 2017
- Presentation on "Developing a Weather Observation System for Mountain Environments" at Annual Meeting of Association of Professional Patrollers meeting in Mammoth CA., 27 April 2017
- Presentation on "Combining Glacial Moraine and Shoreline Evidence to Constrain Past Climates" at the Mono Lake Committee, Lee Vining, CA 28 April 2017

As the Nevada State Climatologist, D. Boyle participated in a significant number of operational meetings related to flood, drought, and other climate related issues.

- Meeting with Governor Sandoval to brief him on recent storms and impact to drought, 18 January 2017
- Meeting with Bradley Crowell, the new State Director of the Department of Conservation and Natural Resources, to brief him on the UNR fire and weather observation cameras NSL and NSCO are installing in Nevada, 4 April 2017
- Meeting with Governor Sandoval at the Nevada Legislature Chambers briefing him on potential regional flooding related to upcoming snowmelt, 13 April 2017
- Meeting with Nevada State Forester Kacey KC to brief her on fire and weather cameras, 24 April 2017
- Briefing of Governor Sandoval at the Nevada Emergency Operations Center on preseason wildfire conditions, 23 May 2017

As the Deputy Nevada State Climatologist, S. McAfee made professional presentations at and/or attended the following meetings in CY2017:

- *NV/CA Drought Early Warning System Steering Committee Member;* attended a 2-day meeting and participated in Quarterly calls.
- *Do Floods Terminate a Drought? Workshop on Drought Recovery Tools, Perspectives, and Situational Awareness (Jun. 2017);* attended this approximately day-long workshop, as the NSCO representative.

As the Deputy Nevada State Climatologist, S. McAfee participated on the following professional committees in CY2017:

- American Association of State Climatologists (AASC) ARSCO Committee Member.
- American Association State Climatologists (AASC) Membership Committee Member.

Monitoring and Impact Assessment

The NSCO has been an active participant in the biweekly CA - NV Drought Monitor and Water Conditions Discussion since they began in late 2013. These meetings are coordinated by the NWS to provide an opportunity for all of the CA and NV NWS office representatives and the California, Oregon, and Nevada State Climatologists to discuss the current drought situation and provide a coordinated drought conditions message to the U.S. Drought Monitor authors, other agencies, and the media. This

has developed into a very important discussion and is well attended (usually at least 50 participants) on the phone and web.

In collaboration with the Nevada State Seismology Lab, the NSCO has developed a high-altitude mountain climate observation network in the Sierra Nevada with the primary goal of observing mountain weather, climate, earthquakes, and wildfires. The primary purpose of the network is to identify and communicate natural hazards to decision makers and the general public. The Nevada Governor and several state agencies are keenly aware and interested in our network and have been incorporating our near real-time web-based information into their daily operations. In 2017, we managed to get five sites near Donner Summit and one on top of Slide Mountain completed. We are currently marketing the proof of concept system to a wide range of federal, state, and private organizations as a valuable tool for expansion in the future.

NEW HAMPSHIRE STATE CLIMATE OFFICE

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About the New Hampshire State Climate Office

The New Hampshire State Climate Office (NHSCO) resides within the Department of Geography at the University of New Hampshire (UNH) – Durham, a land-, sea-, and space-grant institution. In fulfillment of the UNH mission, the NHSCO:

- provides New Hampshire citizens and other constituents with climate information at the local, county, and state levels;
- conducts research on climate-related issues relevant to the state and its residents;
- is a resource in climate science for educational and outreach.

The NHSCO provides the public with quality and timely information on weather and climate though research, outreach activities, production of online materials, regular media interviews, and dissemination of data and analyses to the user community.

Communication Capabilities

The NHSCO disseminated information on weather and climate to a wide variety of users by email, telephone, regular mail, and social media.

- The NHSCO Twitter page (@nh_sco) followed by over 200 users including national and state government offices and officials, news and nonprofit organizations, educators, and students.
- Distribute weather event summaries, state and regional data and graphics to the public online and in person through interviews and presentations.
- Maintain contact with members of the media and continue to work with UNH Media Services to provide expertise on significant weather and climate events.

Information Services

The NHSCO regularly provides information on weather and climate to a wide variety of users including state officials and agencies, local businesses, law enforcement, concerned citizens, K-12 and university faculty and students. In the last year, the NHSCO:

- responded to dozens of data requests from citizens, students and businesses

- presented on state climate services, climate change impacts, and the 2016/17 drought
- conducted interviews for print media and made appearances on WMUR-TV and NH Public Radio news broadcasts. Extreme winter temperatures and the potential for summer drought were of particular interest.

Research, Projects, and Publications

The NH State Climatologist collaborated with university faculty and state agencies on climate science research in support of state climate change assessment and impact studies.

- Serve as a co-author of the Northeast chapter of *The Fourth National Climate Assessment*.
- Co-authored manuscript on a unique albedo dataset developed as a subset of NH CoCoRaHS observers published in the *Journal of Glaciology*.
- Amaral, T., C.P. Wake, J.E. Dibb, E.A. Burakowski, M. D. Stampone (2017) A Simple Model for Predicting Snow Albedo Decay Using Observations from the Community Collaborative Rain, Hail, and Snow-Albedo (CoCoRAHS-Albedo) Network. *Journal of Glaciology*. https://doi.org/10.1017/jog.2017.54
- Co-authored manuscript on perceptions of climate in New Englan's North Country region published in the *Weather, Climate and Society.*
    - Hamilton, L.C., M.D. Lemcke-Stampone, and C. Grimm (2018) Cold winters warming? Perceptions of climate change in the North Country. *Weather, Climate and Society.* https://doi.org/10.1175/WCAS-D-18-0020.1
- Continue to work with state agencies and coastal communities to evaluate risks and management options for coping with coastal flooding and sea-level rise.
    - PI - Morison, N. (2018) *Using Science, Building Social Capital, and Unpacking Tax Incentives for a Resilient Coastal NH*

Outreach and Education

The NHSCO is involved a variety of outreach programs and activities and regularly engages with schools, organizations, businesses and academic institutions.

- Member of the state Drought Management Team and works with state agencies and the media to inform citizens and stakeholders on drought severity and impacts.
    - *Panelist*, "Planning for the Next Big Drought" 2017 Water Resources 7 Sustainability Symposium, Devens, MA October 25, 2017
- Serves on the Mount Washington Observatory Board of Trustees and is a member of the Scientific Advisory Committee.
- Presented on "Climate Adaptation Activities across NH" at the state NOAA Congressional Roundtable
- The NH State climatologist is also an Associate Professor at UNH and teaches undergraduate courses on weather and climate in the Department of Geography and regularly gives presentations on weather and climate to K-12 classes and undergraduate courses at UNH and Dartmouth College.

Monitoring and Impact Assessment

The NHSCO continues to work closely with the NWS Forecast Offices in Gray, ME and Taunton, MA, NOAA to oversee operation and coordinate in the maintenance of state weather observing networks.

- NH CoCoRaHS network Co-coordinator with the NWS Forecast Office in Gray.
- NWS COOP observer for the USHCN station in Durham, NH.
- Maintain the Durham, NH NOAA Climate Reference Network (CRN) stations.

The NHSCO collaborates with state agencies, providing climate data and analyses for state environmental management and planning activities. The NH State Climatologist is a member of the Scientific Advisory Panel to the NH Coastal Hazards Commission and the NH Drought Management Team. The NH Drought Management Team works with NH Departments of Environmental Services to monitor drought development, conditions, and impacts.

OFFICE OF THE NEW JERSEY STATE CLIMATOLOGIST

State Climatologist: David A. Robinson, PhD.
Assistant State Climatologist: Mathieu Gerbush
Staff/Service Climatologists: Dave Fittante, Missy Holzer (PhD)., Erik Namendorf, Jay Read, Joey Fogarty, Chad Shmukler, Christina Speciale, Andrew Sutphen, Ariel Schabes

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About the Office of the New Jersey State Climatologist

The Office of the New Jersey State Climatologist (ONJSC) provides climate services to meet the needs of close to nine million Garden State residents, along with numerous stakeholders and decision makers. As we serve the NJ community, we continue to be mindful of our mission to gather and archive NJ weather and climate observations, conduct and foster research associated with NJ's weather and climate, and provide critical climate services to all seeking assistance.

The ONJSC is affiliated with the NJ Agricultural Experiment Station and is situated within the Rutgers Department of Geography. ONJSC staff includes the state climatologist, assistant state climatologist, technical specialists, field technicians, an education advisor, and student research assistants.

Communication Capabilities

The ONJSC primarily communicates via our main website and the NJ Weather and Climate Network (NJWxNet) site. We also post reports on our Facebook page, have a Twitter presence, and maintain a mailing list of approximately 100 individuals (which includes some reporters). On average, there are approximately 500 unique visits to our websites each day, the number fluctuating greatly depending on ongoing or recent weather/climate conditions.

Information Services, Products and Tools

Some specifics of ONJSC endeavors falling under this heading are found elsewhere in this report. Two products are highlighted here. The first involves employing observations from NJWxNet stations to generate daily evapotranspiration values and couple them with recent precipitation observations to make recommendations regarding the frequency and duration of lawn watering. This is undertaken with Suez Water Company, one of the primary water purveyors in NJ and surrounding states.

A second product is a fire weather page that provides U.S. and NJ forestry staff with updates of weather conditions critical to assessing fire danger. A basic webpage includes observations updated every five minutes from several dozen NJWxNet, NWS and RAWS stations, including fuel moisture and temperature measured at some locations. Based on stakeholder experience, watch, warning and danger thresholds for each variable have been selected and when reached observations are color coded for rapid assessment.

Research, Projects and Publications

Research endeavors within the ONJSC include projects on issues including urban heat and public health, pest management, smart lawn watering, forest fire weather, public safety, transportation, and potential seasonal ENSO influences, to name several. These efforts involve staff, students, Rutgers colleagues, and individuals within state and federal agencies and the private sector. Project results are placed on the ONJSC and other websites, included within a variety of reports, as well as in some published literature. One of the most popular projects continues to be the ONJSC website posting of snowfall observations for any event depositing 2" or more snow at any location in the state. The 2017-2018 snow season, with 16 such events, found the snow page accessed over 20,000 times. These observations are often used to resolve snowplowing contracts that are based on increments of snowfall.

Outreach and Education

The ONJSC produces monthly reports of NJ weather and climate highlights, including societal impacts. These are shared with the Northeast Regional Climate Center, posted on the AASC national and ONJSC websites, and published in the "Weather Shelter" newsletter of the North Jersey Weather Observers.

Examples of ONJSC outreach activities include the creation of online weather training materials for NJ public safety officials, and a wealth of interviews and presentations. The ONJSC gave approximately 200 interviews to the media in the past year and made over two-dozen presentations to schools, civic and other organizations.

Dave Robinson finished his term as a member of the National Academy of Sciences Board of Atmospheric Sciences and Climate. He continues to sit on the NWS StormReady Community Program advisory board, the Sustainable Jersey climate, forestry and urban heat committees, the NJ drought advisory committee. New assignments include participating on climate advisory committees for the NY & NJ Port Authority and the North Jersey Transportation Planning Association. Missy Holzer is past president of the National Earth Science Teachers Association and currently is the secretary of the organization.

Monitoring and Impact Assessment

The ONJSC operates the New Jersey Weather and Climate Network. This unique network of 63 weather stations serves as a one-stop Internet resource for New Jersey weather and climate data. The NJWxNet includes 42 NJ Mesonet sites monitoring a rich suite of atmospheric and surface variables, and 21 NJ SafetyNet stations, monitoring a subset of important variables primarily at public safety locations. Observations are gathered every five minutes and displayed in real time as colorful maps and tables on the NJWxNet web site. The NJWxNet site also displays data from NWS, USGS, NJDOT and other networks to augment NJWxNet observations.

The ONJSC oversees the NJ CoCoRaHS program. Close to 300 citizen scientists participate in the program, with approximately 100 of them missing seven or fewer daily observations in 2017.

Observational data are used by myriad users, such as the NWS, the NJ Department of Environmental Protection, state, county and local emergency management officials, the agricultural community, forest managers, snow removal entities, water utilities, schools and the media.

NEW MEXICO STATE CLIMATE OFFICE

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About the New Mexico State Climate Office

The New Mexico Climate Center (NMCC) resides within the Department of Plant and Environmental Sciences at New Mexico State University in Las Cruces, New Mexico. The climate center is operated by the State Climatologist, one technician, and several student assistants. By law, the duties of the NMCC are to (1) assess the effect of climate on the natural environment, agricultural production, land and natural resources and human health, (2) coordinate climate impact studies and programs, (3) consult and coordinate with the federal and state agencies government in climate related activities, and (4) disseminate climate data, information, advice and assessments to state and local agencies and the general public.

Staff include:
Stan Engle, Database Administrator
Antonio Arredondo, Graduate Assistant
Jaylen Fuentes, Graduate Assistant
Zahra "Vida" Ghodsi Zadeh, Graduate Assistant
Octavio Nayares, Undergraduate Assistant

Communication Capabilities

Our social media outlets include Twitter (@nmclimate), Facebook (facebook.com/nmclimate), and YouTube (youtube.com/nmclimate) for providing climate information to the public. In 2017 we Tweeted out 901 times, gained 237 new followers, and had 12,777 profile visits. Below in Figure 1 is a summary of our Twitter statistics in 2017.

