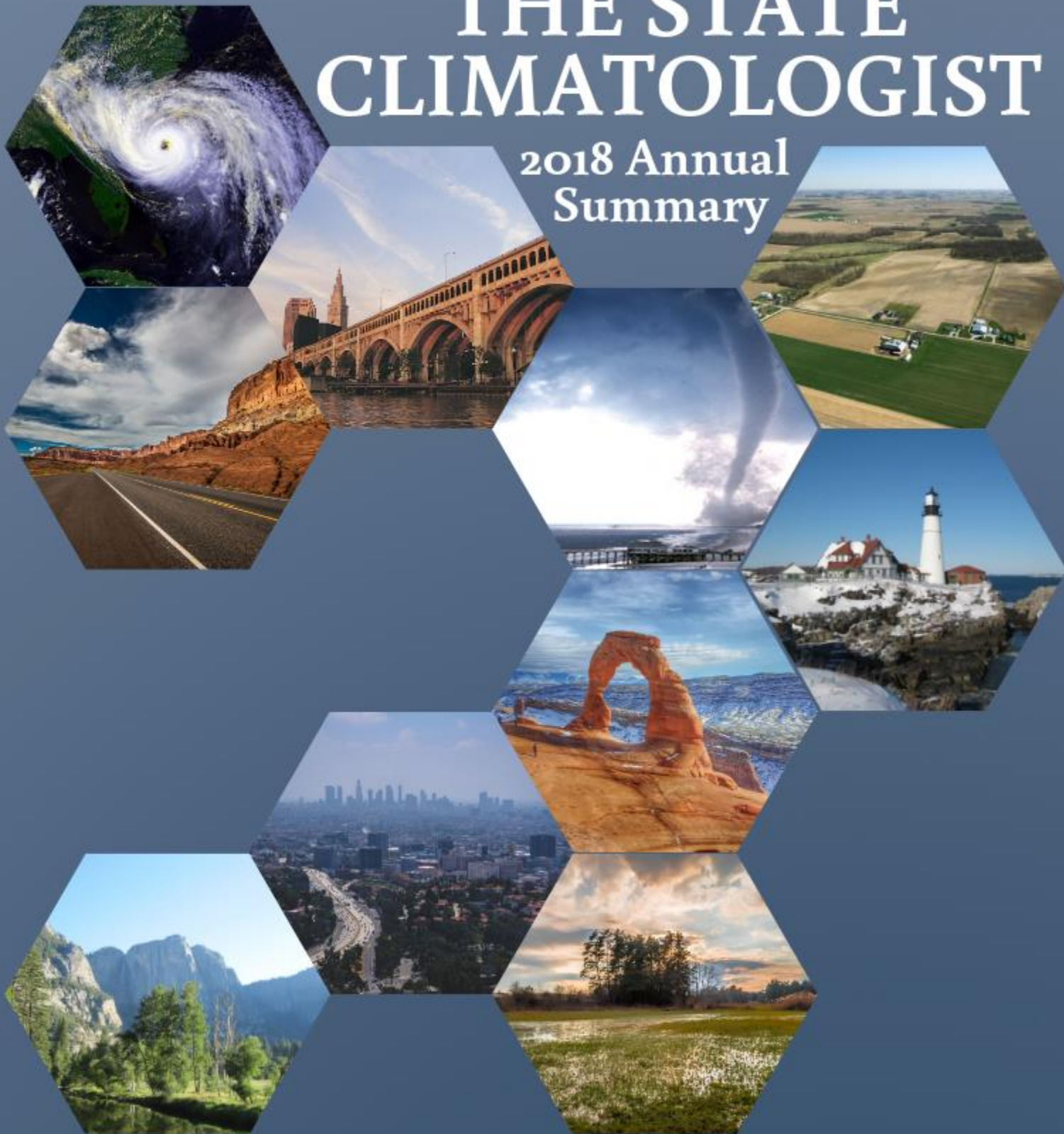


THE STATE CLIMATOLOGIST

2018 Annual
Summary



Compiled By the SC State Climate Office
Volume 37, Issue 1

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



May 6, 2019

My fellow climatologists, partners, and friends of the American Association of State Climatologists (AASC):

Thank you for your interest in and support of the AASC. As you'll see in this 2018 edition of *The State Climatologist*, we have a strong and diverse group of state climate offices who, along with our partners at the six Regional Climate Centers, the National Centers for Environmental Information (NCEI), and the National Weather Service, are committed to advancing the development and delivery of science-based climate services at all scales.

We had quite an exciting 2018 and appreciate your being a part of it. Here are just a few highlights:

- Addition of Associate Member-at-Large position to the Executive Committee to represent interests of our Associate Members
- Addition of Student and Corporate Membership classes and induction of our first Student Members
- AASC Meetup and exhibit at the AMS Annual Meeting in Austin, Texas
- Applied Climate Information System (ACIS) Workshop, in cooperation with the NRCC, offered along with the 2018 AASC Annual Meeting
- 2018 AASC Annual Meeting, hosted by the Nebraska State Climate Office at the Lied Lodge in Nebraska City
- State Climate Office User Engagement Study in cooperation with NCEI with 14 SCOs
- Fall webinar on use of NCEI's EV-2 system to access historical climate data

We continue the momentum in 2019 and look forward to supporting our members and building capacity in state climate office programs well into the future.

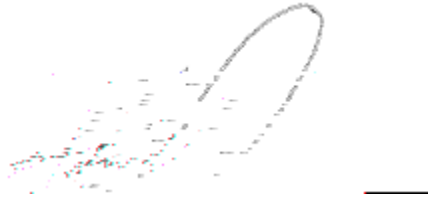
During the past year, we have seen quite a few changes in our state climate offices:

- Whitney Montague became the new Arkansas State Climatologist. She assumed the responsibility from the late Michael Borengasser, Arkansas's first State Climatologist, who passed away January of 2018, after serving more than 30 years as a hydrologist for the Arkansas Natural Resources Commission.
- Justin Glisan, a graduate of the atmospheric science department at the University of Missouri, became the new Iowa State Climatologist. He follows Harry Hillaker, who retired after 31 years of distinguished service.
- Jim Angel retired after 22 years as the Illinois State Climatologist. However, he had served his state as a primary source of science-based weather and climate information for 34 years with the Illinois State Water Survey. The new Illinois State Climatologist has not yet been selected.
- Beth Hall, former director of the High Plains Regional Climate Center, was named as the State Climatologist for Indiana. She replaced Dev Niyogi, who left the position after 14 years of service.
- Martin Stuefer became the new State Climatologist for Alaska. He assumed the position from Peter Olsson, who retired in 2018 after serving for 15 years.

- Walter Robinson was named acting State Climatologist for North Carolina. He replaced Aaron Sims, who transitioned to a private sector position after serving as the acting North Carolina State Climatologist for three years.

Through the years, as I have served within the AASC and my community, I have gained a great deal of wisdom from others who have left an enduring legacy. I am fortunate to be able to say I was there when Ken Crawford, Kelly Redmond, and Arnold Court were leading and creating that legacy. Now, I am honored to be serving the AASC as your president. I thank you for giving me a chance to earn your trust.

Adnan Akyüz

A handwritten signature in black ink, appearing to read 'Adnan Akyüz', with a horizontal line underneath it.

President, American Association of State Climatologists
State Climatologist for North Dakota

ABOUT THE AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS	7
ALABAMA OFFICE OF THE STATE CLIMATOLOGIST	8
ALASKA CLIMATE RESEARCH CENTER (ACRC)	11
ARIZONA STATE CLIMATE OFFICE	14
CALIFORNIA STATE CLIMATE OFFICE.....	17
COLORADO CLIMATE CENTER	21
OFFICE OF THE DELAWARE STATE CLIMATOLOGIST	25
GEORGIA CLIMATE OFFICE	28
HAWAII STATE CLIMATE OFFICE	30
IDAHO STATE CLIMATE SERVICES	32
ILLINOIS STATE CLIMATE OFFICE	35
STATE CLIMATOLOGIST OFFICE OF IOWA.....	37
STATE CLIMATE OFFICE OF KANSAS.....	40
KENTUCKY CLIMATE CENTER.....	43
LOUISIANA OFFICE OF THE STATE CLIMATOLOGY.....	45
MAINE CLIMATE OFFICE.....	49
MICHIGAN STATE CLIMATOLOGICAL RESOURCES PROGRAM.....	51
MINNESOTA STATE CLIMATOLOGY OFFICE.....	53
MISSISSIPPI STATE CLIMATE OFFICE.....	56
MISSOURI CLIMATE CENTER.....	59
NEBRASKA STATE CLIMATE OFFICE	63
NEVADA STATE CLIMATE OFFICE	66
NEW HAMPSHIRE STATE CLIMATE OFFICE	70
OFFICE OF THE NEW JERSEY STATE CLIMATOLOGIST.....	73
NEW MEXICO STATE CLIMATE OFFICE.....	75
NORTH DAKOTA STATE CLIMATE OFFICE	77
STATE CLIMATE OFFICE OF OHIO	84
OKLAHOMA CLIMATOLOGICAL SURVEY	87
OREGON CLIMATE SERVICE	90
PENNSYLVANIA STATE CLIMATE OFFICE.....	92
SOUTH CAROLINA STATE CLIMATOLOGY OFFICE	95
SOUTH DAKOTA STATE CLIMATE OFFICE.....	99
OFFICE OF THE STATE CLIMATOLOGIST, TEXAS	102
UTAH CLIMATE CENTER	105

VERMONT STATE CLIMATE OFFICE	108
VIRGINIA CLIMATOLOGY OFFICE.....	110
OFFICE OF THE WASHINGTON STATE CLIMATOLOGIST	113
WEST VIRGINIA STATE CLIMATE OFFICE.....	116
WYOMING STATE CLIMATE OFFICE	118
NOAA 2018 United States Climate Summary	122
2018 Regional Center Summaries	125
2018 Current AASC State Climatologists/ Directors.....	147

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 Climatic Data Center 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 Climatic Data Center shall be issued. Currently, 38 states have received ARSCO status.

ALABAMA OFFICE OF THE STATE CLIMATOLOGIST

State Climatologist: John R. Christy
Assistant State Climatologist: Lawrence Carey
Staff/Service Climatologists: Jennifer Geary, Whitney Guerin



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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, Projects 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 six 2018 papers address several critical aspects of the global climate, including climate sensitivity.

- Maycock, A.C., W.J. Randall, A.K. Steiner, A.Y. Karpechko, J.R. Christy, R. Saunders, D.W.J. Thompson, C-Z Zou, A. Chrysanthou, N.L. Abraham, et al., **2018**, Revisiting the mystery of recent stratospheric temperature trends. *Geophys. Res. Lett.* DOI:10.1029/2018GL078935.
- Christy, J.R., S. Po-Chedley and C. Mears: **2018**, Lower tropospheric temperature [Global climate; Temperature; Lower Tropospheric Temperature [in "State of the Climate in 2017"], *Bull. Amer. Meteor. Soc.* 99, (8), S16-S17. DOI:1-.1175/2018BAMSSStateoftheClimate.I.
- Christy, J.R. and C. Covey: **2018**, Lower stratospheric temperature [Global climate; Temperature; Lower Stratospheric Temperature [in "State of the Climate in 2017"], *Bull. Amer. Meteor. Soc.* 99, (8), S17-S19. DOI:1-.1175/2018BAMSSStateoftheClimate.I.
- McKittrick, R. and J.R. Christy, **2018**: A test of the tropical 200-300 hPa warming rate in climate models. *Earth and Space Science*, American Geophysical Union. DOI:10.1029/2018EA000401.
- Christy, J.R., R.W. Spencer, W.D. Braswell and R. Junod, **2018**: Examination of space-based bulk atmospheric temperatures for climate research. *Int. J. Remote Sens.*, 39:11, 3580-3607, DOI:10.1080/01431161.2018.1444293
- Chylek, P., P. Tans, J. Christy, and M. Doybey, **2018**: Two El Nino Types: An Observational Study. *Env. Res. Lett.*, DOI/10.1088/1748-9326/aa9c5b

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 State Climatologist was appointed to the Science Advisory Board of the Baron's Critical Weather Institute. BCWI will establish a large room with several weather displays at the U.S. Space and Rocket Center, visited by 700,000 people each year, that will include information on a new state-wide, real-time (10-second data) weather system based on stations developed by the State Climatologist. Included in the display will be a 3-D printed replica of the state's record hailstone.



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. We are also working with BCWI to establish hundreds of in-house designed and built, low-cost stations across the state for very-high-resolution (spatial and temporal) sampling of the weather and climate. 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 (ACRC)

State Climatologist:

Martin Stuefer, Director ACRC, Research Associate Professor

Staff/Service Climatologists:

Lea Hartl, Post-Doctoral Researcher, ACRC

Jason Grimes, Research Technician, ACRC

Gerd Wendler, previous Director, ACRC, Professor Emeritus

Blake Moore, Programmer, ACRC

Telayna Gordon, Research Technician

Chris Waigl, Post-Doctoral Researcher, ACRC



Affiliation/sponsor: Geophysical Institute, University of Alaska

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About the Alaska State Climate Office

The Alaska Climate Research Center (ACRC) is part of the Geophysical Institute, University of Alaska Fairbanks. Historically, the ACRC has shared tasks with the Alaska State Climate Center, and we are excited to report that both centers are in the process to merge. The main tasks and objectives of the Alaska State Climate Center have been renewed within the 2018 Alaska State Statutes 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 externally funded research projects.

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 air pollution potential locally due to strong surface inversions.