Our office fielded numerous media interviews from both local, state-wide, and national news organizations.

Information Services, Products, and Tools

Our center collects, archives, and disseminates climate data and information from federal, state, and private observing stations throughout New Mexico. We maintain

the website, http://weather.nmsu.edu to house climate information and data at no cost to the public. Our office also coordinates the state CoCoRaHS program and helps with recruitment and member retention. Many requests for data and information were also answered by phone, email, and in-person. In addition, we maintain and promote a variety of web based tools for decision support in the areas of drought, air quality, agriculture, hydrology, construction, and economic development. Dr. DuBois continues the Chair of the New Mexico Drought Monitoring Workgroup and conducts monthly conference calls.

Research, Projects and Publications

Our primary research project in 2017 was for the El Paso Metropolitan Planning Organization funded by the Texas Commission on Environmental Quality to collect ozone vertical profiles in the El Paso area. From the middle of May through the beginning of October we released 57 ozonesondes from several locations to better understand local versus transported ozone and ozone precursors to the region. Information from this project will be used in the planning process for the state implementation plan to comply with the 8-hour ozone standards.

The Climate Center continued to be funded by the NOAA RISA Climate Assessment of the Southwest (CLIMAS) to continue work in the area of climate services in New Mexico. We continued collaboration with the New Mexico Department of Transportation on their dust mitigation investigation and collected dust storm information along Interstate 10 in locations where traffic accidents have occurred due to wind-blown dust. A new project was started to engage the trucking community regarding resilience to dust storms on highways across Arizona and New Mexico. We continued to collaborate with the Desert Research Institute on the testing of dust sensors.

Outreach and Education

We participated in numerous outreach activities in public schools and community events including the Master Gardener program promoting climate awareness, CoCoRaHS, and during EarthDay in both Doña Ana and San Juan County. The Center also participated in the annual Las Cruces Water Festival that hosted about 2,000 elementary school students and educated them on water conservation and awareness. We continued to give climate station tours and talks to more than 200 K-12 students in southern NM. We started a new workshop this year during the state 4-H conference. During that workshop we discuss the importance of climate monitoring and how the students can participate through CoCoRaHS and purchasing a weather station. We also continued our active participation in the Joint Advisory Committee for the Improvement of Air Quality in the Paso del Norte Air Basin that meets quarterly. On average we provided at least one talk or activity per week over the course of the year.

Monitoring and Impact Assessment

The NMCC maintains a network of automated weather stations throughout the state, mostly located in agricultural regions. The 10 station ZiaMet network is supported by the National Mesonet Program (NMP) and primarily located at NMSU Agricultural Science Centers across the state. The NMCC also maintains the former USRCRN weather stations in NM. Five of these USRCRN stations are owned and located at National Park Service lands with the remaining 10 owned by New Mexico State University.

Figures

Month	Tweets	Profile Visits	New Followers	Impressions	Mentions
January	93	1,019	14	39,200	40
February	79	836	6	31,000	34
March	78	888	7	31,100	59
April	72	763	20	25,600	59
May	105	1,144	21	34,100	91
June	91	1,027	25	52,400	108
July	100	3,149	59	50,800	714
August	83	1,100	19	45,700	36
September	67	988	20	34,700	57
October	54	577	16	22,700	30
November	39	473	14	25,700	39
December	40	813	16	23,100	16
TOTAL	**901**	**12,777**	**237**	**416,100**	**1283**

Figure 7: Twitter statistics from @nmclimate in 2017

Figure 9: Ozonesonde release from the NWS office in Santa Teresa, NM

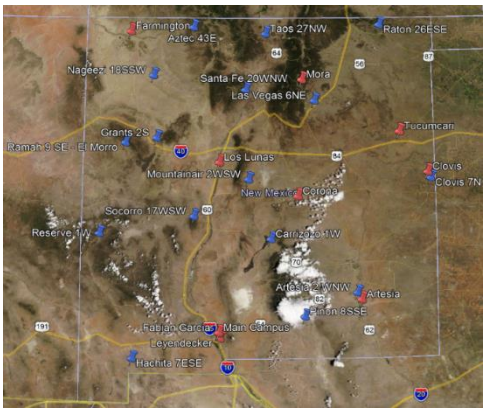


Figure 8: Climate monitoring networks managed by the NM climate center. ZiaMet stations are colored red and the former USRCRN stations in blue.

STATE CLIMATE OFFICE OF NORTH CAROLINA

Acting State Climatologist: Dr. Aaron Sims
Assistant State Climatologist: Ms. Heather Aldridge
Staff/ Service Climatologists:

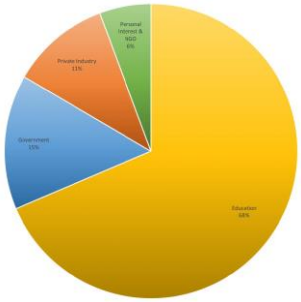
- Ms. Ashley Hiatt, Applied Meteorologist
- Mr. Sean Heuser, ECONet Manager
- Mr. John McGuire, Applied Meteorologist
- Ms. Rebecca Ward, Extension Climatologist
- Mr. Corey Davis, Applied Climatologist
- Mr. Nathan Parker, Systems Analyst
- Ms. Darrian Bertrand, Applied Climatologist
- Ms. Aurelia Baca, Climatologist
- Ms. Colleen Karl, Outreach Specialist
- Mr. Joe Taylor, Instrumentation Technician

Address: NC State University
1005 Capability Drive
Centennial Campus Box 7236
Raleigh, NC 27695-7236
Phone: (919) 515-3056
Website: climate.ncsu.edu
Twitter: @NCSCO
Email: sco@climate.ncsu.edu

About the State Climate Office of North Carolina

The State Climate Office of North Carolina (NCSCO) is a Public Service Center established in 1998 that defines, predicts, and disseminates information about the climatic and environmental factors that impact the people of North Carolina. Extension activities include collection and dissemination of climate information. Research is performed in cooperation with collaborating partners and is designed to enhance the extension work. NCSCO interacts with K-12, community colleges teachers and students, and with other community organizations on different aspects of NC climate and environment. NCSCO is committed towards the improvement of the socio-economic conditions of NC and is involved in managing, accessing, providing, analyzing, disseminating and interpreting climate information.

Communication Capabilities



Direct requests from clients via email and phone during 2017-2018 resulted in a 19% increase in direct requests for services. As with most years, a large percentage of time was devoted to supporting educational requests (68%), while remaining effort went largely to support government (15%) and private industry (11%). Public interest accounted for 6% of requests.

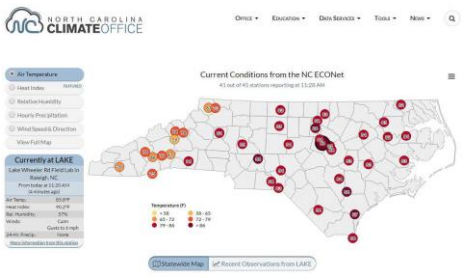
The NCSCO staff and students wrote 25 posts for its Climate Blog, receiving 40,740 total views. NCSCO's posts weekly content on Twitter (@NCSCO), including the blog posts, videos, and blurbs about recent weather, infographics, and updates from outreach events and weather station maintenance visits. NCSCO's account has 1042 followers – a 12% increase from the previous year.

Information Services, Products, and Tools

For the period of May 1, 2017 through April 30, 2018, the number of website visits was over 1.2 million. Since 2009, web traffic has increased 483%. Of these visits, 88.6% were from new visitors, an increase from the previous year.

Nearly 79% of data requests came from North Carolina visits, while 12% did not specify their location when submitting requests. Requests from 16 other states across the country averaged 1 to 4 requests each.

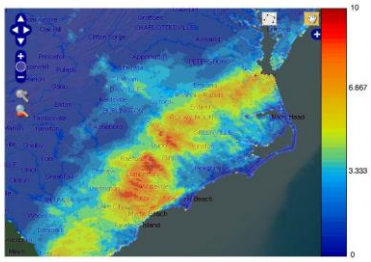
Users requested more than 5.0 million data queries through the CRONOS website interface. More than 2.9 million queries were requested through the Application Programming Interface. Network and data support has increased in the amount of internal data ingest, management, and transfer. NCSCO continues to average over 6 terabytes of internal climate data transferred each month with about 2.2 billion data records selected, updated, or inserted each month. As part of NCSCO's new website launch, data accessibility for mobile devices has been improved. Nearly 40% of all website traffic now comes from mobile devices.



View of NCSCO's new website homepage featuring ECONet data, including current and recent data from around the state.

Over half a billion observations were recorded at NC Environment and Climate Observing Network (ECONet) stations, which are maintained and operated by the NCSCO.

Select Research, Projects, and Publications



Precipitation recurrence intervals exceeded during Hurricane Matthew in 2016. A value of 10

- 14th year providing routine advisories for two peanut foliar diseases.
- More than a decade long partnership with NC Dept. of Transportation to provide operational rainfall alerts for water quality permitting and storm water control saving more than 113,000 work hours each year.
- For over two decades, the NCSCO has been an integral member of the NC Drought Management Advisory Council, participating in weekly drought monitoring conference calls, public presentations, and media interviews on drought in NC.
- Partnership with the Carolinas Integrated Sciences and Assessments, a NOAA RISA, to collect narrative reports describing on-the-ground conditions for use in drought monitoring.
- Develops and maintains the technological infrastructure, web services, and online climate tools in a partnership with Southeast Regional Climate Center (SERCC) for over 10 years.
- Through a USDA cooperative agreement, the NCSCO provides technical, scientific, and extension expertise for Southeast Regional Climate Hub (SERCH) extending climate science to support informed decision making on southeastern US forests, rangelands, and croplands.
- Collaboration with NCSU Department of Biological and Agricultural Engineering to develop the Farm Water Needs Tool, a planning resource to determine how much water from irrigation is needed to satisfy crop water demand in addition to rainfall.
- Currently the NCSCO is deploying and evaluating black globe thermometers at select ECONet stations and comparing with existing algorithms that estimate black globe temperature.
- Deploying soil moisture monitoring stations to improving fire and smoldering risk indicators for organic soils.
- Climate focal point for the Spatial Analytic Framework for Advanced Risk Information Systems (SAFARIS) project, which is a collaboration with NCSU's Center for Integrated Pest Management (CIPM) and USDA Animal and Plant Health Inspection Service (APHIS) working to estimate global risk to trade of agricultural products.

The organic soil moisture monitoring station at Pocosin Lakes National Wildlife Refuge.

- Six manuscripts were accepted for publication; Seven manuscripts are in development or currently in submission; 27 presentations were given at meetings and conferences; 18 staff and students attended 33 meetings and conferences

Outreach and Education

Staff and students at Packapalooza

- The NCSCO regularly leads and attends educational outreach events across the state of North Carolina. Staff and students participated in 14 outreach events, 4 of which were large events including Farm Animal Days and NCSU's Solar Eclipse Day. This year's activities totaled 81,328 direct educational outreach contact hours.
- More than 15 presentations on NC's climate, weather, and ongoing research projects were given to community groups, professional groups, and conference attendees.
- In the past year, more than 12 media interviews were given on weather and climate information including winter outlooks, and climate change impacts on NC winter weather.
- Six students research assistants trained and financially supported.
- Hosted two students from the Climate Change and Society Professional Master's Program as part of their applied climate capstone summer projects.
- The NCSCO is continuing to host a STEM program for rising 7th graders in rural northeastern NC. The NCSCO is refining curriculum for introducing weather and climate concepts through precipitation data collection.
- 10 school and community groups hosted for outreach
- 252 new CoCoRaHS observers recruited

Monitoring and Impact Assessment

The ECONet is a network of real-time research-grade monitoring stations that provide observational data on atmospheric and soil conditions. The ECONet is unique in North Carolina, and provides information that is sparsely collected by other sensors in the state such as solar radiation, soil temperature, and soil moisture.

- Last year 158 site visits were made to perform routine or emergency maintenance covering 21,464 vehicle miles
- New station installed: The 41st ECONet station was installed at the Butner Beef Cattle Laboratory
- New sensors installed: Black globe thermometers have been installed at six ECONet stations to assist in monitoring for heat stress

The NCSCO is the primary source for North Carolina weather and climate information and is involved in all aspects of climate research, education, and extension services. Activities include:

- Observing, collecting, and disseminating climate information
- Over 20,000 surface weather and water resource data are accessible through an online interface.
- Assisting state government agencies in activities, reducing costs and

conserving resources.

- Collaborating with extension scientists to provide agricultural guidance to growers, leading to mitigation of crop loss and better production decisions.
- Involved with drought monitoring and management at community, statewide, and national scales.
- Studying climate variations and impacts on North Carolina, including sensor and model evaluation, severe weather patterns, drought and water resource management, and economic impacts.
- Providing numerous community presentations, science fairs, and other interactions with K-12, college students and teachers.