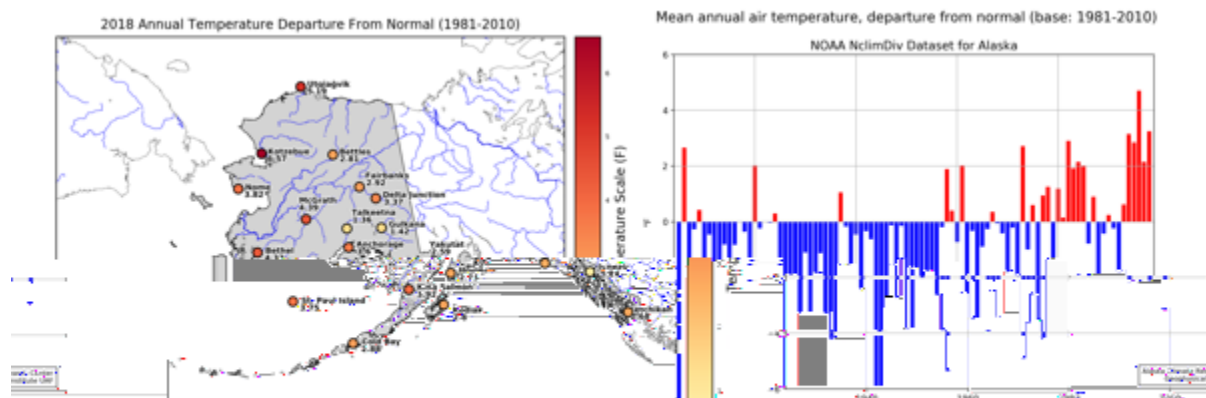
The ACRC website contains many summaries, products, meteorological and climatological information. Furthermore, from our home page, users can select a number of links: Alaska weather and climate, our popular webcam and on-campus weather station, climatological data, up-to-date summaries, information for tourists, seasonal and other weather and climate links, and a 'spotlight on climate' section giving a list of the latest features posted.

Information Services, Products and Tools

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 (Utqiagvik, Fairbanks, Anchorage, Nome, King Salmon, Juneau, Ketchikan, Bethel, Bettles, Delta Junction, Cold Bay, Gulkana, Homer, Kodiak, Kotzebue, McGrath, St. Paul Island, Talkeetna, Yakutat) as well as for Alaska as the State.



for 2018 normal Figure: Left- Mean annual air temperature deviations ($^{\circ}\text{F}$) from the normal (1981-2010); for the selected stations. Right- Mean annual air temperature deviations ($^{\circ}\text{F}$) from the normal (1981-2010).

Research, Projects and Publications

The Alaska state climatologist maintains a program of externally funded projects. Projects include operational support of the Alaska sites of the DOE Atmospheric Radiation Measurement (ARM) program (<https://www.arm.gov/>). ARM sites have been established at Oliktok and Utqiagvik along the Arctic coast of Alaska; Stuefer manages the ARM North Slope of Alaska 'Rapid Response'. ARM project involvement includes mentoring instruments such as a 'Multi-Angle Snowflake Camera' (MASC) or balloon borne Cryospheric Frostpoint Hygrometers (CFH) for reference measurements of humidity within the upper troposphere and lower stratosphere. Other projects involve detection of wildfires and prediction of extreme aerosol in connection with wildfire events or volcanic eruptions (NOAA GOES-R).

A substantial number of journal publications and reports 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 on topics related to the science of Alaska wildfires and volcanic emissions. Alaska has the highest density of active volcanoes worldwide. We have published work on precipitation changes across Alaska, or for example on the climate change of Sitka (the old capital of Alaska under Russia, for which station the records go back to 1827).

C. F. Waigl, A. Prakash, M. Stuefer, D. Verbyla, P. Dennison: Fire detection and temperature retrieval using EO-1 Hyperion data over selected Alaskan boreal forest fires. International Journal of Applied Earth Observations and Geoinformation, March 2019.

M. Hirtl, M. Stuefer, D. Arnold, C. Maurer, S. Natali, G. Grell, P. Webley, B. Scherlin-Pirscher: The effects of simulating volcanic aerosol radiative feedbacks with WRF-Chem during the Eyjafjallajokull eruption, April and May 2010. Accepted for publication in Elsevier Journal of Atmospheric Environment, October 2018.

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 data, slides and figures for use in educating their classes and communities; we have received and responded to a variety of queries from the community regarding issues such as for example Alaska's warming climate, and abnormal weather events in Alaska.

Monitoring and Impact Assessment

We started activities to further enhance and coordinate the CoCoRaHS Network in Alaska. CoCoRaHS support was limited during the last years, and we try to raise funding, find regional coordinators, and advertise the network. Local weather and radiation stations are maintained by the ACRC locally in Fairbanks. The ACRC also maintains a 30-m meteorological tower with instrument booms at 3 height levels. The tower supports measurements of the extreme shallow inversions occurring in Fairbanks repeatedly during the winter months. The inversions trap pollutants; Fairbanks has been rated by the EPA as a serious nonattainment area for PM_{2.5}. The ACRC boundary layer monitoring supports efforts to assess and predict air quality and ice fog within the Borough.

ARIZONA STATE CLIMATE OFFICE

State Climatologist: Nancy J. Selover, Ph.D.
Assistant State Climatologist: None
Staff/Service Climatologists: None



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Fax number: 480-965-1473

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Social media: Twitter: @AzstateClimate

Email address (individual and/or organizational): selover@asu.edu

About the Arizona State Climate Office

The Arizona State Climate Office (ASCO) is part 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

Maintain a 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, monthly Arizona Climate Summary, daily rainfall and evaporation for the Phoenix area, daily North American Monsoon updates (summer), and links to climate education and safety information and other climate data resources.

- Maintain voicemail and e-mail to take data and information requests when the office is not physically staffed. Most 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. The major consumers are law enforcement, researchers, state agencies, and the legal community.

Information Services, Products and Tools

Peak requests are 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 72 media interviews on topics including heat inside cars, (16), drought (15), climate change (9), heat waves (7), urban heat island (7), monsoon (5), wildfire (4), dust storms (3), ENSO (2), Climate Service (2), Arizona Climate (1), and air quality (1). This year we generated monthly summary products for temperature and precipitation records. 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 & weather data for the local Water/Power Utility Salt River Project.

Research, Projects and Publications

- 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
- National Park Service – Monitoring Microclimates in Petrified Forest National Park. \$20,000.
- National Park Service-- Monitoring Microclimates in Joshua Tree National Park. \$20,000.
- Vanos, J. K., Middel, A., Poletti, M. N., Selover, N. J. 2018. Evaluating the impact of solar radiation on pediatric heat balance within enclosed, hot vehicles. **Temperature**. DOI:10.1080/23328940.2018.1468205
- Reviewed two articles for the on-line CLEAN (Climate Literacy and Energy Awareness Network) publication; titled “Solar Energy and Surface Temperature”, and “Carbon Sequestration in Campus Trees”.
- Reviewed a Dissertation Fellowship Application for the Babbitt Center for Land and Water policy.

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 a 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 – advising DM authors on Arizona drought conditions.
- 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 AMS
- Participate in 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

- Twenty Presentations to Community (7), Education (7), Professionals (4), State Agencies (2), on topics including Arizona climate & extreme weather, precipitation & water resources, floods, drought, solar radiation & energy, climate & health, climate change and resilience, monsoon, UHI, heat waves, CoCoRaHS, and Hazard Mitigation Planning.

Monitoring and Impact Assessment

- Monitoring temperature & precipitation in Petrified Forest National Park to inform park archaeologist as to weathering conditions for vegetation & cultural assets. Currently have 4 years of data from 12 stations around the park and in 2018 added a real-time station that will be available on MesoWest.
- Monitoring temperature & precipitation in Joshua Tree National Park to provide climate data for research on changes in the vegetation communities across the park. Currently have 18 months of data from 8 stations in the park and in 2018 added a real-time station that will be available on MesoWest.
- 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 (1498 observers).
- Assist with maintenance of the former USRCRN climate stations in central and northern Arizona with the National Park Service Inventory & Monitoring Group, and Arizona State University Climate Office. Data are ingested by the Western Region Climate Center and pushed out to MADIS.
- Translating and disseminating climate variability and urban heat island research for policymakers in the cities and tribes in the Phoenix metropolitan area.
- Monitoring effects of urban forestry on the urban heat island at four 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/Collaborators:

John Andrew – Executive for Climate Change Programs

Elissa Lynn – Climate Change Program Manager

Peter Coombe – Northern Region Climate Specialist

Julia Ekstrom – North Central 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 Retired Annuitant



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<https://www.water.ca.gov/Programs/All-Programs/Climate-Change-Program>

<http://cdec.water.ca.gov/>

<http://ferix.water.ca.gov/webapp/climate.jsp>

<http://www.cimis.water.ca.gov>

<http://calclim.dri.edu>

<http://www.wrcc.dri.edu/monitor/cal-mon/>

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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. In addition, the State Climatologist collaborates with programs including the California Cooperative Snow Surveys, California Nevada River Forecast Center of the National Weather Service, and the National Weather Service Weather Forecast Offices Serving California. Collaborations with local water agencies across California are also undertaken.

The State Climatologist coordinates with the National Interagency Drought Information System Program, the United States Drought Monitor, 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. This past year has also seen collaborations with the Public Health Working Group.

The State Climatologist also provides numerous media interviews, public presentations, and briefings as requested. In 2018, a new Department of Water Resources policy directs all interview requests through the Public Affairs Office for tracking and coordination.

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 publications and 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, 2016 and 2017. Water year 2018 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. Additional work with the ASO effort is being undertaken by the United States Department of Agriculture Agricultural Research Service Northwest Watershed Research Center. Efforts are underway to develop a MOU for collaboration.

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 2018 work includes the Atmospheric Rivers Research Program which supports advanced observations, modeling, forecasting, and material for decision support developed by CW3E at UC San Diego Scripps Institution of Oceanography. Additional funds to manage research observing efforts including the Tioga Transect through Yosemite National Park are also funded under this contract. 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. In a new collaborative venture, the OSC is working with the Climate Prediction Center and ESRL on projects to advance sub-seasonal to seasonal forecasting. Related collaborative efforts are also underway with NASA's Jet Propulsion Laboratory, and researchers within the University of California. 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.

The Climate Change team provides two climate literacy classes per year for DWR staff and conducts external classes as resources allow. 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 recently completed 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 hosted 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. At the State level, the State Climatologist worked with the Research Working Group of the Climate Action Team on the State's 4th Climate Assessment which was released in 2018. In the area of Sea Level Rise, the State Climatologist has agreed to sit on the Steering Committee of the Bay Area Coastal Hazards Adaptation Resiliency (CHARG) Work Group. This group seeks to coordinate sea-level-rise and storm surge adaptation across the multitude of local, state, and federal jurisdictions that control the shoreline of the San Francisco Bay and Estuary. The State Climatologist and members of the climate change group within the Department of Water Resources are working to develop an Adaptation Strategy for the Department of Water Resources based on results of their recently completed Vulnerability Study. In the area of monitoring, the State Climatologist is participating in a number of activities to rehabilitate and improve California's observation capabilities. In 2018, the climate change team pulled together a work group to evaluate surface in-situ monitoring efforts by the various Department programs and develop a value argument for a budget augmentation request. The work group will continue to meet in 2019. A pilot project to develop a post-fire monitoring capacity was also started in 2018 with six temporary weather stations deployed into post-fire environments.

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:
Peter Goble, climatologist/drought specialist
Noah Newman, CoCoRaHS education coordinator
Henry Reges, CoCoRaHS national coordinator
Zach Schwalbe, CoAgMET manager
Dani Talmadge, CoCoRaHS data quality coordinator
Julian Turner, CoCoRaHS web services



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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.) and also by monitoring networks deployed by the Center.

Communication Capabilities

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

- Website Services
 - <https://climate.colostate.edu> - the CCC's main website provides info to general Colorado climate information and our office.
 - <https://cocorahs.org> - CoCoRaHS, an international volunteer precipitation monitoring network, is managed through the Colorado Climate Center.
 - <https://coagmet.colostate.edu> - Colorado's state mesonet website.
- Social Media
 - CCC on Facebook: 1,151 followers (increase of 289 since last report)
 - CCC on Twitter: 1,567 followers (increase of 311 since last report)
- Presentations
 - We typically accept an average of one speaking invitation per week, giving us considerable visibility across the state.

- Our 37 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. It's estimated that we respond to around 10-20 data and information requests every month.

Information Services, Products, and Tools

- Weekly and Monthly Reports
 - Weekly NIDIS summaries reach about 500 emails.
 - Monthly NIDIS webinars with a typical attendance of 20-50 people.
 - Fort Collins Campus Weather Station – a monthly report of climate conditions at the climate center maintained campus weather station.
- Water Year Report – developed to highlight Colorado-specific events and extremes in Water Year 2018.
- Latest tools and products developed and added to our websites in 2018 include:
 - Interactive SPI map – https://climate.colostate.edu/spi_map.html
 - Precipitation Contribution maps (**Figure 2**) – https://climate.colostate.edu/precip_prop.html
 - Water Year Precipitation tool – https://climate.colostate.edu/wy_data.html
 - CoAgMET drought monitoring – <https://climate.colostate.edu/~drought/et.php>
 - Intermountain West 7-day Quantitative Precipitation Forecast – <https://climate.colostate.edu/~drought/outlook.php>
 -

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.
- In 2018, Peter completed an analysis on the high number of 90°F days experienced across the state (**Figure 3**).
- Peter also continues work on a wine grapes project in western Colorado.
- Publications
 - Schumacher, R. and Coauthors, 2018: [CoAgMET, "Colorado's Mesonet" to Analyze Our State's Weather and Climate](#). Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 35, 5 (Sept/Oct), pp. 38-40.
 - Goble, P., 2018: [Exploring Wind Patterns Over Colorado Agricultural Lands](#). Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 35, 4 (Jul/Aug), pp. 26-29.
 - Schumacher, R., 2018: [High-Impact Rainfall and Floods in Colorado](#). Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 35, 2 (Mar/Apr), pp. 2-6.
 - Bolinger, B., 2018: [The Significance of Snowpack in Defining Drought in Colorado](#). Colorado Water, Newsletter of the Water Center of Colorado State University, vol. 35, 2 (Mar/Apr), pp. 18-21.