NORTH DAKOTA STATE CLIMATE OFFICE

State Climatologist: Adnan Akyuz
Street Address: 1230 Albrecht Blvd.
Morrill Hall 304
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Telephone number: 701-231-6577
Website: https://www.ndsu.edu/ndsco/
Twitter: https://mobile.twitter.com/FAkyuz

About the North Dakota State Climate Office

The North Dakota State Climate Office (NDSCO) is part of the North Dakota Agricultural Experiment Station, in the College of Agriculture, Food Systems, and Natural Resources of the North Dakota State University. As such, the State Climate Office is uniquely positioned to provide information needed for natural resources management and climate assessment to the College of Agriculture, Food Systems, and Natural Resources as well as to the University as a whole, and to the other public and private educational institutions, corporations and government agencies throughout North Dakota and elsewhere. The State Climate Office is in a position to provide linkages and to serve as liaison between the users of weather and climate information in the state of North Dakota and the national and regional climate centers such as National Centers for Environmental Information (NCEI), National Weather Service (NWS) and the High Plains Regional Climate Center (HPRCC). The North Dakota State Climate Office has been an AASC Recognized State Climate Office since 2007. It is also supported by the NOAA Weather Forecast Offices in BIS and FGF as well as HPRCC and NCEI.

Communication Capabilities

The State Climate Office disseminates of climate information in quarterly, monthly and seasonal formats. These reports are available at https://www.ndsu.edu/ndsco/resources/ . The SCO also frequently answers media and public questions. List of outreach activities follow.

Information Services, Products and Tools

- The North Dakota State Climate Office enjoys full access to a State Mesonet: North Dakota Agricultural Weather (NDAWN): https://ndawn.ndsu.nodak.edu//
- Statewide Climate Data (NDSCO): https://www.ndsu.edu/ndsco/data/
- Climate Summaries (NDSCO):
    - Monthly Climate Summary and Impact Reports: https://www.ndsu.edu/ndsco/climatesummaries/monthlyclimatesummary/

- Quarterly Climate Bulletins: https://www.ndsu.edu/ndsco/climatesummaries/quarterlyclimatebulletin/

Research, Projects, and Publications

Peer Reviewed Journals:

Akyuz, F. A., H. Kandel, D. Morlock, 2017: Developing a Growing Degree Day Model for North Dakota and Northern Minnesota Soybean. Journal of Agricultural and Forest Meteorology, 239C (2017) pp. 134-140.

Technical Reports:

Frankson, R., K. Kunkel, L. Stevens, D. Easterling, M. Shulski, and A. Akyuz, 2017: North Dakota State Summary. NOAA Technical Report NESDIS 149-ND, 3 pp.

Extension Publications:

- Kandel H. and A. Akyüz, M. Ostlie, B. Schatz, J. Nielsen, J. Rickertsen, R. Olson, E. Eriksmoen, J. Tarasenko, J. Effertz, B. Hanson, T. Hakanson, L. Henry, J. Bergman, G. Pradhan, J. Jacobs, E. Link, and T. Tjelde. North Dakota Canola Variety Trial Results for 2017 and Selection Guide. NDSU Extension Services/ ND Ag Experiment Station. A1124-17. October 2017.
- Hans Kandel and Adnan Akyüz (NDSU Main Station); Blaine Schatz, Mike Ostlie, Steve Zwinger and Steve Schaubert (Carrington Research Extension Center); John Rickertsen (Hettinger Research Extension Center); Bryan Hanson, Travis Hakanson and Lawrence Henry (Langdon Research Extension Center); Jerry Bergman, Gautam Pradhan, Austin Link and Emma Link (Williston Research Extension Center); Thomas Stefaniak (North Central Research Extension Center, Minot); Glenn Martin (Dickinson Research Extension Center). North Dakota Dry Pea Variety Trial Results for 2017 and Selection Guide. 2017. NDSU Extension Publication # A1469-17

Proposals Funded: Total= $379,650

Funded Activities:

- NOAA's NWS National Mesonet Program
- Adaptation of Geoecosystem
- Gateways North Dakota
- Information Technology Action Fee Weather Observation Entry Project
- Crop Sys- CAP-A: Novel Management Approach to Increase Productivity, Resilience, and Long-term Sustainability in Cropping System in Northern Great Plains

Outreach and Education

- Media Interaction: Total Documented: 61
- Professional Meetings Attended: 4
- Professional/Invited Presentations: 17

- Guest Lectures/K-12 Presentations: 9
- Professional Committees Served In: 24

Professional Affiliations:

- Royal Meteorological Services, Fellow
- AMS
- AASC, President Elect

Education (Teaching):

Classes Taught:

- Fall 20017: AGRI 115/Wonders of Weather (Class Size: 98)
- Spring 2017: Soil 217/Introduction to Meteorology and Climatology (Class Size: 160)

Graduate Students:

- Number of Graduate Students: 1
- Number of Graduate Student Committees Served: 2

STATE CLIMATE OFFICE OF OHIO

State Climatologist: Bryan Mark (Professor)
Assistant State Climatologist: Jim DeGrand (Senior Researcher and Lecturer)
Staff/Service Climatologists: Aaron Wilson (Senior Research Associate)
Jason Cervenec (Education & Outreach Director)
Steven Quiring (Professor)
Wes Haines (Technical staff, meteorologist)
Jeff Rogers (Professor Emeritus)
Affiliation/Sponsor: The Ohio State University, Department of Geography, Byrd Polar and Climate Research Center (BPCRC), and Department of Extension
Address: 108 Scott Hall, 1090 Carmack Road, Columbus, OH 43210
Email Addresses: scoo@osu.edu

Bryan Mark: mark.9@osu.edu
Jim DeGrand: degrand.1@osu.edu
Aaron Wilson: wilson.1010@osu.edu
Jason Cervenec: cervenec.1@osu.edu
Steven Quiring: quiring.10@osu.edu
Wes Haines: wes@weshaines.com
Jeff Rogers: rogers.21@osu.edu

Telephone Numbers:
Bryan Mark: (614) 688-7971; (614) 247-6180
BPCRC main office: (614) 292-6531
Fax number: (614) 292-4697

Website: climate.osu.edu
Social Media: Facebook: https://www.facebook.com/ohioclimate/
Twitter: https://twitter.com/Ohio_Climate

About the State Climate Office of Ohio

The State Climatologist for Ohio has been housed within the Department of Geography and Atmospheric Sciences Program at The Ohio State University (OSU) since the termination of the federal climate program in 1973. The position of State Climatologist has been an unfunded title held by a full time faculty member in Geography who has many other salaried duties. No additional staff were involved, nor funding to develop the office. Professor Jeff Rogers served as State Climatologist from the mid 1980's until 2015 when he retired from his faculty position. This motivated a restructuring and formation of the State Climate Office of Ohio (SCOO) uniting the Department of Geography (Atmospheric Sciences and Climatology) and Byrd Polar and Climate

Research Center (BPCRC) at OSU in a synergistic partnership. The Department of Geography provides 50% of ASC Jim DeGrand's appointment for SCOO activities including improvements to data collection sites and enrichment of student projects. Since January 2017, OSU's Department of Extension has also provided a 50% appointment to Aaron Wilson within the Agriculture and Natural Resources Program. This has expanded SCOO's ability to reach the agricultural community throughout Ohio, taking advantage of the rich and vast Educator network throughout most of Ohio's counties.

SCOO personnel include: State Climatologist, Bryan Mark (herin BM), who started in the position on June 1, 2015 and is responsible for full-time teaching and research in his capacity as a professor in the Geography Department and Atmospheric Science Program and BPCRC researcher; Jim DeGrand (JD) serves as Assistant to the State Climatologist of Ohio, and is a Senior Researcher in Geography/Atmospheric Sciences; Jason Cervenec (JC) is Education & Outreach director at BPCRC; Aaron Wilson (AW) is a Senior Research Associate with the BPCRC and OSU Extension; and Wesley Haines (WH) is Assistant Systems Manager at BPCRC. Emeritus State Climatologist Jeff Rogers (JR) continues to advise and serves as statewide co-coordinator (with Ashley Novak, NWS, ILN) of Ohio CoCoRaHS. Dr. Steven Quiring (SQ) joined our Geography/Atmospheric Science faculty in 2016 and brings his expertise in climate data analytics to solve societally-relevant problems.

SCOO members (L to R): Dr. Aaron Wilson; Jim DeGrand; Prof Bryan Mark; Jason Cervenec; Wes Haines. Absent: Prof Emeritus Jeff Rogers and Prof Steven Quiring.

SCOO Mission: Connecting Climate and People

Climate matters for the well-being of current and future Ohioans. Accessing accurate climate information, education, and interpretation is important for policy makers and many sectors of Ohio's economy, and can make a difference to the quality of life, health, and economic prosperity of all Ohioans.

The SCOO exists to serve as stewards of climate information and related education, research, outreach services for the people of Ohio. We aim to acquire, archive, analyze, disseminate, and interpret scientifically vetted climate data related to environmental factors that impact citizens and livelihoods in Ohio. The SCOO envisions to be the statewide point of focus on issues related to current and future climate change across the state. Accomplishment of this mission is a more climate resilient Ohio.

Communication Capabilities

SCOO maintains communication via email and telephone (contact information listed above). We also have multi-caller video conferencing capabilities using Zoom. We are expanding our redesigned and improved SCOO homepage (https://climate.osu.edu/). The site was re-established on OSU's Arts and Sciences Drupal system in spring 2017 and significant additions and revisions continue to be made to clearly communicate information to our various stakeholder communities. Currently, this site contains basic information on SCOO personnel and history, news items, recent climate maps and data products provided by the Midwest Regional Climate Center (MRCC; http://mrcc.isws.illinois.edu/), our weekly and quarterly summaries, relevant links, and access to climate tools (partner sites and internally developed). From June 1, 2017 to May 14, 2018, the SCOO website has seen 1550 unique pageviews.

SCOO continues its social media presence through Facebook https://www.facebook.com/ohioclimate/) and Twitter (https://twitter.com/Ohio_Climate). SCOO's Facebook stream has over 100 followers with a reach of 1,560 people between April 17, 2018 and May 14, 2018). SCOO's Twitter stream has over 24 followers.

Information Services, Products, and Tools

SCOO conducts and records a weekly/bi-weekly Ohio Hydrologic and Climate Assessment using Zoom to report on current climate/hydrology/drought conditions and a brief outlook for what to expect in coming days (https://bpcrc.osu.edu/hydro). We archive the presentation videos, and provide a link on our website. This information is used as a source for the weekly US Drought Monitor. SCOO coordinates with area NWS Hydrologists, Ohio Emergency Management Agency, Ohio Department of Natural Resources, Ohio Department of Agriculture, and Extension Educators to provide local information to the US Drought Monitor when warranted. The portion of the site containing these PDF and video files has received 154 unique page views over the June 1 ,2017 to May 14, 2018 period. On average, each of the weekly videos is viewed 10 times. SCOO is seeking ways to boost engagement with our videos including transitioning to a podcast format available through iTunes. A Quarterly Climate Summary is also available through the website and is geared toward Extension Educators and other Ag professionals throughout the state.

SCOO maintains partial archives of paper and digital weather records for several locations in Ohio dating back to 1882. The Ohio Historical Society also maintains a partial archive. Records for the Columbus area include many original documents.

Research, Projects, and Publications

SCOO members are participating collectively in four projects detailed below, and SCOO member SQ is PI or co-PI on related research projects with applied climatology foci.

Regional Integrated Modeling of Farmer Adaptations to Guide Agroecosystem: Management in a Changing Climate

Three members of SCOO (BM, JC, and AW) are part of a larger OSU team of researchers from Risk and Decision Science, Sustainable and Resilient Economies, and Ecosystem Modeling that have recently been awarded a USDA NIFA grant. This project will commence August 1, 2018 and will focus on climate change in the eastern Corn Belt Region (ECBR), present and projected. In an effort to assess multiple goals related to agricultural production, conservation, and societal well-being, we will build an integrated set of models of the climate system, regional economy, and agroecological outcomes and use this to evaluate policies and programs by projecting their impacts on the sustainability and resilience of this regional agroecosystem under varying futures. We will address the program area priority of "Climate, Land use and Land Management," generating key outcomes including: (i) innovations in coupling downscaled climate projections with models of heterogeneous farmer behavior, regional economics, and land use/management patterns; (ii) increased awareness of how climate has changed over the last century in the ECBR; (iii) increased understanding of future climate and likely agroecosystem responses in the ECBR; and (iv) improved stakeholder confidence in the ability to mitigate climate-induced risks through more informed land use and management. For the downscaled modeling component, we will be working with the RCC-ACIS (http://www.rcc-acis.org/) and will be taking advantage of the one-day ACIS workshop provided at this year's AASC Annual Meeting.

FARM App and Midwest RISA Center Proposal

Last year, SCOO successfully acquired a Connect and Collaborate Grant from the Ohio State University entitled: *"Connecting Climate and People to Improve Outcomes for Ohio and Beyond."* The small grant ($45k) funds a partnership internal OSU entities (College of Food, Agricultural and Environmental Sciences Department of Extension, Office of Energy and Environment, Office of Outreach and Engagement) and an external private agency (weatherUSA, LLC).

Driven by our mission to serve as data stewards and connect Ohioans with weather and climate information necessary to improve lives, we had two main parts of our project: FARM and RISA

***FARM*:** This collaborative endeavor has lead to a multi-platform prototype tool called "FARM" (Field Application and Resource Monitor; https://farm.bpcrc.osu.edu/) mobile and web app and climate database. This tool provides farmers from all over Ohio (with a particular focus in the Western Lake Erie Basin) with the real-time weather and climate information needed to make compliance decisions concerning fertilizer and manure applications (future plans include expansion into wind and temperature inversions).

Outreach and Education

Workshop and Conferences

2017 American Association of State Climatologists

On June 28-30, 2017, ASC JD and AW attended the AASC Annual Meeting in Asheville, NC. The purpose of the meeting was to represent the State Climate Office of Ohio at the annual meeting of state climatologists (SCs). SCs presented successes and challenges within many of the offices throughout the country. This provided a strong networking and engagement setting to collaborate with others throughout the region in building climate services in Ohio and throughout the US.

Farm Science Review 2017

From September 19-21, 2017, the entire SCOO team participated in OSU's annual Farm Science Review (https://fsr.osu.edu/), which draws approximately 130,000 individuals connected with agriculture throughout Ohio and surrounding states.

The team answered questions related to agricultural weather and climate and climate change, and focused on user testing a new online tool, FARM, for providing the agricultural community with timely precipitation forecasts (FARM is described later in this report). A talk was given by Aaron Wilson and Jason Cervenec titled *Extreme Weather: Small Farms and Rural Communities.*

In connection with Farm Science Review, Aaron Wilson was interviewed by a number of agricultural media outlets (https://agnr.osu.edu/news/changing-climate-

farmers-should-prepare; http://ocj.com/2017/09/ohio-agriculture-in-a-changing-climate/; https://www.farmanddairy.com/news/talking-climate-at-farm-science-review/446126.html;) and Bryan Mark, Aaron Wilson, and Jason Cervenec participated in a radio discussion about climate change on Ohio Farm Bureau's *Town Hall Ohio* (https://ofbf.org/2017/09/07/climate-change-town-hall-ohio/).

Additional Programs On Campus

On January 25, 2018, JC and AW presented a poster at Ohio State's *Community Engagement Forum* on SCOO's leadership in the development of a climate change adaptation plan for the City of Columbus. Ohio State hosted a *Building Resilience Communities in a Changing Climate* conference on May 18, 2018 focused on bridging the researcher-practitioner divide in conversations of climate change and its impacts on planning, infrastructure, and transportation. During the conference, MB, JC, SQ, and AW gave talks or served on discussion panels.

Additional Regional Engagement

Participate in the monthly Midwest Agriculture and Climate Team (MAC-T) conference calls, organized by Dennis Todey of the USDA Midwest Climate Hub. The purpose of this meeting to communicate climate-related Ag issues to the hub which allows for regional coordination of action and awareness. This meeting also serves to summarize the Ag impacts throughout the region which are used in the monthly North Central Region Drought and Climate Outlook.

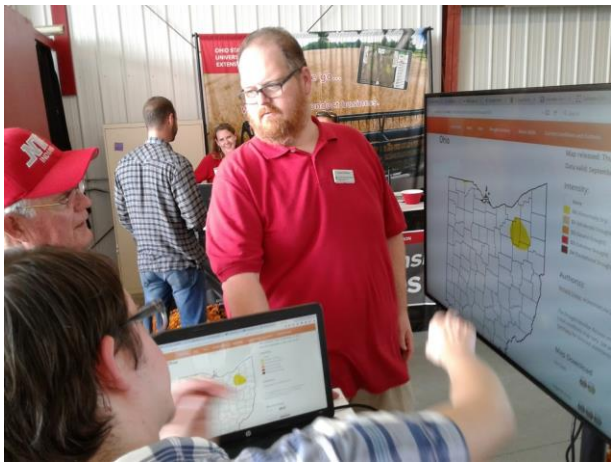
Participate monthly in the North Central Region Drought and Climate Outlook by supplying the selected author information from Ohio regarding weather and climate impacts on Ag, water, transportation, economy, and other sectors for the month. AW facilitated the June 2017 webinar, availabe at http://mrcc.isws.illinois.edu/multimedia/webinars.jsp, and will be conducting the June 2018 webinar as well.

Co-facilitate the North Central Region Water Networks North Central Climate Collaborative (NC3; http://northcentralwater.org/nc3/). Help organize bi-monthly webinars on climate related topics pertaining to the North Central Region to help educate and raise the capacity of Extension professionals in climate-related topics. (Please see **Providing the Foundation for Lasting Climate Education in the North Central Region** in Research and Publications section for more information.)

In outreach, education and engagement, one of our primary stakeholder audiences is the agricultural sector. Much of our activity and effort has involved improving our connection via OSU Extension. Beginning in January 2017, AW acquired a 50 percent appointment in the OSU Department of Extension - the education and outreach arm of the College of Food, Agricultural, and Environmental Sciences (CFAES). Under the area of Agriculture and Natural Resources, AW has increased the professional development within Extension concerning weather and climate

education and the impacts of local climate change on agricultural profitability and sustainability. This has strengthened SCOO's connection to the Ag community throughout Ohio, as SCCO continues to build trust within the network of Extension Educators throughout Ohio.

This position has brought engagements with other county Extension Educators and invitations to field days and farms. AW works with Ag journalists to bring the weather and climate information to Ag-related press releases. Of the 134 outreach programs of SCOO last year, 21 events that reached an audience of 840 individuals were delivered by AW and targeted to the agricultural community.



Invited engagement:
More broadly, we regularly respond to invitations to give presentations and discuss climate to local academic and public communities. Events we've participated in this year include the following:

Jun 2018 **Quiring, S. M.** National Soil Moisture Map. MOISST Workshop, Lincoln, Nebraska.

May 2018 **Quiring, S. M.** National Soil Moisture Monitoring Network. Monitoring
Forest Soil Moisture for a Changing World. Michigan Tech Research Institute, Ann Arbor, Michigan.

May 2018 Building Resilient Communities in a Changing Climate, The Ohio State University, Columbus, Ohio. (https://oee.osu.edu/conference-at-ohio-state-addresses-challenges-from-changing-climate.html) Co-hosted by Mid Ohio Regional Planning Commission (MORPC) and organized by **Jason Cervenec**, with participation by SCOO members: **Moderator - Bryan Mark** and plenary/panel talks:

- **Wilson, A.** Climate Change Impacts Along the Rural to Urban Gradient

- **Quiring, S. M.** Energy Infrastructure Challenges – What Are We Facing?

Apr 2018 **Wilson, A.** Soil and Water Management in the Face of Changing Weather Patterns. Ohio-Kentucky-Indiana Regional Conservation Council Annual Meeting. Hamilton, Ohio.

Apr 2018 **Wilson, A.** Temperature Inversions and Drift Conditions Across Ohio.
OSU Extension Inversion and Drought Mitigation Workshop. Columbus, Ohio.

Apr 2018 **Wilson, A.** Ohio's Climate Through the Ages. Ohio History Connection
Spring Thaw Program. Columbus, Ohio.

Mar 2018 **Mark, B.G.** Climate change assessment, adaptation and mitigation framework-USA. 2nd International Conference on Food & Agriculture. "Sustainable Agriculture for Food Security." Dhandbad, Jharkhand, India. 29 March. Keynote address (via telelink).

Mar 2018 **Quiring, S. M.** Modeling Hurricane Risk: Applying analytics to inform
electrical utilities and the insurance industry. Risk Series, The Risk Institute, The Ohio State University, Columbus, Ohio.

Mar 2018 **Wilson, A.** Weather Trends and Impacts. Ohio Soil Health Symposium.
Tiffin, Ohio.

Mar 2018 **Quiring, S. M.** Modeling the Impact of Hurricanes on Electrical Power
Systems: Lessons Learned from Harvey and Irma. 22nd Annual Severe Weather Symposium, The Ohio State University, Columbus, Ohio.

Mar 2018 **Cervenec, J.** and **A. Wilson.** The Science of Climate Change, invited
talk to College of Food, Agricultural and Environmental Sciences
emeriti and retirees, Upper Arlington, Ohio.

Feb 2018 **Wilson, A.** Weather Trends: Where are we? Ohio Federation of Soil and Water Conservation Districts. Columbus, Ohio.

Jan 2018 **Cervenec, J. and J. Nicolas.** Fluid Earth Viewer, a Freely Available Digital Tool for Investigating Weather and Climate, presentation at Science Education Council of Ohio conference, Lewis Center, Ohio.

Jan 2018 **Wilson, A.** Climate Change and Local Impacts. Guest Lecture for Environment and Natural Resources 3470: Religion and Environmental Values in America. OSU. Columbus, Ohio.

Jan 2018 **Wilson, A., J. Cervenec,** and **G. Dipre.** Building Climate Change Resilience in Columbus through University and Community Engagement, OSU community engagement conference, Columbus, Ohio.

Jan 2018 **Wilson, A**. Climate Change and Health. IM Grand Rounds @ OSU Medical Center. Columbus, Ohio.

Dec 2017 **Quiring, S. M.** Climate Change 101. Maumee Watershed HABRI Stakeholder Advisory Group. Heidelberg University, Tiffin, OH.

Dec 2017 **Quiring, S. M.** Drought and Land-Atmosphere Interactions in a Changing Climate. 7th Annual Water, Climate & the Environment Mini-Symposium. The Ohio State University, Columbus, Ohio.

Nov 2017 **Wilson, A**. Climate Change and Local Impacts. Ohio Public/Private Partnership Homeland Security Fall Conference. Columbus, Ohio.

Nov 2017 **Wilson, A.** Climate Change Communication. Ohio Environmental Leadership Institute. Delaware, Ohio.

Nov 2017 **Quiring, S. M.** Modeling the Impact of Hurricanes on Electrical Power Systems: Lessons Learned from Harvey and Irma. Southern Illinois University, Carbondale, Illinois.

Nov 2017 **Mark, B.G.** Introducing your State Climatologist: Discovering climate change science on glaciers. École Kenwood, Columbus Public Schools (French immersion school), Columbus, Ohio.

Nov 2017 **Mark, B.G.** The politicization of climate change. Invited as State Climatologist to speak at Third Friday Democrats Luncheon, The Boat House, Columbus, OH.

Oct 2017 **Wilson, A.** Climate Change and Local Impacts. Advocates for Community and Education Scholars (ACES) Program. Columbus, Ohio.

Oct 2017 **Wilson, A.** Climate Change and Health. Ohio Hospital Association Environmental Leadership Council Meeting. Columbus, Ohio.

Oct 2017 **Cervenec, J.** Climate Change: Causes, Impacts, and Options, invited talk as part of Diocese of Toledo Care for Our Common Home workshop, Findlay, Ohio.

Sep 2017 **Mark, B.G.** Invited as Professor, State Climatologist and Presbyterian Elder to D.C. fly-in to join group led by National Religious Partnership for the Environment to visit Senate Delegations for OH, MO, PA and IN for "Toxic and Clean Water Advocacy Day."

Sep 2017 **Cervenec, J.** and **A. Wilson.** Changing Climate in Ohio: Impacts on Small Farms and Rural Communities, invited talk as part of 2017 Farm Science Review, London, Ohio.

Sep 2017 **Cervenec, J.** Climate Change: Causes, Impacts, and Options, invited talk for SAVE Organization at Lourdes University, Sylvania, Ohio.

Sep 2017 **Quiring, S. M.** Drought and Land-Atmosphere Interactions in a Changing Climate. Department of Geography, The Ohio State University, Columbus, Ohio.

Sep 2017 **Cervenec, J., B.G. Mark,** and **A. Wilson.** Long-form interview with Joe Cornely on Town Hall Ohio, available at https://ofbf.org/2017/09/07/climate-change-town-hall-ohio.

Aug 2017 Shafer, M. and **S. M. Quiring.** Developing Effective Drought Monitoring Tools for Farmers and Ranchers in the South Central U.S. National Climate Change and Wildlife Science Center.

Aug 2017 **Mark, B.G.** Invited as Geography Professor and State Climatologist to speak at Columbus Metropolitan Club for panel, "What Changes if Climate Changes?" In collaboration with Dispatch Media Group and partnership with OSU Environmental Professionals Network. Panel discussion is taped and televised on WOSU PBS. The Boat House at Confluence Park, Columbus, Ohio.

Jul 2017 **Cervenec, J.** Climate and Energy Education for Physical Science and Physics Classrooms, invited talk at 2017 Summer Meeting of American Association of Physics Teachers, Cincinnati, Ohio.

Jun 2017 **Quiring, S. M.** Modeling weather-related storm outages for Southern California Edison. Fifth Annual California Utility Forecasters Meeting, San Diego, California.

Mar 2017 **Mark, B.G.** From tropical glaciers to Kroger: Reflections on climate change from your unintentional State Climatologist. Chemistry and Biochemistry Club, Ohio State University, Columbus, Ohio.

Feb 2017 **Mark, B.G.** From Glaciers to Asparagus: Tracing Climate Change in Peru. Feature keynote at 19th Annual Stone Lab Winter Program, Longaberger Alumni House, Ohio State University, Columbus, Ohio.

Monitoring and Impact Assessment

OARDC Upgrades

We have initiated a project to fill a coordinating role in inter-connecting and managing an extended network of weather instrumentation around the State of Ohio. As part of this initiative we expect to partner with other agencies and institutions to expand and develop the existing network of Ohio climate stations. We are currently engaged in improving the network of stations operated by the Ohio Agricultural Research and Development Center (OARDC) in Wooster. In 2017-18 we installed soil moisture sensors at 2 levels for 4 stations in the network. We are currently in the process of upgrading communications at the OARDC stations and outfitting them with the capability of monitoring temperature and humidity at 3 levels (0.5 m, 1.5 m and 3.0 m) above the surface using equipment purchased by the USDA Midwest Climate Hub. We anticipate these upgrades will be completed by Fall 2018. We hope to build on this effort with OARDC by collaborating with other agencies such as the Ohio Emergency Management Agency (OEMA), and departments of Natural Resources (ODNR) and Transportation (ODOT) to improve environmental/climate monitoring around the state.