Outreach and Education

- Speaking Engagements
 - APEC Climate Symposium – Papua New Guinea – Becky
 - State of the River meetings and water forums - Russ, Becky, Peter, and Zach
 - Colorado Water Congress and Governor’s Forum – Russ and Zach
 - Colorado Farm Show – Russ, Becky, Peter, and Zach
 - Russ’s many speaking engagements included the Western CO Horticultural Society conference, Ditch and Reservoir Company Alliance conference, Independent Bankers of CO Ag conference, Water Education CO Recovery to Resilience Flood Tour, CO Seed Growers Association annual meeting, and the American Public Works Association Western Snow and Ice Conference.
- Henry continues to travel around the country and internationally to promote CoCoRaHS, including a WMO meeting in Geneva, Switzerland and the Commission for Environmental Cooperation Committee Meeting in Quebec, Canada. In 2018, he visited 24 National Weather Service Forecast Offices and 8 State Climate Offices.
- Outreach
 - Noah did a total of 23 presentations in 2018, reaching approximately 1,600 people, including teachers, students, and the general public.
 - Noah and Russ interacted with an audience of over 12,000 people at Coors Field in Denver for Weather and Science Day.
 - Noah continues to provide tours of the historic Campus Weather Station to students and teachers.
 - Becky wrote an article, [How Far Away Was That Lightning?](#), for The Conversation in June. The article has logged a reach of over 100,000 readers.
- Media Inquiries – Russ, Becky, and Peter are regularly interviewed by media outlets to provide information on climate, snow, and drought conditions across the state.

Monitoring and Impact Assessment

The CCC operates and maintains several different weather observing systems:

- Provide comprehensive climate monitoring for the Fort Collins campus weather station. <http://climate.colostate.edu/~autowx/>. 2018 was the 130th year of data.
- The Colorado Agricultural Meteorological nETwork, CoAgMET, is a mesonet of 85 stations. There are now 63 stations with 5-minute reporting. Zach continues to coordinate with the National Mesonet.
- We currently own and maintain 17 previous National Weather Service RCRN stations.
- We continue to host, store, and quality control CoCoRaHS data records. Julian manages the website. In 2018, 4,417 observers signed up, and 2,708 of those submitted at least one daily precipitation report. The following obs were reported in 2018:
 - 4,287,687 daily precipitation and 85,131 multi-day precipitation reports
 - 5,383 significant weather and 2,006 hail reports
 - 14,120 condition monitoring reports
- 2018 Four Corners Drought Monitoring and Impacts
 - Due to severe drought over most of our state in 2018, our response to and monitoring of drought significantly increased for the year.
 - Increased response to media requests.
 - Increased invitations for travel and presentations related to the drought.
 - Contributed to the NIDIS Southwest Drought Webinar series.
 - Attended a drought tour in southwest CO to assess impacts.

- Participated in the CSU Extension Drought Task Force, and the State of Colorado's Drought Impact Task Force and Ag Impact Task Force.
- Provided guidance on which counties in the state should be included in drought activation by the governor according to the state's Drought Response Plan.

Figures

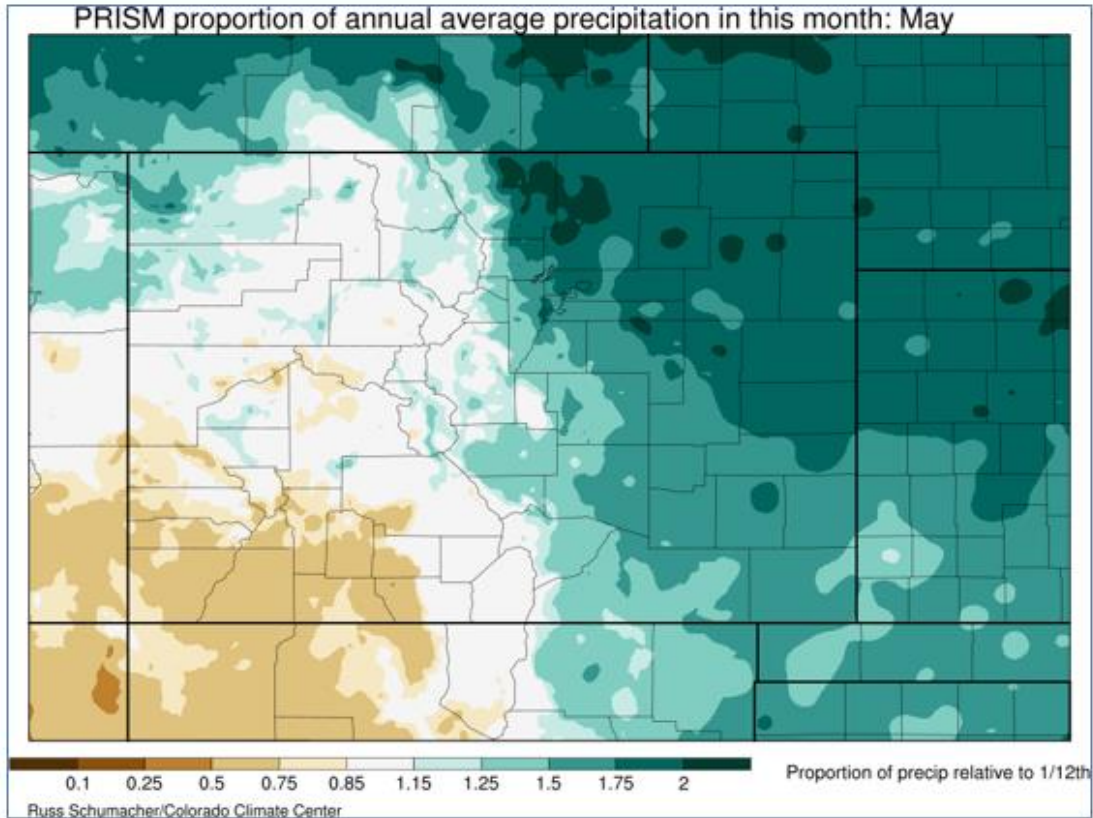


Figure 1: relative contribution of May precipitation to total annual precip for CO. Areas in green show where May precipitation is very important to the total annual average.

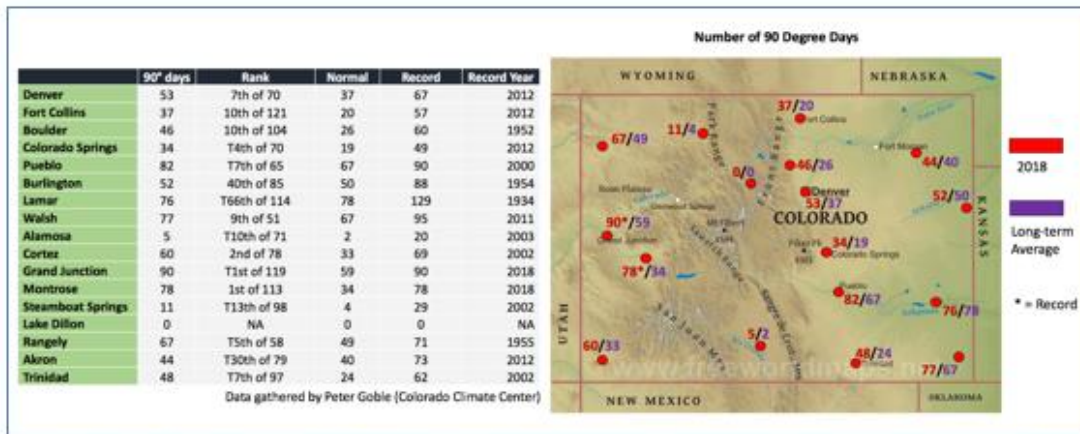


Figure 2: analysis of the number of 90 degree days in 2018 shows that all locations such many more than average, with 2 stations reporting a record number.

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), 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 (www.climate.udel.edu; www.cema.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

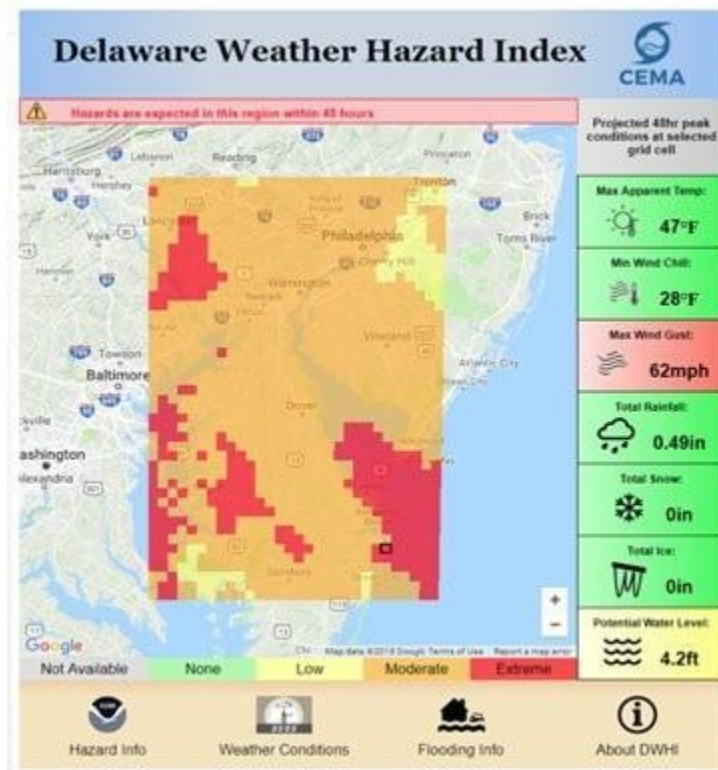
The DEOS Snow Monitoring Network

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, 36 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 DeIDOT 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 DeIDOT to deploy snowplows and other snow removal equipment within each maintenance area during an event.

The Delaware Weather Hazards Index (DWHI)

The Delaware Weather Hazard Index incorporates data from the National Digital Forecast Database (NDFD) and the Delaware Bay Operational Forecast System (DBOFS) to visually represent the severity of meteorological hazards across Delaware and regions nearby. The system allows the user to view a map of the region to gain an idea of the severity of any weather threat for their particular location during the next 48-hours. The user is then able to click on their area of interest, and the system will display the nature of the hazard and all relevant meteorological extremes for the next two days. Water level data is included along select areas near the coastline of Delaware alerting residents to coastal flooding as a weather hazard and pointing them to the CEMA Coastal Flood Monitoring System described above.



Research, Projects and Publications

The ODSC is currently involved in State funded research projects to:

- Update and expand a mid-Atlantic coastal storm climatology that includes data for all coastal storms from 1945 through March 2019.

- Develop for the State of Delaware a “Coastal Dashboard” to integrate real-time, historical, and forecast weather and ocean data concerning coastal storms and coastal flooding (ongoing project).
- A downy mildew risk tool for lima beans in Delaware has been developed and is in use.
- Several additional pond water-level monitoring sites will be installed in the next year. This will bring the total number of pond monitoring sites to over 20 statewide. Data from these sites are used to reduce the risk of dam breaches and failures across the State.

Outreach and Education

Outreach

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 61 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.

Education

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. CEMA/ODSC fund at least two graduate students each year, and generally have 2-4 undergraduate students working with the ODSC on Delaware specific research projects.

Monitoring and Impact Assessment

The Delaware Environmental Observing System (DEOS)

The ODSC and DEOS continue to work together to develop real-time weather, climate and environmental data systems to meet the needs of a growing constituency. For over 15 years, DEOS 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.

GEORGIA CLIMATE OFFICE

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Social media: www.facebook.com/georgiacclimate/
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. The office 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 several 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.

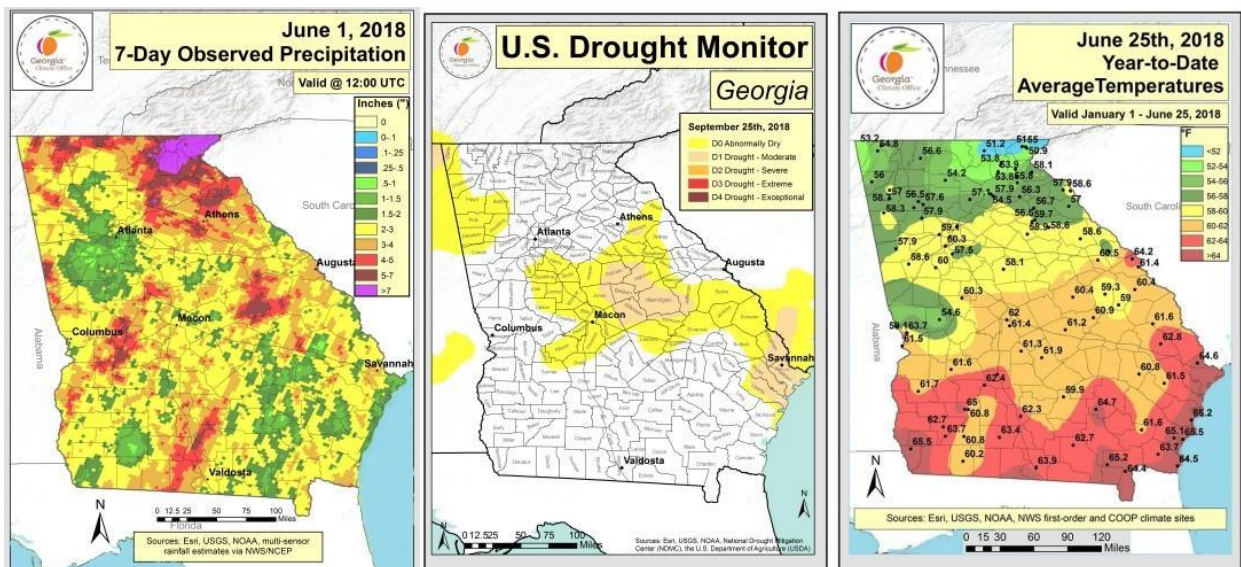


Figure 1 - Examples of 2018 GIS climate data plots generated within the State Climate Office

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. The State Climate 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 also 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, primary, and secondary school presentations, children 4-H programs, guest lectures at various Georgia universities and education centers, 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 by 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 daily 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. Criteria pollutant information is used to calculate the Air Quality Index (AQI) and update the information every hour in order to protect public health for the citizens of Georgia. A future goal of the office is to enhance automated archived and real-time data on our website and eventually utilize a portable monitoring network to assist in case study analysis and monitoring climate conditions within the state.