State Hydrostress Test

We have developed a proposal to conduct a hydroclimate stress test to look at the impact of a geographically widespread, long-duration precipitation event on the State of Ohio. Such as project would involve contributions from hydrologists and stakeholders in additional to significant computing assets. SCOO is currently looking for funding from state and regional government entities to complete this three-year project.

OKLAHOMA CLIMATOLOGICAL SURVEY

Dr. Kevin Kloesel Director
Dr. Chris Fiebrich Associate Director
Gary McManus State Climatologist
Dr. Mark Shafer Associate State Climatologist & Director of SCIPP
Monica Deming Assistant State Climatologist

Oklahoma Climatological Survey
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About the Oklahoma Climatological Survey

The Oklahoma Climatological Survey, a research unit of the College of Atmospheric & Geographic Sciences at the University of Oklahoma, was established in 1980 to provide climatological services to the people of Oklahoma, conduct research on the impacts of climate on human activities, and serve as a support facility for the State Climatologist. OCS has a legislative mandate to acquire, process, and disseminate climate and weather data and information for use by the state's citizens. The Survey maintains an extensive array of climatological information, operates the Oklahoma Mesonet, and hosts a wide variety of educational outreach and scientific research projects.

Outreach and Education

Public and stakeholder outreach were again a prime focus of OCS during 2017, including the Oklahoma Mesonet's public safety, K-12, climate and data services, and agricultural programs. Research was another area of emphasis, both internal and in support of outside efforts, utilizing data collected by the Oklahoma Mesonet.

The Mesonet's public safety outreach program, OK-First, concluded a major effort to obtain updated OK-First Participant agreements. In total, 589 completed agreements were received and processed. Another significant accomplishment was the completion and submission of a journal manuscript to the Bulletin of the American Meteorological Society (BAMS) entitled, "The Evolution and Impact of a Meteorological Outreach Program for Public Safety Officials: An Update on the

Oklahoma Mesonet's OK-First Program." The manuscript serves as an update to the program following the initial OK-First publication in BAMS back in 2001. The manuscript is co-authored by several Mesonet staff, NWS colleagues, and a public safety official and covers program history, participant training, data access technology, and program impact. OK-First had its biggest training year in program history with 425 public safety officials receiving training (exceeding the previous high mark of 401 set in 2016). This included 322 people attending in-person training, another record high, and 103 people attending online training.

K-12 outreach participated in dozens of activities attended by thousands of students and adults. In June, OCS held its fifth Regents camp "Partly Weather with a Chance of Fun" with 30 participants. Campers were challenged with contouring surface and upper air maps, charting upper air data on skew-T diagrams, and researching weather careers. As a new component this year, two new activities were added to the camp: issuing warnings with AWIPS systems provided by Warning Decision Training Division and tours of the Radar Innovation Lab and Innovations Hub. Each camper went home with their own Midland weather radio after learning to program them for their local county. Our half-day field trip
included a tour of the KOCO Channel 5 TV station and the Science Museum of Oklahoma. The National Weather Festival was held on 21 October with an estimated crowd size of 7,000 (the largest attendance to date). Mesonet staff answered questions at the Crawford tower, served coffee, apple cider and cookies inside near the OCS front office, sold hats and umbrellas, and had displays of instruments with informational handouts to help visitors learn about the Mesonet.

The Mesonet's Climate and Data Services (CDS) team's duties were driven by Oklahoma's weather and climate extremes. Drought dominated both the beginning and ending quarters of 2017. The drought-fueled "Northwest Oklahoma Complex Fire" that ignited in early March across Beaver and Harper counties became the largest reported wildfire in Oklahoma history, burning over 1 million acres in Oklahoma and Kansas. By the year's end, the "days without precipitation" had neared triple-digits in western Oklahoma, and drought had expanded rapidly despite the diminished influence of the cool season. Drought development places a significant time burden on CDS' time demands as the state's main input in the U.S. Drought Monitor effort. State Climatologist Gary McManus briefed participants at the Governor's Water Conference on drought conditions and gave an outlook for the future months. Assistant State Climatologist Monica Deming began an 11-month appointment with the Southern Climate Impacts Planning Program (SCIPP) within OCS on 1 October. This appointment will provide Monica some "in-house" professional development as she works under the leadership of Associate State Climatologist and Director of SCIPP, Dr. Mark Shafer. Monica's duties will be to help update the state of Oklahoma's drought plan, which has remained unchanged since 1996.

Agricultural outreach staff members Al Sutherland and Andrea Melvin also provided Mesonet booths at numerous meetings and conferences across the state, as well as providing informational talks concerning climate, weather and Mesonet products. Al Sutherland and Gary McManus produced 48 Mesonet Weather segments for OETA's SUNUP-TV program, airing most Saturday mornings. Al Sutherland produced 12 informational Weather and Agriculture blog entries during 2017, addressing weather and climate tools and science of value to agriculture. A highlight of those blog entries was a three-part series covering the Northwest Oklahoma Fire Complex and the conditions that led up to and exacerbated the worst wildfire in Oklahoma history. The blogs told the story using Mesonet data. A search committee was formed to hire an OSU Mesonet Assistant Extension Specialist to work with Al Sutherland, who is retiring in 2018. Wes Lee was offered and accepted the position to start March 1.

Research, Projects, and Publications

Mesonet personnel continue to perform research and provide information on the data collected by the Oklahoma Mesonet. Team leader Dr. Brad Illston represented the Mesonet at the 97th Annual Meeting of the American Meteorological Society. Dr. Illston continued to track research publications used by the Oklahoma Mesonet. To date, there are 736 peer-reviewed manuscripts, 118 Master's theses, and 65 doctoral dissertations. Dr. Jad Ziolkowska of the Department of Geography and Environmental Sustainability, in collaboration with Mesonet personnel, published a major study of the benefits of the Oklahoma Mesonet to the state of Oklahoma in the journal *Weather, Climate and Society (*Benefits and Beneficiaries of the Oklahoma Mesonet: A Multisectoral Ripple Effect Analysis. Weather, Climate, and Society 9 (3), 499-519). Oklahoma Mesonet personnel continue to support the UAS-3D Mesonet research effort in coordination with CLOUD-MAP, a multi-year study which would extend measurements from the Oklahoma Mesonet vertically using small unmanned aircraft systems collocated at the observing towers. Test flights of the UAS vehicles were performed in conjunction with researchers from NSSL, the University of Colorado, and Swiss Meteometrics.

Monitoring and Impact Assessment

During 2017, the Mesonet Calibration Lab and Sensor Development team completed 1898 laboratory calibrations of sensors. Field Technicians made a total of 1390 site visits to Oklahoma Mesonet stations, Little Washita and Fort Cobb ARS stations, repeaters and bases. The Field team resolved 1031 problem trouble tickets and rotation tickets during 2017 in the three networks.

Quarterly and/or Annual Reports for SCIPP and Mesonet can be found on file at the Oklahoma Climatological Survey.

OREGON CLIMATE SERVICE

State Climatologist: Dr. Philip Mote
Assistant State Climatologist: Kathie Dello

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About the Oregon State Climate Office

The Oregon State Climate is housed at Oregon State University, and provides weather and climate information and knowledge to Oregonians. The office is housed at in the College of Earth, Ocean, and Atmospheric Sciences (CEOAS) at Oregon State University, and co-located with the Oregon Climate Change Research Institute and the Pacific Northwest Climate Impacts Research Consortium (CIRC), which is the NOAA-funded Regional Integrated Sciences and Assessment (RISA). OCS is funded in small part by state funding through the Oregon Climate Change Research Institute; time is leveraged on other projects for relevant matters.

OCS exists in Oregon State statute **2015 ORS 352.816,** which designates the official home as Oregon State University and serves as a framework for activities that the office should undertake.

Communication Capabilities

Both Kathie and Phil give numerous interviews each year to local, regional, and national media outlets. OCS operates one of the inaugural Twitter feeds of the state climate offices, with 900 active followers. OCS uses this feed to connect with local media, the general public, and state and federal agencies. Phil and Kathie both maintain separate personal/professional twitter accounts and regularly tweet interesting tidbits on Oregon climate and weather. Kathie and Phil are asked to address various groups for public presentations about Oregon climate and weather, including an annual Pacific Northwest-oriented field trip for incoming CEOAS graduate students.

Information Services, Products and Tools

On the state level, Kathie Dello serves on both the Water Supply Availability Committee and the Drought Readiness Council. These are two bodies which serve as

the technical and policy group for drought declarations in the state of Oregon. Kathie was also a part of the Governor's Office communication team regarding public drought matters, and also participated in the Governor's drought team meetings. OCS was an integral part of the launch of the Pacific Northwest Drought Early Warning System. Kathie has revived a US Drought Monitor coordination call with the National Weather Service, the Natural Resources Conservation Service, and the Oregon Water Resources Department to ensure the US Drought Monitor drought depiction is as accurate as possible for Oregon. The US Drought Monitor is popular with local media, and sometimes gets conflated in state declarations. The synergy between the state and federal processes is crucial as sometimes cash and employee-strapped counties look to the federal product for guidance in making state declarations.

Research, Projects and Publications

OCS is helping to contribute to a state climate clearinghouse that is under the purview of its host institute, the Oregon Climate Change Research Institute. The state climate clearinghouse will have maps and graphs of Oregon climate meant to serve resource managers and decision makers.

Outreach and Education

Kathie and Phil gave a combined 35 talks in 2017, to various audiences, including state legislative committees and at the AGU annual meetings. The topics range from climate change impacts, research, drought, and general Oregon climate and weather.

Kathie and Phil usually give 1-2 media interviews per week, more in times of fire and drought.

Kathie has been an active member of AASC, participating on the value proposition committee, and calls about early career options.

Monitoring and Impact Assessment

OCS is working with an intern at the Oregon Water Resources Department to quantify state drought impacts in a systematic way.

PENNSYLVANIA STATE CLIMATE OFFICE

State Climatologist: Kyle Imhoff
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Twitter: @PAClimateOffice
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About the Pennsylvania State Climate Office

The Pennsylvania State Climate Office provides support and services to numerous users and clients across the state spanning numerous economic sectors such as agriculture, transportation, and energy. In 2017, the Pennsylvania State Climate Office continues to participate in the collaborative efforts of the National Mesonet Program. The CoCoRaHS network continues to expand across Pennsylvania under the auspices of the state climate office and with the name FROST. By the end of 2017, over 1000 volunteer observers comprise the network, with about 100 new observers joining in the annual year. Typically, about 150-200 faithfully report each day.

Communication Capabilities

Development of new products has mainly focused on grant-related items, such as those connected with a data inventory and display. Our web server has been secure since January 2013 after a serious breech into our database during the previous year and has been placed on a virtual machine for added reliability and support services. Along with grant-related decision-support tools and initiatives, a new electronic data request submission tool has been developed, and is now displayed on our office home page, to allow for tracking of request counts and for users to more easily request information. Last year, data requests were received at a rate of approximately 3-5 requests per week.

User Base Assessment: The number of visitors to the site/usage statistics have remained relatively constant this past year as compared to 2016. While some declines were seen in users and new users, there was an increase in page views and session duration. Some of the behavior in traffic and site view patterns are related to hazardous weather events, such as the spike in sessions displayed below due to the Northeast snowstorm in mid-January 2016. Over two-thirds of site visits originated in the state of Pennsylvania, followed distantly by New York and New Jersey. The chart in the Figures section shows the 2017 session counts and their respective statistics.

Information Services, Products and Tools

The Interactive Data Archive continues to provide data which include data queries for specific dates and strings of dates. An archive of high-impact weather events in the Mid-Atlantic region is near completion by some of our undergraduate students. In addition, provisional climate divisional data will continue to be updated to more closely reflect data available from NCEI. A monthly newsletter is sent out at the beginning of each month by the climate office that provides a summary of the month's weather in the state, a climate highlight that focuses on climate science and long-range forecast topics, and a 2-month forecast based on analog forecast techniques.

Information Technology Capabilities:

- About a dozen web data requests were logged each month (besides those by phone and the occasional US mail)
- Primary users are commercial, educational and government organizations
- The entire North American Regional Reanalysis data set (approximately 4.7 terabytes) is updated routinely so that the data have been completed through 12/31/17. This constitutes a 39-year data set. We have added select fields from the CFSv2 global analysis (1979-2017) (approximately 2.5 terabytes). Approximately a decade of RTMA data has been stored on our servers as well as the newly-developed URMA datasets for grant-related work.

Research, Projects and Publications

- A new study developed by NCEI to gauge use of resources began in late 2017. The Pennsylvania State Climate Office is participating in this study in collaboration with the AASC.
- SGT has collaborated with the climate office regarding the National Mesonet Program by contributing metadata from the COPAMS (DEP's air quality network) as well as sub-hourly data sets. In addition, new data streams have been established in collaboration with the Pennsylvania Turnpike Commission and the Allegheny County Health Department. These datasets are being sent to MADIS in real-time, as well.

- The Pennsylvania State Climate Office continues to contribute monthly state weather summaries, including its societal impacts, to the Northeast Regional Climate Center during all of 2017.
- A new statewide mesonet (Keystone Mesonet) is in planning stations with the assistance of the Pennsylvania Emergency Management Agency (PEMA). A user interface along with data access to state partners and stakeholders will be developed. Data will be provided from various existing weather networks across the state. Funding will likely be in place by the middle of 2018.