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 is 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, such as precipitation and temperature, in a timely manner.

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 dramatic disaster in Hawaii was the very heavy rainfall and flooding on the northern coast of the Island of Kauai on 14-15 April. The 24-hr total from this event was 49.69" observed at Waipa Garden, which exceeded the previous 24-hr records of 43" at Alvin, Texas. Because of the potential new U.S. records, a National Climate Extremes Committee (NCEC) was subsequently formed, consisting of Deke Arndt (NCEI), Jim Zdrojewski (NWS Climate Services Branch) and Pao-Shin Chu (Hawaii State Climatologist). Kevin Kodama (NWS Forecast Office in Honolulu) performed a site survey. After considering the observation and various other factors, the NCEC determined that the Waipa Garden record was valid and it set a new 24-hr precipitation record for the United States. Please see the attachment. As in the past, we handled data requests for precipitation, wind and temperature from a wide range of fields, including government agencies, researchers and students, and private citizens. We also helped the NWS to observe daily rainfall data. We again assisted the State Department of Business, Economic Development and Tourism (DBEDT) to update their annual Data Book as we have for the past 13 consecutively years.

Research, Projects and Publications

This year, we conducted a research project on the application of Bayesian model averaging (BMA) to improve the CPC's seasonal forecasts of ENSO. The BMA method was developed for multi-model ensemble forecasts of SST in Niño 3.4 region. The BMA weights were derived directly from the predictive performance of the combined models. The BMA method can be used to assess the performance of the individual models and assign greater weights to better performing models. The paper is in press in *Climate Dynamics*. Another paper, which is also in press in *Meteorological Applications*, focuses on the changing climate of the US affiliated Pacific Islands using observations and CMIP-5 model outputs.

The Climate Office continues our dynamical downscaling project on Oahu to reduce the uncertainty of future projected rainfall simulation. This year, we are also doing 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 his former student, Hanpei Zhang and Drs. Hui-Ling Chang and Adele Chen of the Central Weather Bureau in Taiwan, published a paper on estimating trends in return levels of precipitation extremes in the *International Journal of Climatology*, 2018, 38, 5107-5124. Dr. Chu also published another paper with the goal of improving typhoon intensity forecasts with Drs. Kim and Moon of Jeju National University in South Korea.

Outreach and Education

In 2018, Dr. Chu was 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. The team meets regularly to discuss various kinds of natural hazards in Hawaii (e.g., volcanic eruptions, flooding, hurricane) and its vulnerability assessment. Dr. Chu assisted the Hazard Mitigation team to update their comprehensive 2018 Plan.

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 for planning and every day work, the Idaho State Climate Services strives to acquire, archive, process and disseminate 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 Idaho 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 established 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.
- Fulfill 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.

2018 Publications and Presentations:

Crago, R.D., and R. J. Qualls, Evaluation of the generalized and rescaled complementary relationships, *Water Resources Research*, 54(10):8086-8102, <https://doi.org/10.1029/2018WR023401>, 2018.

Qualls, R.J. (Invited) Alleviating Poverty through Water, WSU Engineers Without Borders, 3/5/2018.

Qualls, R.J., (Invited) Remote Sensing of the Recurrent Annual Melt Pattern of Mountain Snowpack, UI Water Resources Seminar, 11/13/2018.

Qualls, R.J. and C.D. Woodruff, Spatial patterns of snowmelt, NW Climate Change Conference, Boise, Idaho, 9-11, October, 2018.

Outreach and Education

- 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, and community groups
- 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/>)

Acknowledgements

Research at ISCS is supported in part by NIFA grant IDA01584

ILLINOIS STATE CLIMATE OFFICE

State Climatologist: James Angel, PhD
(retired end of 2018)

Assistant State Climatologist: None

Staff/Service Climatologists: None

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I ILLINOIS

Illinois State Water Survey

PRAIRIE RESEARCH INSTITUTE

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 and has retired from the position at the end of 2018. The contact information above can be used for the Illinois State Climatologist Office.

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 2018, the blog had dozens of posts and more than 70k views. The Twitter account had approximately 1000 followers with about 1 to 5 tweets per week.

Information Services, Products and Tools

The SC Office is actively engaged in providing information services within Illinois. In 2018, the media contacted the office over 100 times. Each month the SC Office 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. In addition, the SC gave many talks throughout the state to specific constituent groups. Social media has been increasingly used to provide climate information.

The SC Office writes regular contributions to the monthly ISWS Water and Climate Summary. The SC Office provides both data and information for various agencies in Illinois, such as the Water Supply Task Force, the Drought Response Task Force, Department of Natural Resources, the Department of Transportation, the Attorney General's office, and the Illinois Emergency Management Agency.

Research, Projects and Publications

In 2018, the SC was involved in several projects including a US Army Corps of Engineers project to incorporate 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; and a State of Illinois project to updated the rainfall frequency atlas (Bulletin 70).

Publications:

Al-Basha, Sam, Jim Angel, et al. 2018: 2018 Illinois Natural Hazard Mitigation Plan Update. Bruce Rauner, Governor. 752 pp.

https://www2.illinois.gov/iema/Mitigation/documents/Plan_IllMitigationPlan.pdf

Angel, J., C. Swanston, B.M. Boustead, K.C. Conlon, K.R. Hall, J.L. Jorns, K.E. Kunkel, M.C. Lemos, B. Lofgren, T.A. Ontl, J. Posey, K. Stone, G. Takle, and D. Todey, 2018: Midwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 872–940. doi: 10.7930/NCA4.2018.CH21

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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IOWA DEPARTMENT OF
**AGRICULTURE &
LAND STEWARDSHIP**

About the State Climatologist Office of Iowa

The State Climatologist Office (SCO) is a bureau of the Iowa Dept. of Agriculture and Land Stewardship with duties specified in State Code 159.5.4 and 159.5.5. The Iowa Secretary of Agriculture, who is an elected official, appoints the State Climatologist of Iowa. The 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 and Crop Service. Finally, the SCO was made a bureau of the newly created Iowa Department of Agriculture in 1923. The SCO was co-located with the National Weather Service (NWS) from 1890 until 2003 and has worked very closely with that agency since its inception.

Information Services, Products and Tools

The State Climatologist maintains archives of NWS coop and first order station data back to the beginning of records. This includes the regular National Center for Environmental Information (NCEI) reports such as *Storm Data*, *Iowa Climatological Data* and *Local Climatological Data*, as well as the original observations. Access to federal and state weather and climate data archives are also maintained. With 144 years of continuous operation the Climatology Bureau 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 SCO is the documentation of Iowa's historical climate-monitoring networks, such as station locations, instrumentation and observation procedures.

Research, Projects and Publications

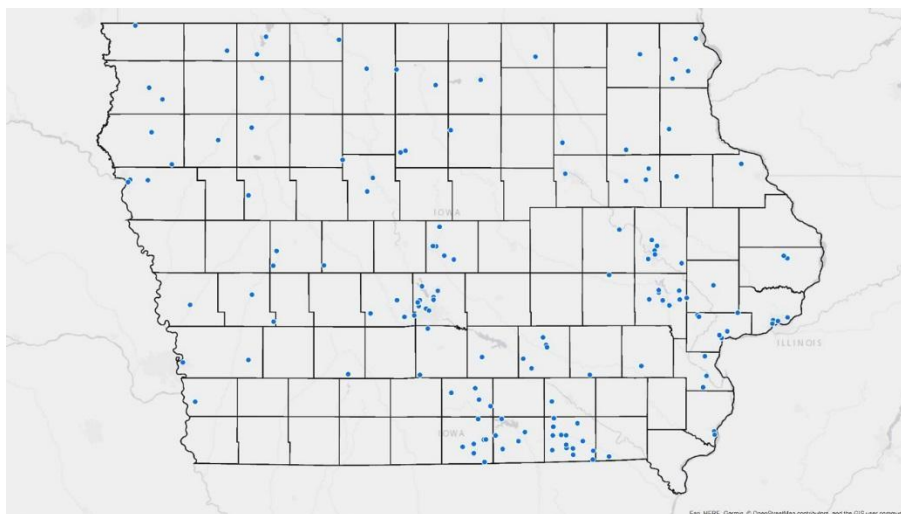
One of the main responsibilities of the State Climatologist is the acquisition, processing, dissemination and archiving of weather and climate data. However, research activities have been undertaken as funding permits and have been conducted in cooperation with various state and federal agencies including NCEI (NWS coop 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 Department of Natural Resources (development of more timely temperature data resources).

An ongoing project of the office is the detailed quality control of daily and monthly NWS automated and coop data for locations within Iowa. These data are updated monthly and, in cooperation with the Department of Agronomy at Iowa State University, made available online at: <http://mesonet.agron.iastate.edu/request/coop/fe.phtml>. The data have also been published in a summarized document known as the *Iowa Climate Review*. The quality control of this data routinely identifies equipment and/or reporting issues that allow for more timely NWS maintenance and thus minimize the duration of periods of poor data quality.

Outreach and Education

The Climatology Bureau maintains very open communication with the news media; the State Climatologist receives hundreds of media inquiries annually. This, combined with preparation of Public Information Statements issued in cooperation with the NWS, and weekly and monthly crop-weather summaries prepared for the USDA provides very wide dissemination of climate products and information. Over 1400 specific climate data information inquiries are answered in a typical year. Most inquiries are received from government agencies, news media, attorneys and insurance, in that order. Virtually every branch of State government utilizes Climatology Bureau data on a regular basis. For example the Iowa Utilities Board utilizes heating degree day data as part of its rate-setting policies for energy companies across 18 regions in the state. Data from the Climatology Bureau was also used in dozens of investigations of the Iowa Department of Inspections and Appeals during 2018 and in 125 cases of potential misapplication of pesticides investigated by the Iowa Department of Agriculture and Land Stewardship Pesticide Bureau.

The office also prepares regular monthly climate reports, the *Preliminary Iowa Monthly Weather Summary*. The Preliminary Monthly Weather Summary is issued within the first few business days of the month and provides a brief summary of Iowa's weather conditions for the previous month. A final version of the report is issued later in the month after quality control of the observations have been completed. This report is available online: <https://iowaagriculture.gov/climatology-bureau/monthly-weather-report>. The State Climatologist works closely with the NWS in monitoring the coop and ASOS data networks so as to improve the quantity, quality and timeliness of Iowa weather and climate observations. In the past, the State Climatologist has served on several NWS regional and national committees involved with climate and data issues. The State Climatologist is 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; 148 new observers were registered in 2018 (Figure 1). The State Climatologist typically gives multiple topical climate presentations per month to various agricultural groups, community service organizations and government agency meetings. In the event of anomalous weather behavior or historical events, the State Climatologist will perform higher frequency outreach to the media and public groups.



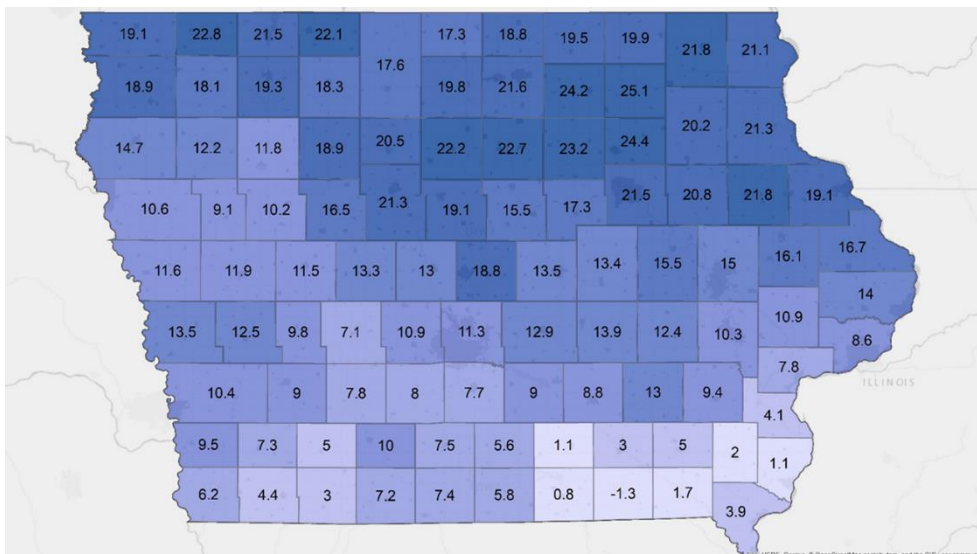
Monitoring and Impact Assessment

The State Climatologist of Iowa is a member of the Governor’s Drought Task Force and Flood Task Force and the State of Iowa Hydrology Working Group. The Climatology Bureau 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 Climatology Bureau provided weather summaries for ten issues of the Iowa DNR’s Water Summary Update in 2018.

Extreme dryness and wetness were the largest weather/climate impact in Iowa during 2018. Extreme (D3) Drought covered portions of six counties in south central and southeast Iowa counties in the U.S. Drought Monitor from late summer into early fall. At peak of drought in 2018 (August 21st), abnormal dryness and drought conditions covered 30.52% of Iowa, generally the southern third of the state.

Annual precipitation totals varied from a record 67.42 inches at New Hampton, 22.52 inches above normal to 27.60 inches at Spencer, 1.91 inches less than normal. Above normal annual precipitation totals were reported across a majority of the state, especially the northern third of Iowa; northeast Iowa averaged 18.61 inches above normal. All but one county in Iowa reported below average precipitations (Figure 2). Preliminary estimates have 27 northern counties breaking their annual precipitation records. In 2018, Iowa temperatures averaged 47.5 degrees or 0.7 degrees below normal while precipitation totaled 45.08 inches or 9.81 inches more than normal. This ranks as the 51st coolest and 2nd wettest year on record. A colder year was last recorded in 2014 while a wetter (and wettest on record) occurred during the Great Flood year of 1993. 2018 was the 26th snowiest calendar year among 131 years of records, tying with 1905 at 38.0 inches, 5.8 inches above average.

2018 county precipitation departures (inches) from the 1981 – 2010 historical average.



STATE CLIMATE OFFICE OF KANSAS

State Climatologist: Dr. Xiaomao Lin

Assistant State Climatologist: Mary Knapp

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About the State Climate Office of Kansas

The Kansas Office of the State Climatologist, continues in its 43rd 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.

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 technician. The Kansas Climate Office has maintained strong relationships with the seven National Weather Service Offices that serve Kansas including: 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, education seminars/training, 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 60 automated environmental monitoring stations. The network began in the 1980s with 13 stations which now consists of a 30-year observation record. Outside these stations, the network has continued to grow, collaborating with countless agencies and cooperators both within and outside of Kansas.

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. In 2018, there were over 350 requests for information received by written and verbal communication. In addition, staff in our office participated in over 60 outreach events reaching at least 4,500 people without considering media or online interactions. Our main website (<http://mesonet.k-state.edu>) continues to provide real-time environmental data, as well as historical

summaries, and various products for end users. In 2018, the Mesonet website had reached up to 325k views by over 30k individuals. The climate website (<http://climate.k-state.edu>) continues to provide numerous tools and data resources for Kansans.

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, soil moisture, soil temperature, animal comfort, inversion monitoring, and much more.

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, staff, and students affiliated with the Kansas Climate Office presented research papers at annual meetings of American Society of Agronomy, the Ogallala Aquifer Research Workshop, and the International Precision Agriculture Conference. We also presented papers at number of state and regional professional meetings and workshops, including the North Central Weed Science meeting. In addition, faculty also made invited presentations nationally and internationally.

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. Directed training included presentations for spray applicator training, wildfire courses, and fire weather forecasting. 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

Kansas Mesonet continues to grow with the addition of two new stations in 2018 as well as upgrades to three to 30 foot towers, the new network standard. The Mesonet continues to create applicable tools necessary for the public and decision makers of Kansas. Soil moisture installations were completed at all 40 tower stations on the network with the addition of an online access tool to capitalize on data. This dataset provided its use immediately during the flash drought in eastern Kansas observed in summer 2018. Another vital application is the animal comfort page (mesonet.ksu.edu/agriculture/animal) that will

aid in producers understanding the current stress levels and identifying weather parameters during livestock losses due to wet/cold/hot weather conditions. Inversion monitoring has also been developed on the network. This real-time product provides sprayers guidance on the current state of the lower atmosphere, critical in determining drift potential in each station's region. It has also been instrumental in Kansas Department of Agriculture drift complaint resolution and educating producers/sprayers on weather impacts of spraying applications.

Data from the Mesonet and other networks within the state are distributed to numerous cooperators including the National Weather Service, the Drought Monitor, High Plains Regional Climate Center, Kansas Department of Emergency Management, and many other agencies.

The Climate Web page capitalized on the new National Centers for Environmental Information (NCEI) county temperature and precipitation data from 1895 to the present. This interface allows mapping by month and also provides annual maps. We've already received feedback that this will be incorporated in classroom activities at both the High School and college level.

KENTUCKY CLIMATE CENTER

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About the Kentucky Climate Center

The Kentucky Climate Center (KCC) observed its 40th full year of operation in 2018. Housed within the Department of Geography and Geology, the center is a charter member of the Applied Research and Technology Program created in 1998 and provides opportunities for undergraduate and graduate students to participate in research and service activities. The KCC is recognized by the AASC as the State Climate Office for Kentucky and has working relationships with the five National Weather Service forecast offices (Jackson, KY, Louisville, KY, Paducah, KY, Wilmington, OH, and Charleston, WV) that serve portions of Kentucky. The KCC is affiliated with the Midwestern Regional Climate Center. In addition to housing the Office of the State Climatologist, the Kentucky Climate Center is home to the Kentucky Mesonet, 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.

Communication Capabilities

The Kentucky Climate Center maintains two websites. www.kyclimate.org provides a range of content highlighting historical climate information, current climate conditions, and climate outlooks. www.kymesonet.org provides historical and current observations from the Kentucky Mesonet. The Kentucky Mesonet also maintains an active Facebook and Instagram presence.

Information Services, Products and Tools

Information services provided by the KCC are primarily driven by the Kentucky Mesonet website. This includes maps of current statewide weather conditions, climatological monthly summaries by station, and annual climatological summaries. Live data feeds are available to the Kentucky Emergency Management Agency and the Kentucky Transportation Cabinet. The KCC website also provides climatological summaries of temperature and precipitation trends by climate division and statewide. The KCC gives frequent presentations regarding Kentucky's climate to various professional and public organizations.

Research, Projects and Publications

The KCC received funding through National Integrated Drought Information System for the Kentucky Drought Early Warning and Preparedness Project. A kickoff meeting was held in September to begin laying the groundwork for multiple project initiatives.

Student research projects included a case study funded by the Kentucky Department for Public Health to investigate the impact of heat waves on public health, an analysis of recent extreme cold weather outbreaks, and an analysis of frozen soil observations and their application. Each of these projects led to presentations by students at local and/or state-level professional conferences. Kentucky Mesonet staff engaged in a variety of research projects using the WRF and WRF-Chem atmospheric models, including modeling land-atmosphere interactions in conjunction with the Great Plains Irrigation Experiment and a study of extreme precipitation in the Louisiana Gulf Coast. Work is also underway on two longer term initiatives to develop the Kentucky Forecasting System and to develop a broad climatology for approximately 75 indices derived from reanalysis data and Kentucky Mesonet data.

Outreach and Education

The KCC engaged in a wide variety of outreach and education activities and events. These included multiple events held by National Weather Service forecast offices focusing on severe and winter weather, as well as community farm events, public school outreach events, and a science exposition event. Invited presentations were made to a variety of professional associations and social organizations, including the Kentucky Science Teachers Association and the Kentucky Drinking Water Advisory Council. The Kentucky Mesonet was featured in a display at the Frazier Kentucky History Museum as part of the Kentucky Bourbon Trail Welcome Center. The Kentucky Mesonet maintained an active presence on Facebook and Twitter. The KCC also maintained active engagement with the Kentucky Farm Bureau Water Management Working Group. Through the course of the year, the KCC also provided outreach through the television, radio, and newspaper media addressing various weather events, climate change, and the Kentucky Mesonet.

Monitoring and Impact Assessment

The Kentucky Mesonet included 69 stations at the end of 2018. A new station in Pulaski County was added, while a station in Breckinridge County was decommissioned and a station in Warren County was destroyed by a lightning strike. Station upgrades included the addition of barometers at 37 sites, soil monitoring packages at 13 sites, temperature inversion monitoring packages at 13 sites, and cameras at six sites. The KCC actively contributes to the Kentucky Agriculture Science and Monitoring Committee with its focus on strengthening and integrating weather, stream, and groundwater monitoring networks to support hydrologic modeling in Kentucky.

LOUISIANA OFFICE OF THE 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

Derek Thompson, Graduate Student

Marisa Karpinski, 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).

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.

Communication Capabilities

The LOSC has taken on the responsibility of producing daily, weekly, and monthly summaries of the State's weather and climate which is 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*. 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

Refereed Publications

Keim, B. D., Kappel, W. D., Muhlestein, G. A., Hultstrand, D. M., Prazybok, T. W., Lewis, A. B., Tomlinson, E. M., Black, A. W. (2018). Assessment of the Extreme Rainfall Event at Nashville, TN and the Surrounding Region on May 1-3, 2010. *Journal of the American Water Resources Association*, 54(2), 1001-1010.

Xue, Z. George, Gochis, D. J., Yu, W., Keim, B. D., Rohli, R. V., Zang, Z., Sampson, K., Dugger, A., Sathiaraj, D., Ge, Q. (2018). Modeling Hydroclimatic Change in Southwest Louisiana Rivers. *Water*, 10(5), 596.

Gilliland, J. M., Keim, B. D. (2018). Position of the South Atlantic Anticyclone and Its Impact on Surface Conditions across Brazil. *Journal of Applied Meteorology and Climatology*, 57(3), 535-553.

Gilliland, J. M., Keim, B. D. (2018). Surface Wind Speed: Trend and Climatology of Brazil from 1980-2014. *International Journal of Climatology*, 38(2), 1060-1073.

Invited Talks

Keim, B. D. (Author & Presenter), NAACP Experience, Environmental Climate Justice, Sea Level Rise, Coastal Flood Risk, and Social Vulnerability Training, "Overview of Sea Level Rise and Coastal Flood Risk," NAACP - Louisiana Chapter, Baton Rouge, LA. (October 13, 2018).

Keim, B. D. (Author & Presenter), The Baton Rouge Flood of 2016: What Happened, What We Did, What We Lost, and What We Learned, "South-Central Louisiana Flooding Event: August 2016," The Louisiana Geological Survey, Baton Rouge, LA. (August 13, 2018).

Keim, B. D. (Author & Presenter), Early Career Researcher Professional Development Training Workshop, "Baton Rouge Flood: August 2016," South Central Climate Science Center, Baton Rouge, LA. (August 8, 2018).

Keim, B. D. (Author & Presenter), Annual Meeting of the Coasts, Oceans, Ports, and Rivers Institute, "Louisiana Weather and Climate," The Coasts, Oceans, Ports, and Rivers Institute, Baton Rouge, LA. (April 5, 2018).

Panel Member

Keim, B. D. (Author & Presenter), Early Career Researcher Professional Development Training Workshop, "Media Relations Panel," South Central Climate Science Center, Baton Rouge, LA. (August 10, 2018).

Paper

Thompson, D. T. (Author & Presenter), Keim, B. D. (Author), SWAAG Meeting, "A Comparison of Tropical Cyclone Landfall Locations between the HURDAT2 Best Track and the NCEP/NCAR Reanalysis I Datasets," Southwest Division of the American Association of Geographers, New Orleans, LA. (2018).

Troutman, J. A. (Author & Presenter), Keim, B. D. (Author), Black, A. W. (Author), American Meteorological Society Conference on Hurricanes and Tropical Meteorology, "An Analysis of Storm Surge Swaths from Significant Gulf of Mexico Hurricanes," American Meteorological Society, Ponte Vedra, FL. (2018).

Grondin, N. S. (Author & Presenter), Keim, B. D. (Author), SWAAG Meeting, "Spatial and Temporal Characteristics of Tropical Cyclone Strikes along the Mexican Riviera," Southwest Division of the American Association of Geographers, Baton Rouge, LA. (October 2018).

Bartels, R. J. (Author & Presenter), Black, A. W. (Author), Keim, B. D. (Author), American Association of Geographers Annual Meeting, "A Seasonal and Monthly Analysis of Precipitation Days in the United States," American Association of Geographers, New Orleans, LA. (April 2018).

Thompson, D. T. (Author & Presenter), Keim, B. D. (Author), American Association of Geographers Annual Meeting, "Construction of a Tropical Cyclone Size Database using Retroactive Analysis Data with a Damage Application," American Association of Geographers, New Orleans, LA. (April 2018).

Brown, V. (Author & Presenter), Black, A. W. (Author), Keim, B. D. (Author), American Association of Geographers Annual Meeting, "Hourly Precipitation Climatology of the Southeastern U.S.," American Association of Geographers, New Orleans, LA. (April 2018).

Grondin, N. S. (Author & Presenter), Trepanier, J. C. (Author), Keim, B. D. (Author), American Association of Geographers Annual Meeting, "Influence of ENSO on Tropical Cyclone Tracks along the Mexican Riviera," American Association of Geographers, New Orleans, LA. (April 2018).

Poster

Kreller, S. J. (Author & Presenter), Keim, B. D. (Author), American Meteorological Society Annual Meeting, "ADCIRC Model Verification of Tropical Cyclone Storm Surge along the Louisiana Gulf Coast," American Meteorological Society, Austin, TX. (January 2018).

Troutman, J. A. (Author & Presenter), Keim, B. D. (Author), American Meteorological Society Annual Meeting, "An Analysis of Storm Surge Swaths from Gulf of Mexico Tropical Cyclone," American Meteorological Society, Austin, TX. (January 2018).

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 12,591 Facebook Post Views; 120,933 Twitter Views, and 605,202 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.