Outreach and Education

The Pennsylvania State Climate Office provides numerous talks to agricultural conferences and meetings during the year. In additions, training sessions for weather observational networks are provided upon request.

Discussions are underway to convene a "climate summit" for the state of Pennsylvania. This summit would be to engage stakeholders, government personnel, and interested parties across the state and to communicate the capabilities and products developed by the state climate office and its partners.

A climate studies course is taught each semester that allows undergraduate students to be exposed to the daily work of a state climate office. These students are able to assist with numerous research grants and data quality control of our datasets. Office staff also provide support for courses in agricultural science and weather forecasting.

Monitoring and Impact Assessment

Collaboration with experts at Kansas State University continues with the refinement of environmental data monitoring systems for a Wheat Scab project.

As discussed in the Research section, PEMA is working closely with the PA State Climate Office to develop a statewide mesonet. This network will not only provide real-time weather data access, but plans are in place to develop impacts-based decision support tools tailored to emergency management personnel across the state.

Figure

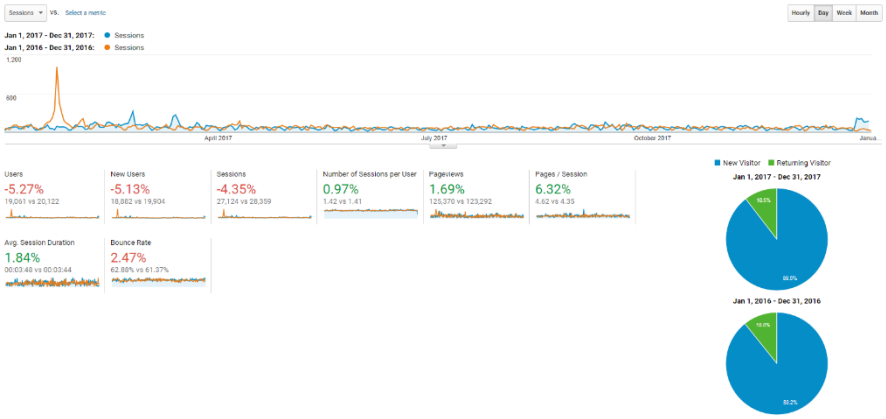

Figure 10: Image courtesy of Google Analytics

SOUTH CAROLINA STATE CLIMATOLOGY OFFICE

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About the South Carolina State Climatology Office

Created in 1986, the Office of State Climatology (SCO), as mandated by the South Carolina General Assembly (Section 49-25-10 et seq., Code of Laws of South Carolina, 1976), represents the State in all climate and meteorology matters. The SCO resides within the South Carolina Department of Natural Resources (SCDNR). The SCO serves as liaison between the National Weather Service and State agencies, such as the Governor's Office, SCDNR, SC Department of Public Safety, and the SC Emergency Management Division (SCEMD). The SCO assists other State and Federal agencies in data acquisition and interpretation before, during, and after periods of severe weather.

The SCO provides a unique service to the state by archiving and distributing climate and meteorological data, reports, and research that date back to the late 1800s. The SCO administers the *South Carolina Drought Response Act*, which requires the office to formulate, coordinate, and execute a comprehensive drought response program for the State of South Carolina.

Communication Capabilities

- The office expanded the SCO website (http://www.dnr.sc.gov/climate/sco). Products and links were updated as needed.
- The office expanded the email notification system focused on severe weather notification and tropical advisories. The notification list was merged with the GovDelivery subscriptions per requirement by SCDNR Media Outreach. This merging of subscription address lists resulted in an increase from 2,688 subscribers in 2016 to 9,172 in 2017.
- A new layout was designed for the Annual CoCoRaHS Newsletter issued in August of 2017. This re-designed newsletter utilized visuals, statistics, and infographics, further enhancing the readability of the information for the CoCoRaHS observers.

Information Services, Products, and Tools

- The SCO averaged 26 monthly phone and email requests for climate data.
- Staff assisted SCDNR Law Enforcement, SC Highway Patrol, and County Solicitor Offices with 15 watercraft, vehicle, and criminal investigations.
- Media inquiries averaged 5 per month.
- The office issued weekly and annual summaries of the State's weather and climate in the *South Carolina Weekly Weather and Climate Report* and the *South Carolina Year in Review*, both of which are available on the SCO website.
- The SCO provided 12 special weather event summaries to the Governor's Office, selected staff from Department of Agriculture, Department of Forestry, Department of Commerce, State Law Enforcement Division, SC Department of Natural Resources, city governments, selected television meteorologists, NOAA Regional Climate Centers, and all SC NWS forecast offices. Examples include the Upstate's heavy snow and cold of January 6 – 8, late season cold of March 15, the hard freeze of March 16 and the severe weather wind and hail event on March 21, April 3 and 5 tornadoes, and hail and flooding events and the heavy rains of April 22 – 24.
- The Drought Response Program requires regular correspondence with 48 Drought Response Committee Members, four major power companies, and over 500 water utilities. Correspondence during drought events includes drought projections, official declarations, and suggested response. During 2017, the SC Drought Response Committee was convened 4 times via teleconference.
- The office worked with hydroelectric dam operators and other resource agencies to enhance drought mitigation efforts as a part of the implementation of their Federal Energy Regulatory Commission's (FERC) hydro-power dam license. Staff served as a member on the Catawba-Wateree, Yadkin Pee Dee, and Keowee-Toxaway Drought Management Advisory Committees participating in conference calls as needed.

Research, Projects, and Publications

- The research project focused on analyzing 1901-2015 seasonal and annual temperature (maximum, minimum, mean) and precipitation trends for 75 stations throughout Georgia, South Carolina and North Carolina was completed. The statistical trends and GIS maps are posted online. http://dnr.sc.gov/climate/sco/Publications/2015TP_Trends/2015TP_main.php This is an on-going research project conducted every five years (1901-2005, 1901-1910, 1901-1915).
- The office is a cooperating institution in the Carolinas Integrated Sciences and Assessments (CISA) project focused on integrating climate science and water management in North and South Carolina.

- The office collaborated with SCDNR Freshwater Fisheries in temperature research regarding spawning practices within Lake Marion 1990 – present.
- Staff continually developed weekly Crop Moisture and Palmer Drought Severity Index maps.
- Staff continued work developing a comprehensive, user-friendly hurricane and tropical storm database of events affecting South Carolina throughout history.

Outreach and Education

- The SCO provided approximately 23 annual presentations to various governmental, private sector, and civic organizations. Staff were speakers* or participants at many state and national conferences and meetings such as the American Association of State Climatologists Annual Meeting *, Palmetto Sportsman Classic, State Hurricane Task Force/ NWS Coordination quarterly meetings*, monthly SCDNR Board Meetings*, SC Association of Environmental Professionals meeting, the American Meteorological Society conference, FEMA conference calls, and the Drought and Water Shortage Tabletop Exercise.
- Staff worked with Carolinas Integrated Sciences and Assessments (CISA) and the SC Water Resources Center to conduct three one-day educational workshops focused on the impacts of extremes on SC's built and natural environments. These workshops, titled the Climate Connections workshops, were held in Greenville in Dec. 2017, Columbia Feb. 2018, and Charleston in March of 2018. The workshops were attended by a total of 212 attendees.
- The Assistant State Climatologist serves as commissioned law enforcement officer to assist SCDNR during weather emergencies.
- The State Climatologist serves on the Carolinas Integrated Science and Assessment Steering Committee, the Coastal Climate Extension Specialist Advisory Committee, and the American Association of State Climatologist's Executive Committee. The State Climatologist is serving as President of the American Association of State Climatologists for the period July 2015 to June 2018.

Monitoring and Impact Assessment

- SCO recruited 70 new CoCoRaHS volunteers throughout the year.
- Retention rate analysis of CoCoRaHS observers from 2008 to 2017 determined 4% retention rate for 9 years, 45% retention rate for 1 year, and of the 1,520 observers who have joined since 2008 66% have made observations.
- Of the 480 active observers in 2017, 76 observers in SC have been with the program since 2008 (9 years). 211 observers in SC have been with the program since 2012 (5 years). SC averages around 320 daily observations,

showing about 67% daily participation from our active CoCoRaHS observers.

- Through a Harry Hampton grant the office distributed 34 complimentary rain gages to new CoCoRaHS observers.
- A document about the total solar eclipse in SC was published online. http://www.dnr.sc.gov/climate/sco/Publications/solareclipse2017.pdf. The document won the South Carolina State Library Notable Document Award. Annually the South Carolina State Depository System selects ten notable publications that were released in the past calendar year out of a pool of 2,500 publications.
- Staff were activated to the State Emergency Response Center in response to Hurricane Irma from 9/8 – 9/11 in support of State Emergency Response Team operations.
- Staff spent significant time consolidating Hurricane Matthew heavy rain, wind, flood reports, streamflow measurements and damage assessments from sources such as the National Weather Service, River Forecast Center, United States Geological Survey, Community Collaborative Rain, Hail, and Snow Network, and local weather observation networks. Staff teamed with MetStat, Inc. Arvarda, Colorado to develop total precipitation and return interval maps for the event. A presentation, two Open-file Reports, and an ArcGis Online Story Journal were developed.
- Interactive On-line Story Journal outlining Hurricane Matthew
    - http://dnr.sc.gov/matthew2016
- Two Open-File Reports were produced on Hurricane Matthew.
    - Chronological Description of the Event http://www.dnr.sc.gov/water/climate/sco/matthew/matthewChron.pdf
    - Hurricane Matthew Synoptic Review http://www.dnr.sc.gov/water/climate/sco/matthew/matthewSynoptic.pdf
- As a member of the State's Emergency Operations Team, SCO staff participated in quarterly hurricane task force meetings, SCEMD State Emergency Response Team hurricane functional exercise and training, SC State Emergency Response Team Hurricane Workshop at SCEMD, and National Weather Service's Hurricane Season Training Workshop. The office also briefed SC Department of Public Safety regarding Hurricane Irma Coordination, worked at the State Emergency Operations Center during Hurricane Irma in support of State Emergency Response Team operations, provided the 2017 Hurricane Season Forecast at the Governor's Hurricane Season Seminar Rehearsal and the Tabletop Seminar, briefed the State Hurricane Task Force at Santee on current and projected hurricane potential, and assisted in the completion of SCDOT's Tropical Storm Bonnie and Hurricane Matthew flooding summary.
- 5 exercise weather briefs were provided to SCDOT, SCDPS/HP, and SCEMD.

- Staff issued 7 advisories for Hurricane Irma, 4 advisories for Hurricane Jose, 4 advisories for Hurricane Maria, 11 strong thunderstorm/tornado advisories, 17 tropical advisories/updates, 4 winter weather advisories, and 6 pre-event Weather outlooks for SC Emergency Management Division/SC Department of Public Safety/SC Department of Transportation.
- During the late summer, significant time was spent planning for, preparing for, and conducting the 1st Annual Statewide Drought and Water Shortage Tabletop Exercise, which occurred on 9/27. The goal of the exercise was to enhance South Carolina's drought response and preparedness and the State's capacity to address a statewide water shortage.
- Customized forecasts were routinely issued to various SC organizations. Examples include a marine forecast outlook for opening and closing strategy for the shrimp trawl season, winter weather outlooks for SC Department of Public Safety and SCDOT, rain forecast updates to USC Special Events director supporting outdoor function, and a 2017 Hurricane Season forecast at the Governor's Hurricane Season Seminar Rehearsal and Tabletop Seminar.

OFFICE OF THE STATE CLIMATOLOGIST, TEXAS

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About the Texas State Climate Office

The Office of the State Climatologist (OSC) has been housed in the Department of Atmospheric Sciences at Texas A&M University since 1973. The current State Climatologist, John Nielsen-Gammon, was appointed by then-Governor George W. Bush in 2000. The mission of OSC is to help Texas and its residents make the best possible use of weather and climate information.

Communication Capabilities

The OSC maintains a web site (http://climatexas.tamu.edu), Facebook page (ClimaTexas), and Twitter (@climatexas). The website and social media pages were created to provide a wide-range of sources for information delivery.

The Facebook page was created in 2014 and now boasts 905 likes and 900 follow subscriptions. Of the 65 Facebook items posted during 2017, 11 were shared with more than 1000 users. The most popular item was viewed by nearly 22,000 users, with 74 likes, and 88 shares. On average, each Facebook post reached 500 users.

The Twitter page was created in September of 2016. Currently the page is following 58 users, mainly Texas National Weather Service offices and other meteorological and climate pages. Since 2016, the profile has grown from 30 to 180 followers at the end of 2017. The Office sent 25 tweets in 2017 with an average of 500 views per tweet. Tweets are most frequently shared by 4 users using retweets and favorited by

7. The most popular tweet saw engagement by 7000 users who shared it 18 times and favorited 80 times. Other OSC twitter engagement is through the sharing of posts made by National Oceanic and Atmospheric Administration entities and Texas A&M University stories relating to the State Climatologist or general Texas climate.

The http://climatexas.tamu.edu is now up and running as of the summer of 2017 and follows the same ADA rules and general format of other departments within the College of Geosciences at Texas A&M University. This upgraded website provides updates on the key aspects of climate that are pertinent to Texas citizens.

Information Services, Products and Tools

The OSC does not generate climate data of its own. Instead, it serves as a clearinghouse for connecting climate data needs with climate resources. During 2017, the OSC received and satisfied 23 data requests via email and 7 requests via telephone.

The OSC also generates and posts weekly drought monitoring information for Texas at http://climatexas.tamu.edu/drought/index.html. These products were generated to fill the spatial gap between climate division drought information and the need to identify the severity of drought on a sub-county scale. Through external funding, a national-scale version of this product is now hosted at North Carolina State University.

Since December 2008, with occasional assistance from SCEP funding from NOAA, the Office has produced a monthly climate impacts report that documents the print media coverage of weather and climate effects on the general public and is posted on both the OSC and AASC websites. Reports are gathered from newspapers and other sources throughout the state.

Research, Projects and Publications

An ongoing research project funded by the National Oceanic and Atmospheric Administration focuses on improvement of our high-resolution drought monitoring tool. The Texas A&M component of the research involves improvements in the accuracy of the input precipitation data to adjust for biases inherent in radar-based precipitation estimates and input to high-resolution land surface models for monitoring of soil moisture and other applications.

The Texas Water Development Board funded the OSC to lead a feasibility study for a statewide TexMesonet. The report, a collaboration among Texas A&M University, Texas AgriLife Extension, and the University of Texas at Austin, included a survey of statewide mesonets across the United States, many of which are operated by state climate offices. The final report was delivered in early 2018 and is available online at https://drive.google.com/open?id=13UDeJMJS81iffWmxz0iO1eLnwub1FH1q.

In late 2017, the State Climatologist secured RAPID funding from the National Science Foundation to compile rainfall measurements from official and unofficial networks and casual observers across Texas and produce comprehensive rainfall analyses. That project is ongoing.

Outreach, Education, and Coordination

In addition to the regular reports posted on the OSC web site, and responses to requests for climate data, the OSC conducts outreach through speaking engagements and press interviews.

During 2017, the State Climatologist made invited presentations to or for the following organizations: The National Hydrologic Warning Council, the Gulf Coast Power Association, the National Oceanic and Atmospheric Administration, the American Society of Civil Engineers, the Texas A&M Forest Service, the Environmental Protection Agency, the National Drought Mitigation Center, the Texas Bankers Association, Texas AgriLife Extension, and the City of Houston. Issues of frequent interest were climate change and impacts on extreme rainfall and flooding.

The State Climatologist fulfilled 94 interview requests and 24 information requests from members of the press in the United States, Canada, Norway, Germany, and Great Britain. He also contributed to multiple press releases and published a commentary on Fortune.com.

Monitoring and Impact Assessment

The State Climatologist is an appointed member of the Texas Drought Preparedness Council, a statewide interagency committee created by the Texas Legislature in 1998 to monitor drought conditions and coordinate drought mitigation activities.
The State Climatologist is also a member of the State Hazard Mitigation Team and contributed to the 2018 Texas State Hazard Mitigation Plan. Both committees are chaired by the Division of Emergency Management.

Beginning in 2012, the OSC has served as host and organizer for weekly Texas Drought Monitor Coordination Conference Calls. These calls, held every Tuesday morning at 10:40 AM CT, are attended by National Weather Service personnel, extension agents, agency representatives, and drought monitor authors. The State Climatologist prepares a draft of suggested changes to the Texas portion of the weekly US Drought Monitor, and those changes are then discussed and amended. A summary of changes is sent to the Drought Monitor author and a copy is posted on the OSC web site.

UTAH CLIMATE CENTER

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About the Utah Climate Center

The mission of the Utah Climate Center (UCC) is to facilitate access to climate data and information, and to use expertise in atmospheric science to interpret climate information in an accurate and innovative fashion for the public. The mission includes the design of new products to meet present and future needs of agriculture, natural resources, government, industry, tourism, and educational organizations in Utah and the intermountain region.

As the site develops, functionality will be expanded beyond products available in the past to include interpretative and visualization tools that will benefit both the specialist as well as a wider audience.

Communication Capabilities

Weather Station network (120 weather stations statewide) communicate / transmit data via cell phone network.

Information Services, Products, and Tools

1. Long-term means of April 1 snow water equivalent (SWE) observations projected onto the 4-km grid mesh

2. Winter Precipitation

3. Inversion Forecast

4. The Utah Climate Center's Snow Forecast for the state of Utah

5. The Utah Climate Center's First Fall Freeze Forecast for Cache Valley and surrounding areas

6. The Great Salt Lake Annual Level Prediction

Research, Projects, and Publications

- Sun, Y., S.-Y. Wang, R. Li, B. Buckley, R. Gillies, and K. Hansen, 2018: Feasibility of Predicting Vietnam's Autumn Rainfall Regime Based on Tree Ring Record and Decadal Variability. *Climate (Special issue on Decadal Variability and Predictability of Climate)*, DOI:10.3390/cli6020042.
- Wang, S.-Y., L. Zhao, J.-H. Yoon, P. Klotzbach, and R. R. Gillies, 2018: Attribution of climate effects on Hurricane Harvey's extreme rainfall in Texas. *Environmental Research Letters*, DOI:10.1088/1748-9326/aabb85.
- Wang, S.-Y., R. R. Gillies, O.-Y. Chung, and C. Shen, 2018: Cross-Basin Decadal Climate Regime connecting the Colorado River and the Great Salt Lake. *Journal of Hydrometeorology*, DOI:*10.1175/JHM-D-17-0081.1*.
- Li, R., S.-Y. Wang, R. R. Gillies, B. Buckley, J.-H. Yoon, and C. Cho, 2018: Regional trends in early-monsoon rainfall over Vietnam and CCSM4 attribution. *Climate Dynamics*, in press.
- Wang, S.-Y., J.-H. Yoon, E. Becker, and R. R. Gillies, 2017: California from drought to deluge. *Nature Climate Change*, 7, 465-468.
- Fosu, B. , S.-Y. Wang, S.-H. Wang, R. Gillies, and L. Zhao, 2017: Greenhouse Gases Stabilizing Winter Atmosphere in the Indo-Gangetic Plains May Increase Aerosol Loading. *Atmospheric Sciences Letters*, DOI: 10.1002/asl.739 (open access).

Outreach and Education

14 media stories were released on various news outlets. 17 outreach and education events occurred around Utah.

Monitoring and Impact Assessment

https://climate.usu.edu/mchd/index.php
https://climate.usu.edu/traps/

UNIVERSITY OF VIRGINIA CLIMATOLOGY OFFICE

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About the University of Virginia Climatology Office

The University of Virginia Climatology Office is a Research and Public Service Center in (and is a part of) the Department of Environmental Sciences. The AASC has designated it the state climate office for Virginia. The office is also an integral member of the Southeast Regional Climate Center and the director is on the center's Technical Advisory Committee.

The office provides information and conducts research on the atmospheric environment and the impacts of weather and climate on economic and ecologic systems to government, education, industry, the media and individuals. Its on-line, *Climate Advisories* feature climate research and/or educational material, and its web site offers an array of climatic information and guidance to a broad spectrum of climatic data users.

Communication Capabilities

The University of Virginia Climatology Office has digital phone, fax, email and videoconferencing capabilities with high-speed network service, along with ready access to the UVa's extensive network development, software and programming services. The office maintains a web site devoted to a variety of its educational, informational, data provision and outreach goals. The office has enhanced real-time lightning detection and storm development monitoring capabilities, through the Telvent System.

In coordination with the University of Virginia's Emergency Services office, this office is participating in the WeatherStem weather data system, and is involved in a program for assistance in emergency communications (primarily at the local level) through the use of Amateur Radio. The Director is also a recognized NOAA

Weather Spotter. These are all in addition to the office's usual role as a provider of weather information in emergency situations through regular communications channels.

Information Services, Products and Tools

The University of Virginia Climatology Office serves as the official repository and provider of climatic records within Virginia. It handles thousands of requests for information annually, and provides general guidance on climate issues of all spatial and temporal scales. Its web-based information services are accessed tens of thousands of times a year, with an estimated total download of information in the hundreds of thousands of pages. These inquiries come from individuals, industry, the media and dozens of governmental and educational entities, worldwide.

The office's monthly video production *Climate Advisory*, a brief discussion of relevant topics regarding the climate of Virginia, was televised statewide on Public Television, public access channels and agricultural information networks. This collection is made available through the YouTube website.

The office frequently provides interviews to print, radio, television and web-based media. This includes taped and live broadcasts and regular radio call-in shows. The University also makes additional informational webcasts, podcasts, and general news releases. In addition, the office has been involved in a number of legal cases, including the provision of direct expert witness testimony, some of which has led to precedent-setting decisions.

Research, Projects and Publications

The office was a long-term integral participant in the Shenair Institute Research Program, which focused on the Shenandoah Valley of Virginia. Under this program, the office was involved with air quality climatology, development of an asthma alert system and demographic relationships to respiratory health. After the formal conclusion of the contract period, the office has been involved in follow-up discussions, publications and impact planning based on this work. This work continues to provide a foundation for additional research and related publications.

Additional significant research efforts of the office include:

- Examination of the relationships between climatic regimes and exacerbation of respiratory distress in collaboration with researchers at the U.Va. Health Sciences Center.
- Investigation of relationships between large-scale atmospheric teleconnections and tropical cyclone impacts in the Mid-Atlantic region.
- Investigation into the objective definitions of seasons, secular changes in season onset, and the magnitude of seasonal transitions.
- Analyses of secular changes in objectively defined warm and cold season onset

and intensity.
- Drought and drought impact research and monitoring.
- Analyses, in conjunction with researchers in the UVa medical center regarding relationships between barometric pressure changes and the onset of cervical aneurysm dissections.

Papers (In Preparation) During 2017:

Stenger, P.J.. Macko, S.A., Epstein, H.M., and Shugart, H.H., : Secular variations in the onset of objectively defined seasons in the U.S., In Preparation.

Stenger, P.J.. Macko, S.A., Epstein, H.M., and Porter, J.H.,: Temporal trends in the average temperatures of objectively defined seasons in the U.S., In Preparation.

Outreach and Education

- Provides data and expertise to dozens of state, federal and local government entities, and educational institutions each year.
- The office distributes information via hundreds of contacts with the print, radio, on-line and television media.
- The office serves as a lead scientific contributor to the Virginia Governor's Drought Monitoring Task Force, with periodic conferences, drought reports, presentations, analyses, and decisions regarding drought declarations.
- A series of Video Climate Advisories regarding aspects of Virginia climate, produced for television and web-based distribution, including PBS and Farm Bureau networks are archived and available through the office website and YouTube.
- Over the years, the office has been increasing emphasis on its web site as a vehicle for making information available to potential users and serving as a first point of contact with the office. This has succeeded in reaching larger numbers of individuals and organizations in a more cost-effective fashion. The estimated amount of information accessed continues to increase substantially each year.
- Presentation of education and training lectures for the Virginia Master Naturalist Program at numerous locations around the state on an ongoing basis. This includes core instruction requirements for the program's many chapters.
- Informational presentations before local government and advisory groups regarding climate-related topics of community concern.
- Involvement with school (K-12) and community groups regarding climate science.
- Work with graduate students at the University of Virginia and other institutions on degree research and class-related projects.

- The office has been recognized by the National Weather Association as an approved institution for seal holders to receive recertification education and experience. As such, it provides this service to local media weather forecasters.
- Teaching of classes on weather related subjects as part of the University of Virginia Lifetime Learning Institute.

Monitoring and Impact Assessment

- Continuing work and publication regarding human health impacts in relation to changing weather conditions.
- Provision of data and impact assessment for and service as a member of the
- Virginia Drought Monitoring Task Force as lead climatologist.
- Participation as a member of the Virginia Hazard Mitigation Steering Committee, including development of climatic hazards analyses. The Virginia Hazard Mitigation Plan is accepted by FEMA, and now provides the guidelines for planning across the state. Assessment work continues for ongoing plan review and update.
- Investigation of secular variations in characteristics and time of onset for the seasons across the US.

OFFICE OF THE WASHINGTON STATE CLIMATOLOGIST

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About the Office of the Washington State Climatologist

This report summarizes the Office of the Washington State Climatologist (OWSC) activities during the 2017 calendar year. The objectives of OWSC continue to be as follows: (1) to provide Washington climate data to users ranging from the public to state agencies to other scientists, (2) to be a resource in the analysis and interpretation of the past, present, and future climate of the state, and (3) to conduct outreach and educational activities on behalf of the residents of Washington State. The office is affiliated with the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) of the University of Washington and receives the majority of its financial support from the State of Washington. It seeks additional support from federal, state, and local agencies to conduct research on issues related to regional climate.

Communication Capabilities

OWSC maintains a website (www.climate.washington.edu) with links to climate and weather information from reputable sources and OWSC-developed tools for the interpretation of climate data. OWSC has continued to maintain an active social media presence on Facebook and Twitter (@WAstateclimate). Currently, the OWSC has 305 “likes” on Facebook and 589 followers on Twitter. Our Twitter presence has grown over the last year, while our Facebook followers have remained steady.

Information Services, Products and Tools

OWSC has continued to serve as a reputable source for climate data requests for the general public, media, and state agencies. Last year, our office answered over 90 of these data requests, which varied greatly in topic from inquiries about specific weather events (e.g., summer dry spell, winter cold snap) to requests for ENSO and seasonal forecasts. One of OWSC's most popular products - a monthly newsletter that provides an overview of the previous month's weather events and puts them into a climatic context – amassed 555 subscribers, about 20 of which were new subscribers in the last year.