Newspaper, Magazine, Radio, and Television Interviews and Stories

Stories and Multiple stories in each of the following Television Stations, Newspapers and Magazines in 2018: *Los Angeles Times* – 1, *The Advocate* – 7 (Baton Rouge), *Times-Picayune* – 2, *Washington Free Beacon* – 1, *The Tennessean* – 1, WWL Radio (New Orleans) – 3,

I have given at least 55 radio interviews to *Louisiana Network* on a variety of weather topics involving Louisiana LA Network has 75 radio station affiliates in Louisiana. Was interviewed on Portuguese National Radio, iHeart Radio 107.3 in Baton Rouge, and WWNO Radio New Orleans. Was a Guest on *Sunday Journal* with John Pastorek WBRZ, Channel 2, and interviewed on WWL-TV (New Orleans). I also was a guest on Louisiana Public Television – The State We’re In – 5 times in 2018, as well as 2 appearances on WVLA, Channel 33 in Baton Rouge.

MAINE CLIMATE OFFICE

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About the Maine State Climate Office

The Maine Climate Office (MCO) was established in 2018 and resides within the Climate Change Institute at the University of Maine in Orono, Maine. The role of the MCO is to 1) disseminate climate data, information, and interpretation to Maine stakeholders and the general public, 2) consult and coordinate with federal and state agencies and other academic units in climate related activities, and 3) undertake basic climate research. The MCO is directed by the Maine State Climatologist with assistance from a graduate student. Support for the MCO is provided by the Climate Change Institute and the University of Maine.

Communication Capabilities

The MCO communicates via websites, e-mail, phone, media interviews, and public lectures. Climate Reanalyzer, developed and maintained by state climatologist Birkel, receives >2,000 users daily. The Climate Reanalyzer has a Facebook page with ~3,900 follows. The MCO website was initiated recently made public and does not yet have a regular user base.

Information Services, Products and Tools

The MCO offers climate data tools on state (MCO website), regional, and global scale (Climate Reanalyzer website). Birkel regularly provides media interviews, and answers questions from Maine stakeholders and the general public. In 2018, Birkel and Climate Change Institute director Paul Mayewski produced a report, “Coastal Maine Climate Futures”, wherein plausible scenarios for the next 20 years are developed from an analysis of historical climate data and model projections. The report is available in print and online and has been distributed to stakeholders around the state. At the end of 2018 Birkel and UMaine Cooperative Extension colleague Glen Koehler began a new web/e-mail service, AgEye Weather, which brings 10-day forecasts 2x-daily with agricultural metrics (e.g., growing degree days and evapotranspiration) to about 60 customers.

Research, Projects and Publications

The Maine State Climatologist Dr. Sean Birkel is involved in a variety of climate research projects across different timescales. Birkel's research interests include North Atlantic climate variability, climate modeling, and data visualization. Graduate assistant Julia Simonson is undertaking research to quantify the history and impact of extreme storm events in Maine over the past century. Recent and ongoing research projects include understanding volcanic impact on regional and global climate, paleoclimate reconstruction from Andean ice cores, and development of climate/weather data visualization products.

Current Research Funding from the National Science Foundation:

(NSF #1600018; PI Mayewski, P.A., co-I **Birkel, S.D.**) Collaborative Research: P2C2 - Ultra-High-Resolution Investigation of High Andean Snow and Ice Chemistry to Improve Paleoclimatic Reconstruction and Enhance Climate Prediction

Publications in 2018:

Auger, J.D., **Birkel, S.D.**, Maasch, K.A., Mayewski, P.A., Schuenemann, K.C., 2018. An Ensemble Mean and Evaluation of Third Generation Global Climate Reanalysis Models. *Atmosphere* 9, 236. doi: 10.3390/atmos9060236.

Birkel, S.D., Mayewski, P.A., 2018. Coastal Maine Climate Futures. Orono, ME: Climate Change Institute, University of Maine. 24pp.

Birkel, S.D., Mayewski, P.A., Maasch, K.A., Kurbatov, A.V., Lyon, B., 2018. Evidence for a volcanic underpinning of the Atlantic Multidecadal Oscillation. *NPJ Climate and Atmospheric Science* 1, article 24, doi: 10.1038/s41612-018-0036-6.

Graeter, K.A., Osterberg, E.C., Ferris, D.G., Hawley, R.L., Marshall, H.P., Lewis, G., Meehan, T., McCarthy, F., **Birkel, S.D.**, 2018. Ice Core Records of West Greenland Melt and Climate Forcing. *Geophysical Research Letters* 45, 7, doi: 10.1002/2017GL076641.

Outreach and Education

The Maine State Climatologist gives public lectures several times a year around the state. The MCO also provides media interviews, interacts with K-12 teachers and university researchers, and communicates and collaborates with state and federal agencies on a variety of climate related issues.

Monitoring and Impact Assessment

The MCO does not yet undertake specific climate or weather monitoring activities but may begin to do so in 2019 in conjunction with NWS-Caribou (frost monitoring) and colleagues in UMaine Cooperative Extension (farm weather stations). Birkel participated on advisory panels in 2018: 1) NOAA National Integrated Heat Health Information System (NIHHIS) (culminating in stakeholder workshop in Nov. 2018), and 2) NCAR Command Language (NCL) (summer 2018).

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 (MCRP), 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 2018 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. MCRP receives the majority of its funding support from the Michigan AgBioResearch 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 the Enviro-Weather information access system.

Information Services, Products and Tools

The total number of requests for climate information, interviews, and speaking engagements decreased significantly in 2018. The total number of formal public requests for climate-related data and information during the year was 52, down from 88 in 2017 and well below the five-year average of 87. 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 \$67.07, which was up slightly from \$62.21 in 2017. These numbers are 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 2018, staff at MCRP authored or co-authored 2 refereed articles and 3 non-refereed articles and technical reports. MCRP was associated with 1 new external grant totaling \$85,000, 6 grants in force from previous years, and 10 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 2018, the MCRP staff provided 9 ad hoc interviews to print, radio, and television media (including 4 TV or radio appearances) and 35 talks or seminars to the public. In 2018, the SC continued a regularly scheduled weekly weather/climate radio updates with Michigan Agriculture Information Network (50 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 2018, 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 MCRP 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 mesonet network (formerly the Michigan Automated Weather Network), which has grown considerably from 6 sites at its formation in 1997 to 90 in 2018. Geographical coverage of the network has also grown to additional areas of the state and to nearby sections of 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 data are available at seven new sites to assist with low-level (3m) inversion monitoring and at two sites with 20m towers 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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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

The MN_SCO is designated by the AASC as the official state climate office for Minnesota. The following describes the ways in which the MN_SCO addresses each of the ARSCO qualifications:

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

- 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.
- During the polar vortex episode in late January 2019 (Jan 20-Feb 3) our website had over 126,000 visitors.
- We now have over 3400 followers on Facebook, which is up from roughly 3100 in June 2018.

Research

- Each year the MN_SCO is 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

- Staff give frequent interviews to electronic and print media. From August 2018 through March 2019, our office has had 117 media contacts.
- 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.
- This year the MN_SCO added several new value-added data products which utilize ACIS web services.
- 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. This year the MN_SCO added a new mesonet station at William O' Brien State Park.
- The MN_SCO are continuing work related to 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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Assistant State Climatologist: Chris Fuhrmann, PhD
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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. In 2018 we began providing climate summary graphs for 10 locations across the state to public and government stakeholders.

Research, Projects and Publications

Grants

Mississippi State Climate office personnel for 2018 worked on three funded projects. 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), and the third is a study abroad program for Coastal Science and Climate Science through the Association of International Educators (\$25,000)

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.

SCO personnel are involved in the publication preparation from the 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 water stress on cotton using small UAVs. This project has shown promise in detecting water stress on vegetation prior to visible signs on the plants (wilting or restricted leaf growth).

This past year the SCO (in conjunction with MSU Extension) continued work with the 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

- M. E. Brown**, K. Alexander, 2018 Using emerging mobile technologies to better mitigate drought conditions in Mississippi. *J. Geogr and Nat Disast*: Accepted
- Gutter, B.F., Sherman-Morris, K., and **Brown, M.E., 2018**: Severe Weather Watches and Risk Perception in a Hypothetical Decision Experiment. *Weather, Climate, and Society*, 10:4, 613-623.
- Sugg, M.M., **C.M. Fuhrmann**, and J. Runkle, 2018. Temporal and spatial variation in personal ambient temperatures for outdoor working populations in the southeastern USA. *International Journal of Biometeorology*, 62, 1521-1534.

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 (6). 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.

Representative Presentations

- *Weather and Climate of the Caribbean*. Presented to GR 4533/6533: Bahamas Field Course, Mississippi State University, San Salvador Island, June 2018
- *Results from the U.S. National Climate Assessment and Implications for Agriculture in the Southeast U.S.* Presented to AELC 4803: Contemporary Issues in Agriculture, Mississippi State University, March 2018
- *Making Sense of Climate Models*. Presented to HON 3183: History and Policy of Climate Change, Mississippi State University, February 2018

- *Weather and Climate of the Caribbean*. Presented to GR 4990: Caribbean Geography, Mississippi State University, February 2018
- *Climate Change in the Southeast United States: What Do We Know and What Do We Need to Know?* Presented at the 29th Annual BMP/OMP Workshop, Department of Geosciences, Mississippi State University, August 2018, Mississippi State, MS
- The SCO has been the driving force behind the develop 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

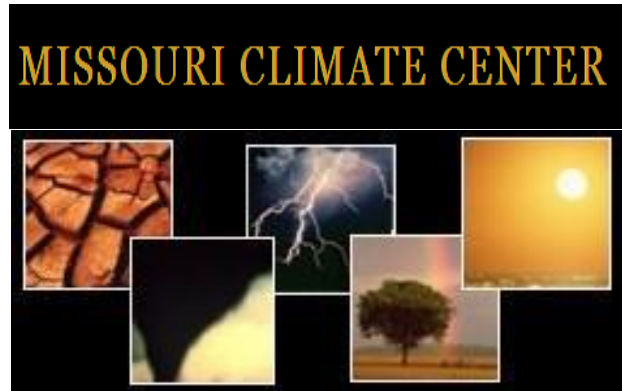
This past year the SCO has continued working on the update of the MSU All Hazards Mitigation Plan. The SC has also delivered video lectures to other colleges and universities in order to help them develop or modify their mitigation documents.

This SCO has also provided climate summaries and weather threat analysis to the cities of Richland, MS, Southaven, MS, and Corinth, 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 2018 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;
- 28 Missouri Mesonet stations provide 5-min near real-time conditions;
- 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 1,000 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 10 press releases in 2018 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 over 100 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 & 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 the MU 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 station at St. Louis Science Center, MO: <http://agebb.missouri.edu/weather/realTime/slsc.asp>;
- Upgraded Charleston weather station to real-time status: <http://agebb.missouri.edu/weather/realtime/charleston.asp>;
- Charleston weather station was added to the Temperature Inversion Potential tool: http://agebb.missouri.edu/weather/realTime/maps/index.php#temp_inversion;
- County Precipitation Departure Maps were updated to include PRISM data <http://agebb.missouri.edu/drought/accurain.htm>;
- Design Storm Alert System tool captured several extreme events in 2018 <http://agebb.missouri.edu/weather/designstorm/>;
- Missouri Frost/Freeze Guide widely used: <https://ipm.missouri.edu/frostfreezeguide/>;
- Collaborated with the NDMC and NIDIS to create the Missouri Extension Drought Impact Survey
The 2018 survey archive can be found at: <https://droughtreporter.unl.edu/submitreport/>
- The Missouri Mesonet plays a critical role in the Crop Water Use App, which has 789 active fields participating in Missouri: <http://ag3.agebb.missouri.edu/horizonpoint/cropwater/>

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 28 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 2018, the average number of actual internet visits made to our 26 real-time weather web sites was over 337,000 per station, or, over 9,000,000 visits;

- Providing real-time weather status to 28 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). Strong components of the grant are science education, research, technology and community outreach. 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 MU weed scientists, Dr. Kevin Bradley and Dr. Mandy Bish, to accessorize 3 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. In 2018, Travlos and Guinan accessorized an additional station with inversion monitoring equipment in Charleston, MO;
- The Design Storm Alert System (DSAS) tool remained active in 2018, The tool identifies extreme precipitation events that meet specific design storm criteria in Missouri. In 2018, the DSAS identified 7 extreme rainfall events as they relate to the 25-yr/24-hr design storm event and 25 extreme events meeting 10-yr/10-day criteria;
- Rabinowitz, Jordan L., Lupo, Anthony R., **Guinan**, Patrick E., 2018. "An Investigation of Atmospheric Rivers Impacting Heavy Rainfall Events in the North-Central Mississippi River Valley". International Journal of Climatology.
<https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.6061?af=R>
- Rabinowitz, Jordan L., Lupo, Anthony R., Guinan, Patrick E., 2018. Evaluating Linkages between Atmospheric Blocking Patterns and Heavy Rainfall Events across the North-Central Mississippi River Valley for Different ENSO Phases. Advances in Meteorology, Volume 2018, Article ID 1217830, 7 pages, <https://doi.org/10.1155/2018/1217830>

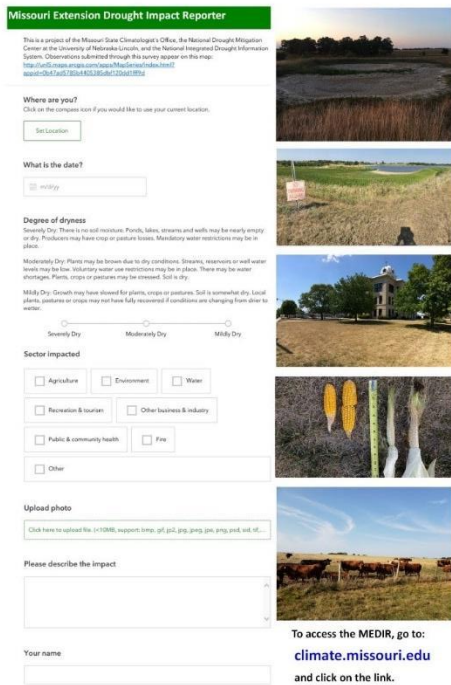
Outreach and Education

- 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;
- Information resource for media outlets including Missouri Net, Brownfield Network, Cooperative Media Group, and local TV, radio, and newspaper outlets.