Research, Projects and Publications

As previously reported, OWSC began participating on the WA State Department of Ecology's Drought Contingency Task Force to update the state's drought plan in 2016. OWSC's work on the project, which primarily involved identifying appropriate drought monitoring indicators, assessing the state of knowledge on seasonal climate forecasting, and a literature review on the impacts of climate change on future WA drought, was completed in 2017. Revisions on the plan are still ongoing, but OWSC's work has been completed.

As previously reported, OWSC has been involved in the Pacific Northwest Drought Early Warning System by NOAA's National Integrated Drought Information System (NIDIS). OWSC is a member of the PNW DEWS steering committee and has continued to provide feedback on the NIDIS strategic plan for the region over the last year.

OWSC began redesigning and updating our most popular web-based tool, the PNW Temperature, Precipitation, and Snow Water Equivalent Trend Analysis Tool, in late 2017. The project is ongoing, but in addition to updating the base data, an entirely new interface is being built using Tableau software. The design is intended to be much more user-friendly with more options available to the user. In addition, the tool will include the option to test the statistical significance of the trend, which is a new capability.

Publications:

Washington State Department of Ecology (WA ECY) 2018. Washington State Drought Contingency Plan. [in revision]

Outreach and Education

OWSC has continued their outreach and education activities over the 2017 calendar year, including presentations in conferences, talks to the general public, and outreach activities. Some examples include:

- "Climate Science on Tap" (climate change and fish)
- Western WA & Western OR Fall Forecast meeting (climate recap)

    - Seattle Youth CAN event (career in science talk)
    - AMS WeatherFest (hands on climate activities)
    - Keynote speaker for WA State Attorneys (water in the west)
- Served on science panel for the Puget Sound Partnership (a WA state agency leading protection and restoration efforts)

Media requests are also a part of the office's regular involvement with the public. Over the course of past year, OWSC has been interviewed approximately 50 times by radio, TV, and print journalists. Some examples include:

- Washington Ag Network (seasonal climate outlook)
- KING5 News (ENSO and winter weather)
- Capitol Press (summer water supply)
- Seattle Times (summer smoke & recent climate variations related to salmon)

Monitoring and Impact Assessment

As mentioned in previous reports, OWSC has been a participating member of the Water Supply Availability Committee (WSAC) for the past 5 winters as an additional support for the state agencies in monitoring drought. OWSC has continued to provide monitoring and forecast information to the WSAC.

Drought conditions were not present for a majority of the year, so input to the US Drought Monitor was not a priority for OWSC. However, OWSC did lead discussions with partners to provide recommendations for the US Drought Monitor map in late summer/fall 2017 when there was some concern about conditions.

WEST VIRGINIA STATE CLIMATE OFFICE

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About the West Virginia State Climate Office

The mission of the West Virginia State Climate Office (WVSCO) is to deliver weather and climate information to the public and to provide professional consultation where expertise is essential. Various stakeholders, such as engineers, researchers, government agencies and law firms have contacted the office.

The WVSCO was invited to Ohio University in Athens, OH to give a colloquium presentation. The title of the presentation was "*What is a State Climatologist? Taking a Look Inside the Role and Responsibilities of a State Climatologist*". The presentation went through a brief history of the office and gave examples of weather and climate information the office provided to the public. Historic weather events were also presented as well as recent research.

The office has also been cooperating with the Marshall University Center for Environmental, Geotechnical, and Applied Sciences in their grant to help install weather stations in portions of the state that are poorly represented. The goal of the project is to install a mesonet to supplement existing weather networks.

The WVSCO remains active with the CoCoRaHS network and participated in new recruiting activities and career day programs by visiting local schools around the state to help increase the visibility of the program.

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About the Wyoming State Climate Office

The Wyoming State Climate Office (SCO) is a part of the Wyoming Water Resources Data System (WRDS). Together these entities are the single largest providers of water- and climate-related data in the state. WRDS was established in 1967 as part of Water Planning efforts enacted by the Wyoming Legislature. More than 50 years later, one of our primary functions continues to be the support of the State Water Planning Program. The WRDS/SCO is within the Department of Civil and Architectural Engineering at the University of Wyoming and is funded primarily through contracts with the Wyoming Water Development Commission.

The WRDS/SCO staff provides a variety of services, ranging from the development of enhanced drought-monitoring products to the online dissemination of water and climate data. WRDS and the SCO also support a wide range of groups by assisting in the development of the State Water Plan and helping to coordinate climate- and hydrologic-monitoring efforts throughout Wyoming.

In 2018, as a result of budget cuts, we began to transition our Water Library to online only access and are in the process of converting much of our physical holdings to a digital format.

Communication Capabilities

The WRDS/SCO is housed on the University of Wyoming campus and, as such, makes full use of the infrastructure present in the form of high-speed data lines through which we serve our various products online. A number of servers support the operations and house the various websites and database used by the office. The office has made use of various social media platforms as another means of reaching a wider range of audience.

As the office of the State Coordinator for CoCoRaHS (the Community, Collaborative, Rain, Hail, & Snow Network), Facebook and Twitter channels have been created for this effort with 245 and 80 followers respectively. The WRDS/SCO itself has over 1100 followers on its Facebook page and almost 50 on its Twitter feed. The number of followers is holding about the same with new followers offsetting those who "unfollow."

Use of these platforms has had mixed results and the impact of a particular overture is highly dependent on time of day, day of week, time of year, and whatever other events are going on. All of these conditions affect the audience response.

The WRDS/SCO has had an online presence since the early 1990s (first using Gopher and later the World Wide Web) and log nearly 150,000 user-sessions and 400,000 page views in a year. Use of the sites are very seasonal with some of our most busy times being the spring as interest in snowpack climbs.

The WRDS/SCO is in the process of updating websites to a more mobile-friendly presentation. Currently all pages are available to mobile devices but they are simply shown as smaller representations of a desktop-style page. While this serves to provide access, it is not the friendliest way for viewing on smaller screen sizes. As one-third of our users are now accessing our sites using mobile devices (e.g. phones and tablets), this transition to having a more dynamic layout has becoming more of a priority.

Information Services, Products and Tools

The WRDS/SCO actively handles a few hundred data requests per year. These are the traditional type of request made by people calling, emailing, or even stopping in and can range from giving a person one single number to answer a question all the way to providing a write-up complete with repackaged data. WRDS/SCO tries to anticipate as many of these requests as possible and has been, over the years, making these products available online where they fulfill passive or unattended requests. Active requests peaked at exactly 700 a year in 1997 and have been on a downward trend since. The number of online accesses, however, continues to go up and we anticipate that this will continue as long as we are posting new data and products, as well as the promotion of such.

Digitization of Water Development Reports continues as new projects are finished. About 20 WWDC projects per year are placed online and linked to our Water and Climate Atlas map server.

We are continuing work with the Wyoming State Engineer's Office (WSEO) by digitizing historical diversion record. These data are often consumed by State Water Plan studies for determining water availability in a given River Basin or watershed.

Our office is now performing the QA/QC for and is disseminating the data from the Water and Climate Network (WACNet) stations in Wyoming, a small mesonet funded by the WSEO. These data are currently available in csv format from static maps and lists, and the locations of the stations have been fed into the Water and Climate map server.

In the past year we've increased the number of stations in WACNet by entering into partnerships with researchers on campus and at the USDA Agricultural Research Station. The network now consists of three groups totaling 25 stations.

The range of stakeholders served by the WRDS/SCO is quite broad and includes government entities at all levels (Federal, State, and Local), private consultants, utilities, news media, and the public. We are always finding new applications for the data we provide and it is truly a "if you provide it, they will consume it" dissemination model.

Research, Projects, and Publications

Work continues on making data available via the WRDS/SCO website. Oftentimes we notice a pattern in the types of data requested and, if we can, will give priority to making those datasets available online.

In the last year we have expanded our Temperature Extremes projects by generating charts showing record and normal maximum and minimum temperatures for each day of the year. Originally, these data were only available for one stations per county but in the last year this has expanded to include all COOP stations with a significant period of record.
http://www.wrds.uwyo.edu/temperature/extremes/extremes.html

Another product recently released is a set of graphs showing the dates and probabilities of various temperature thresholds for purposes of showing frost potential through the year.
http://www.wrds.uwyo.edu/temperature/frost/froststations.html

A Snowpack Meltout storymap has been made available online. It allows users to view stations ranked by their historical time of meltout date. A chart showing the history of meltout dates is included for each station for the period 1997-2017. The Storymap may be found here.
http://www.wrds.uwyo.edu/snow/meltoutdates/meltout.html

Outreach and Education

WRDS/SCO took part in several conferences over the past year in which we display various posters detailing who we are, what we do, and available data products for different stakeholder groups. The office also gave talks and media interviews which further served to "spread the word" about the office and various topics.

Outreach and education also takes place in the form of social media engagement and mailing lists. These allow us to let people know of new products or upcoming meetings that might be of interest to various stakeholders.

The WRDS/SCO is part of the ongoing collaborative effort between its funding agency, the Wyoming Water Development Office, and the State Engineer's Office to provide support for River Basin Planning in the state. This includes webhosting, data dissemination, materials review, and presentations at various meetings.

> Nicholson, C. 2017. Laramie's Past, Present, and Future Climate: A Careful Look into the Modeled Crystal Ball. Presented at the Laramie Local Food Group Summer Symposium. Laramie, WY.
>
> Hatch, R., and C. Nicholson, 2017. Give Us Metadata or Give Us Death! Streamlining data collection and distribution of Wyoming's geospatial water data. Presented at the 2017 GIS in the Rockies Conference, Denver, CO.
>
> Gill, P., J. Pring and C. Nicholson, 2017. Streamlining the Development of a Statewide Water GIS: Methods & Tools. Presented at the 2017 GIS in the Rockies Conference, Denver, CO.

Monitoring and Impact Assessment

The WRDS/SCO, continues to maintain local climate and hydrological stations for early-warning of potential flash flooding. We also are continuing our partnerships with State and University entities who have deployed their own agriculture and climate networks. The WRDS/SCO serves as the central data dissemination point for the output from these stations and provides the data in various formats.

The office is also actively involved in the Drought Monitor and working with local entities to compile conditions around the state to form Wyoming's input to the Monitor.

CoCoRaHS continues to be an important part of office operations. Recruiting of new volunteers takes place any time personnel are out where there are groups of people interested in water and climate. CoCoRaHS also gives us more "eyes on the ground" and a network we

can call upon if we need information from a particular area, such as for drought monitoring. Most of these volunteers will go out of there way for you if they feel that they can help.

While WRDS/SCO does not issue any warnings or forecasts, itself, it does relay those issued by the National Weather Service offices covering Wyoming via social media, which gives those products and even larger distribution.

AASC Current State Climatologists/ Office Directors:

State	State Climatologist/ Office Director	ARSCO Designation?
Alabama	Dr. John Christy	Yes
Alaska	Dr. Peter Olsson	Yes
Arizona	Dr. Nancy Selover	Yes
Arkansas	VACANT	No
California	Dr. Michael Anderson	Yes
Colorado	Russ S. Schumacher	Yes
Connecticut	Dr. Xiusheng (Harrison) Yang	Yes
Delaware	Dr. Daniel J. Leathers	Yes
Florida	David Zierden	Yes
Georgia	Bill Murphey	Yes
Hawaii	Dr. Pao-Shin Chu	Yes
Idaho	Dr. Russell Qualls	Yes
Illinois	Dr. Jim Angel	Yes
Indiana	Dr. Dev Niyogi	Yes
Iowa	Justin Glisan	Yes
Kansas	Dr. Xiaomao Lin	Yes
Kentucky	Dr. Stuart Foster	Yes
Louisiana	Dr. Barry Keim	Yes
Maine	Dr. Sean D. Birkel	No
Maryland	Dr. Konstantin Vinnikov	No
Massachusetts	VACANT	No
Michigan	Dr. Jeff Andresen	Yes
Minnesota	Dr. Luigi Romolo	Yes
Mississippi	Dr. Mike Brown	Yes
Missouri	Dr. Patrick Guinan	Yes
Montana	Dr. Kelsey Jencso	No
Nebraska	Dr. Martha Shulski	Yes
Nevada	Dr. Douglas Boyle	Yes
New Hampshire	Dr. Mary D. Stampone	Yes
New Jersey	Dr. David A. Robinson	Yes
New Mexico	Dr. David Dubois	Yes

New York	Mark Wysocki	No
North Carolina	Aaron Sims	Yes
North Dakota	Dr. Adnan Akyüz	Yes
Ohio	Dr. Bryan Mark	Yes
Oklahoma	Gary McManus	Yes
Oregon	Dr. Phillip Mote	Yes
Pennsylvania	Dr. Kyle Imhoff	Yes
Puerto Rico	Luis Bejarano	Yes
Rhode Island	Lenny Giuliano	No
South Carolina	Dr. Hope Mizzell	Yes
South Dakota	Laura Edwards	Yes
Tennessee	VACANT	No
Texas	Dr. John Nielsen-Gammon	Yes
Utah	Dr. Robert Gillies	Yes
Vermont	Dr. Lesley-Ann Dupigny Giroux	Yes
Virginia	Jerry Stenger	Yes
Washington	Dr. Nicholas Bond	Yes
West Virginia	Dr. Kevin Law	No
Wisconsin	Dr. John Young	No
Wyoming	Christopher Nicholson	Yes