Monitoring and Impact Assessment

In 2018, the Missouri Climate Center partnered with the National Integrated Drought Information System (NIDIS) and National Drought Mitigation Center (NDMC) to develop an online survey for reporting drought impacts in Missouri. The survey was activated on July 6, 2018 and called the Missouri Extension Drought Impact Reporter, Figure 1. By the end August, Missourians submitted more than 400 impact reports, including over 100 pictures. The NDMC also developed a Drought Conditions and Impacts Map for Missouri, Figure 2. Information was critical for assessing drought severity in Missouri and used extensively by decision makers at the state and national level, including the authors of the U.S. Drought Monitor.

Missouri Extension Drought Impact Reporter



Missouri Extension Drought Impact Reporter

This is a project of the Missouri State Climatologist's Office, the National Drought Mitigation Center at the University of Nebraska-Lincoln, and the National Integrated Drought Information System. Observations submitted through this survey appear on the map.
<http://climate.missouri.edu/Map/extension/index.html>
extension@climate.missouri.edu

Where are you?
Click on the compass icon if you would like to use your current location.
Set Location

What is the date?
entry

Degree of dryness
Severely Dry: There is no soil moisture. Ponds, lakes, streams and wells may be nearly empty or dry. Producers may have crop or pasture losses. Mandatory water restrictions may be in place.
Moderately Dry: Plants may be brown due to dry conditions. Streams, reservoirs or well water levels may be low. Voluntary water use restrictions may be in place. There may be water shortages. Plants, crops or pastures may be stressed. Soil is dry.
Mildly Dry: Growth may have slowed for plants, crops or pastures. Soil is somewhat dry. Local plants, pastures or crops may not have fully recovered if conditions are changing from drier to wetter.

Severely Dry Moderately Dry Mildly Dry

Sector impacted

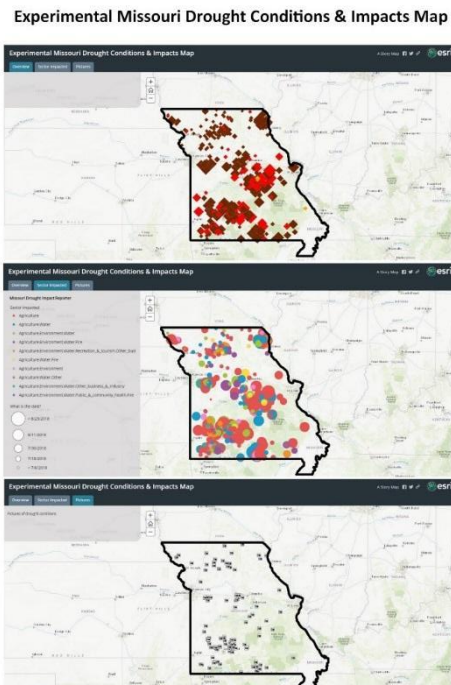
Agriculture Environment Water
 Recreation & tourism Other business & industry
 Public & community health Fire
 Other

Upload photo
Click here to upload file (1-10MB, support: bmp, gif, jpg, jpeg, png, png, png, png, pdf, tiff, ...)

Please describe the impact

Your name

To access the MEDIR, go to:
climate.missouri.edu
and click on the link.



NEBRASKA STATE CLIMATE OFFICE

State Climatologist: Dr. Martha D. Shulski
Agriculture Extension Climatologist: Allen Dutcher



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University of Nebraska - Lincoln

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About the Nebraska State Climate Office

The Nebraska State Climate Office Staffing is housed in the School of Natural Resources at the University of Nebraska – Lincoln. Personnel at the office include 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, Extension Educator and undergraduate intern. 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 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 574 data requests in 2018 (Figure 1). 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.

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. Shulski served as an author for the Northern Great Plains chapter of the 4th National Climate Assessment. 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-funded project to increase resiliency to climate change impacts for municipalities in the lower Missouri River Basin states. Localized climate reports were developed with this project and a web tool to assist with planning for municipal staff is housed at the HPRCC. One peer-reviewed publication and one video was produced focusing on research results from this topic. A one-year NSF project on climate resilience in the context of a rapidly changing Arctic was ongoing for 2018. A series of workshops were organized (two in Alaska, one in Nebraska) that included researchers, practitioners and indigenous leaders from around the world. In this project, the NSCO partnered with the Nebraska Cooperative Fish and Wildlife Research Unit at UNL and The Nature Conservancy office in Nebraska.

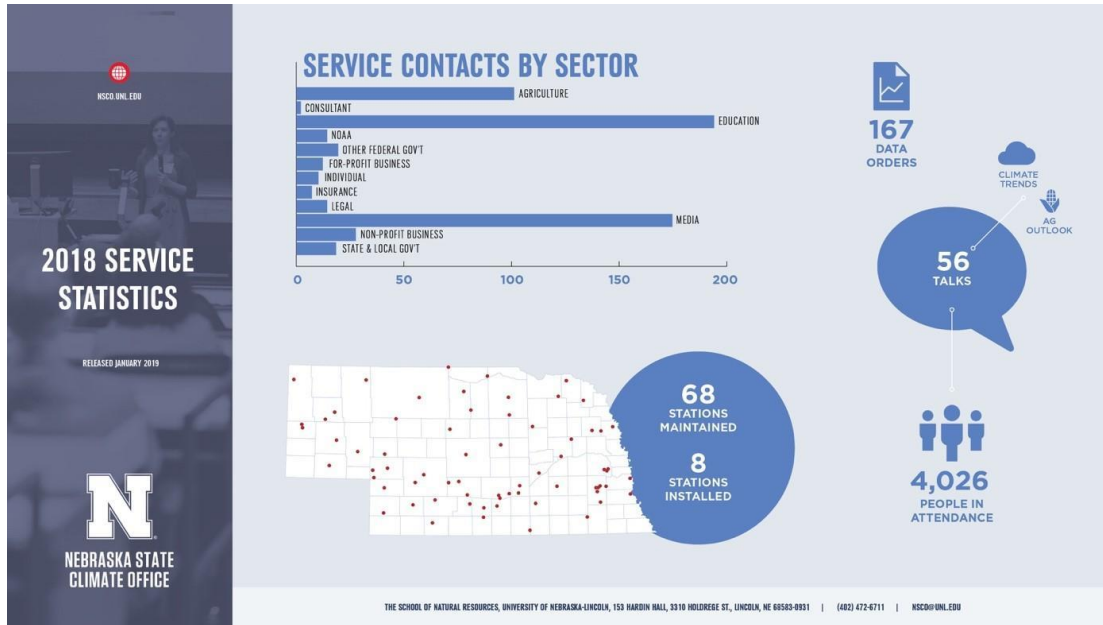
Outreach and Education

In 2018 NSCO staff delivered 56 talks that reached approximately 4,026 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 and cropping systems and weather-ready farms. Monthly, seasonal and annual temperature and precipitation historical trends for all climate divisions were analyzed and produced as a part of this effort. Both short term (1987 – 2016) and long term (1895 - 2016) trend assessments were performed. A professional development workshop was developed and hosted to train Nebraska Extension staff on climate variability and change, climate communication, and garner feedback on NSCO products and services. 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. Eight new stations were installed in 2018. 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 Nebraska Public Power District and a myriad of organizations.



2018 Service statistics for the NSCO

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, was been supported by the NSCO June 2015 through May 2018.

Communication Capabilities

During 2018, 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.

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.

Research, Projects and Publications

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.

The NSCO also 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 megadrought conditions that we know happened in the past. It is really important to us that 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.

Peer-reviewed Journal Articles

- Hatchett, B., Boyle, D., Garner, C., Kaplan, M., Bassett, S., Putnam, A. (2018). 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*. [https://doi.org/10.1130/2018.2536\(05\)](https://doi.org/10.1130/2018.2536(05))
- Hudson, A., Hatchett, B., Quade, J., Boyle, D., Bassett, S., Ali, G., De los Santos, M. North-south dipole in winter hydroclimate in the western United States during the last deglaciation. *Nature Scientific Reports*. In press.
- McAfee, S. A., McCabe, G. J., Gray, S. T., Pederson, G. T. (2018). Changing station coverage impacts temperature trends in the Upper Colorado River Basin. *International Journal of Climatology*.

Professional Presentations

- Boyle, D., Comer Abrupt Climate Change Conference, Academic, Conference, "Constraining Estimates of Past Climates using Glacial Moraine & Lake Level Evidence" Comer Family Foundation. (October 1, 2018) - Invited
- Boyle, D., Native Waters on Arid Lands (NWAL) Tribal Summit, Academic, Conference, "Impact of Climate Change on Water Resources in the Walker River Basin" Accepted, Native Waters. (October 16, 2018).
- McAfee, S. A., McCabe, G., Pederson, G., Gray, S., Elevation-dependent warming signals in the Upper Colorado Basin are suppressed by systematic changes in the station network., Accepted Talk, MtnClim Meeting (September 19, 2018).
- McCabe, G., Wolock, D., Pederson, G., Woodhouse, C., McAfee, S. A., Evidence that Recent Warming is Reducing Upper Colorado River Flows, Accepted Talk, American Association of Geographers Annual Meeting. (April 10, 2018).

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 2018, D. Boyle and S. McAfee participated in the following outreach and educational activities as representatives of the NSCO:

Cattlemen's Association Update

As the Nevada State Climatologist, D. Boyle made presentations titled "Nevada Climate and Drought Update" to members of the Cattlemen's Association at the following meeting locations:

- Washoe County Cooperative Extension, Reno, NV (8 January 2018)
- Sierra Valley Grange, Vinton, CA (8 January 2018)
- Smith Valley Community Hall, Wellington, NV (9 January 2018)
- Fallon Convention Center, Fallon, NV (9 January 2018)
- Old St. Lawrence Hall, Ely, NV (10 January 2018)
- Great Basin College Solarium, Elko, NV (11 January 2018)
- Humboldt County Cooperative Extension, Winnemucca, NV (12 January 2018)

As the Nevada State Climatologist, D. Boyle developed and made presentations on the Impacts of Climate on Farms and Ranches under the Southwest American Indian Outreach Program and the USDA Program Update Workshops. These workshops provided discussion and expertise on United States Department of Agriculture (USDA) federal assistance programs available to crop and livestock producers in the southwestern U.S. The 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 2018 agricultural year. The workshops took place at following locations:

- San Carlos Apache Indian Reservation, San Carlos, AZ (17-18 July 2018)
- Colorado River Indian Tribes, Parker, AZ (19-20 July 2018)
- Duck Valley Indian Reservation, Owyhee, NV (31 July 2018)
- South Fork Indian Reservation, South Fork, NV (1 August 2018)

Other professional presentations

As the Nevada State Climatologist, D. Boyle made professional presentations at and/or attended the following meetings in CY2018:

- Presentation on water resources and climate change policy to a U.S. State Department contingent of Iraqi delegates through the Northern Nevada International Center (13 February 2018)
- Presentation on NSCO mountain weather observatory to the local National Weather Service forecasters in Reno (27 February 2018)
- Presentation on Climate Impacts on Nevada Reservations at the Nevada Indian Summit, Reno, NV (18 April 2018)

Other NSCO Service Activities

- Task Force Member (S. McAfee), AASC Annual Meeting. (2018 - Present)
- Committee Member (S. McAfee), NV/CA Drought Early Warning System Steering Committee. (August 2016 - Present)
- Committee Member (S. McAfee), AASC ARSCO Certification Guidelines Committee. (2016 - Present)
- Committee Member (S. McAfee), American Association State Climatologists Membership Committee. (2015 - Present)

Monitoring and Impact Assessment

The NSCO has been an active participant in the monthly to 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.

NEW HAMPSHIRE STATE CLIMATE OFFICE

State Climatologist: Mary Stampone

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Twitter: https://twitter.com/nh_sco

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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 stakeholders 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 climate science resource for citizens, government, and education.

The NHSCO provides the public with information on weather and climate through research, outreach, media interviews, and dissemination of data and analyses.

Communication Capabilities

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

- 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.
- Migrated website content to the new UNH domain: <https://mypages.unh.edu/nhsco/home>
- 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, businesses, and local/regional media;
- presented on state climate services and the regional climate change risks and impacts;
- conducted interviews for print media and made appearances on WMUR-TV and regional Public Radio news broadcasts.

Research, Projects and Publications

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

The Fourth National Climate Assessment, Vol II published in November 2018.

Dupigny-Giroux, L.A., E.L. Mecray, **M.D. Lemcke-Stampone**, G.A. Hodgkins, E.E. Lentz, K.E. Mills, E.D. Lane, R. Miller, D.Y. Hollinger, W.D. Solecki, G.A. Wellenius, P.E. Sheffield A.B. Macdonald, and C. Caldwell (2018) Chapter 18: Northeast. In *Impacts, Risks, and Adaption in the United States: The Fourth National Climate Assessment, Volume II*. [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742. doi: 10.7930/NCA4.2018.CH18.

Co-authored manuscript on perceptions of climate change in New England’s North Country region published in July 2018.

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>

Member of the 2019 Coastal Flood Risk Science and Technical Advisory Panel for the NHDES Coastal Program.

PI - Morison, N. (2018) *Using Science, Building Social Capital, and Unpacking Tax Incentives for a Resilient Coastal NH*

Science and Technical Advisory Panel (in preparation) 2019 Coastal Flood Risk Science Summary

Outreach and Education

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

- Works with state agencies, county cooperative extension services and the media to inform citizens and stakeholders on drought severity and impacts.
 - *Press release*, “U.S. Drought Outlook Predicts Drought Development: NHDES is Urging Residents to Conserve Water” NH Department of Environmental Services July 21, 2018
- Presented on the regional climate change impacts described in the 2018 National Climate Assessment Impacts report.
 - “Summary: Fourth National Climate Assessment Vol II” Dartmouth College, Hanover, NH, January 29, 2019.
 - “4th National Climate Assessment Vol II – Chapter 18 | Northeast.” NOAA Eastern Region Climate Services, Monthly Webinar, December 18, 2018.
 - “Climate Change and Hurricanes – What to Expect.” Global Humanities Undergraduate Research Lab – Puerto Rico Lab Brown Bag Seminar, UNH-Durham, NH, October 10, 2018.
- Serves on the Mount Washington Observatory Board of Trustees and is a member of the Scientific Advisory Committee.
- The NH State climatologist is also an Associate Professor at UNH and teaches undergraduate courses on weather and climate in the Department of Geography.

Monitoring and Impact Assessment

The NHSCO collaborates with state agencies, providing climate data and analyses for state environmental management and planning activities. The NH State Climatologist works directly with state agencies including the:

- Departments of Environmental Services, Homeland Security, and Agriculture to monitor drought development, conditions, and impacts as a member of the state Drought Management Team;
- Department of Environmental Services Coastal Program to assess future risk of coastal flooding in response to sea level rise and increased precipitation.

The NHSCO also continues to work closely with the NWS Forecast Offices in Gray, ME to oversee operation and coordinate in the maintenance of state weather observing networks (e.g. USHCN – COOP, USCRN, CoCoRaHS).

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, Chad Shmukler, Andrew Sutphen

Student Associates: Joey Fogarty, Ariel Schabes, Zack Mages, Rohan Jain



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Twitter: <https://twitter.com/NJClimate>

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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 Rutgers NJ Weather Network (NJWxNet) site. We also post reports on our Facebook page, have a Twitter presence, and maintain a mailing list of over 100 individuals (which includes some reporters). On average, there are nearly 3000 unique pageviews 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, potential seasonal ENSO influences, and excessive precipitation, 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 2018-2019 snow season, with 13 such events, found the snow page accessed over 11,000 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 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 continues to sit on Sustainable Jersey climate, forestry, and urban heat committees and the NJ drought advisory committee. In 2018 he also participated 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 Rutgers New Jersey Weather Network. This unique network of 67 weather stations serves as a one-stop Internet resource for New Jersey weather and climate data. The NJWxNet includes 45 NJ Mesonet sites monitoring a rich suite of atmospheric and surface variables, and 22 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 325 citizen scientists participate in the program, with approximately 115 of them missing seven or fewer daily observations in 2018. A recruitment campaign led to approximately 125 new observers signing on in late 2018. 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

State Climatologist: Dr. Dave DuBois

Database Administrator and ZiaMet pro: Stan Engle

PhD Graduate Assistant: Antonio Arredondo

MS Graduate Assistant: Jaylen Fuentes

MS Graduate Assistant: Josue Gutierrez

MS Graduate Assistant (graduated in Dec.

2018): Zahra “Vida” Ghodsi Zadeh

Undergraduate Assistant (graduated in Dec. 2018): Octavio Nayares

Undergraduate Assistants: Natalie Franco, Anna Wall, Jonathan Consford



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City, State, Zip Code: Las Cruces, NM 88003

Phone: (575) 646-2974

Website: <http://weather.nmsu.edu>

Twitter: @NMclimate

Instagram: NMclimate

Email: dwdubois@nmsu.edu

Communication Capabilities

We rely heavily on social media outlets for our engagement to the public. Our social media accounts include Twitter (@nmclimate), Facebook (facebook.com/nmclimate), Instagram (nmclimate), and YouTube (youtube.com/nmclimate) for providing climate information to the public. Our office fielded numerous media interviews from both local, state-wide, and national news organizations. Our office appeared several times on TV stations KRQE Albuquerque, KRWG Las Cruces, and KVIA in El Paso, Texas and on radio with KRWG and KTAL. We regularly are interviewed and quoted in the following newspapers: Albuquerque Journal, Santa Fe New Mexican, Carlsbad Current-Argus, USA Today Network affiliates such as Las Cruces Sun-News and the El Paso Times.

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 as the Chair of the New Mexico Drought Monitoring Workgroup and conducts monthly conference calls. This year our office participated in updating the State of New Mexico’s Drought Plan. In 2018 we began developing a tool for pecan orchard irrigation scheduling using data from our ZiaMet weather station network and forecast evapotranspiration estimates from the NOAA FRET product.

Research, Projects and Publications

We continued collaboration with the New Mexico Department of Transportation (NMDOT) on their dust mitigation investigation and collected dust concentrations and weather information along Interstate 10 in locations where traffic accidents have occurred due to wind-blown dust. Another collaboration with NMDOT included installing seven automated weather stations across New Mexico and having 65 patrol yards participate in the CoCoRaHS network. 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. A video was produced by NOAA to highlight our work this year that involved the trucking community and NMDOT regarding highway safety during dust storms.

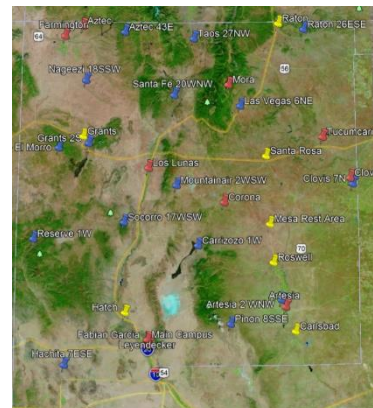
<https://www.youtube.com/watch?v=ENy1O-coRKg>. In 2018 we partnered with the USDA Southwest Climate Hub on two projects. The first was creating an online dust handbook for USDA NRCS. The second was an air quality and agriculture project to produce a synthesis paper and workshop covering the Southwest and Southern Great Plains regions. This year our office participated in a USDA NIFA grant “Agroecosystems Resilience in Times of Drought” involving New Mexico State University, Oklahoma State University, USDA Southwest Climate Hub, and Zeigler Geologic Consulting. State Climatologist Dave DuBois participated in a USAID Farmer to Farmer program during the summer of 2018 to explore climate services opportunities in northcentral Colombia and partnering with the NGO, Salva Terra based out of Medellín, Colombia. Our office worked with the NMSU College of Engineering capstone office for students to work on an automated rain gauge project using elements from a CoCoRaHS gauge.

Outreach and Education

We participated in numerous outreach activities in public schools, tribes, and community events across the state of New Mexico. 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 150 K-12 students in southern NM. We continue to offer a 4-H summer workshop covering climate monitoring, CoCoRaHS, and assembling 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. We partner with the USDA Southwest Climate Hub on giving drought workshops in collaboration with Cooperative Extension and USDA Farm Service Agency staff. On average we provided at least two talks or outreach activities per week over the course of the year. State Climatologist Dave DuBois served on PhD student committees at Texas A&M Kingsville and Universidad Autonoma de Ciudad Juárez, Mexico. In 2018 our office helped run the New Mexico State University Climate Change Education Seminar Series that brought in six climate change talks to Las Cruces.

Monitoring and Impact Assessment

The NM Climate Center maintains a network of automated weather stations throughout the state, mostly located in agricultural regions. The 11 station ZiaMet network (red pins) 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 (blue pins). Five of these former USRCRN stations are owned and located at National Park Service lands with the remaining 10 owned by New Mexico State University. In 2018 we partnered with the NM Department of Transportation to operate and maintain seven automated stations across the state (yellow pins).



STATE CLIMATE OFFICE OF NORTH CAROLINA

Acting State Climatologist: Dr. Walt Robinson

Assistant State Climatologist: Ms. Heather Aldridge

Staff/Service Climatologists:

- Mr. Aaron Sims, Interim Director
- Ms. Ashley Hiatt, Applied Meteorologist
- Mr. Sean Heuser, ECONet Manager
- Mr. John McGuire, Applied Meteorologist/Data Manager
- Ms. Rebecca Ward, Extension Climatologist
- Mr. Corey Davis, Applied Climatologist
- Mr. Nathan Parker, Systems Analyst
- Ms. Darrian Betrand, Applied Climatologist
- Ms. Aurelia Baca, Climatologist
- Ms. Colleen Karl, Outreach Specialist
- Mr. Joseph Taylor, Instrumentation Technician
- Ms. Myleigh Neill, Instrumentation Technician



Affiliation/sponsor: NC State University, 1005 Capability Drive, Centennial Campus Box 7236, Raleigh, NC 27695-7236

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Website: climate.ncsu.edu

Social media: @NCSCO(Twitter)

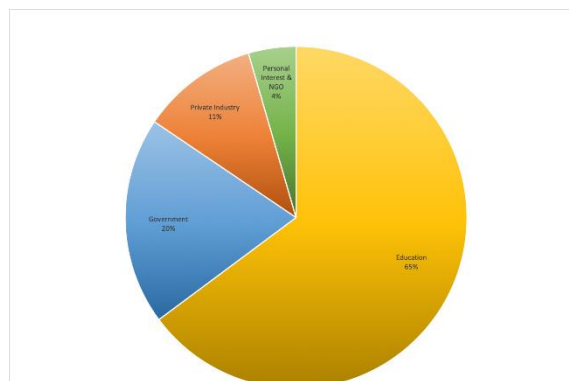
Email address: sco@climate.ncsu.edu

About the State Climate Office of North Carolina

The State Climate Office of North Carolina (SCONC) 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 college teachers, and students, and with other community organizations on different aspects of the NC climate and environment. NCSCO is committed toward 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 2018-2019 resulted in an 11.1% increase in these services as compared to last year. Similar to previous years, educational requests (65%) were the leading support group for data requests. Remaining effort went primarily to supporting government (20%) and private industry (11%). The NCSCO staff and students wrote 25 posts over the previous year for the Climate Blog. These posts received 53,037 total views, an average of 2,121 views per post. This



Breakdown of direct data requests by sector

is a 30% increase in average viewership over the previous year. NCSCO posts weekly content on Twitter (@NCSCO), including blog posts, videos, and information about recent weather, infographics, and updates from outreach events and weather station maintenance visits. Over the past year, total accounts following @NCSCO increased to 1,222, a 17% gain from this time last year.

Information Services, Products and Tools

The SCONC website received 874,937 visits over the previous reporting period. This is a decrease of nearly 28% from the previous year. This decrease likely can be attributed to the launch of a new website in late 2017 that consolidated and streamlined many products and services provided by the SCONC. Nearly 87% of clients requesting data came from North Carolina, while 1.6% of clients did not specify their location when submitting a request. Requests from 18 other states averaged 1 to 7 requests each. Users submitted 2.8 million data queries through the CRONOS website interface. Another 2.7 million queries were requested through the web services Application Programming Interface (API). Along with these point data observations, SCONC provides access to 66 terabytes of gridded data to its partners and users. Over half a billion observations were recorded at NC Environment and Climate Observing Network (ECONet) stations, which are maintained and operated by the NCSCO.

Research, Projects and Publications

- 15th year providing routine advisories for two peanut foliar diseases.
- More than a decade long partnership with NC Department 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 partnership with the Southeast Research Climate Center (SERCC) for over 10 years.
- Climate focal point for the Spatial Analytic Framework for Advanced Risk Information Systems (SAFARIS) project, a collaboration between the Center for Integrated Pest Management (CIPM) at NC State University and the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) working to estimate global risk to trade of agricultural products.
- Deployment of soil moisture stations in eastern NC to improve fire smoldering risk indicators for organic soils.
- Partnership with decision makers to assess and improve the usability of drought-relevant information for the agriculture, forestry, and water resources sectors in North Carolina.
- Monitoring of soil temperatures along the beaches on Bald Head Island to better predict potential genders of sea turtle hatchlings along the Bald Head Island Coast.
- Deployment of temperature sensors at 9 meters at 13 ECONet stations to better monitor low level temperature inversions across NC.



Soil temperature station on Bald Head Island

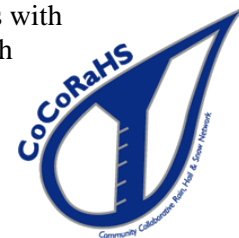
- Two publications were accepted for publication; Five manuscripts are in development or currently in submission; 12 presentations were given at meetings and conferences; 18 staff and students attended 19 meetings and conferences.

Outreach and Education

- The NCSCO regularly leads and attends educational outreach events across the state of North Carolina. Staff and students participated in 22 educational outreach events, 3 of which were large events including Farm Animal Days and NC Museum of Natural Sciences' Groundhog Day.
- 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.
- In the past year, 50 media interviews were given on weather and climate information including observed trends and climate change impacts in NC, and the NC ECONet and its value, especially in instances where there are no other weather stations in the area.
- SCONC scientists were invited to give three presentations to professional or community groups on topics including climate patterns and outlooks, drought, and climate change.
- SCONC participated in more than a dozen knowledge-sharing meetings with other groups on campus and across the state to discuss potential research collaborations or to provide climate expertise.
- Six students research assistants trained and financially supported.
- Seven school and community groups hosted for outreach.
- 238 new CoCoRaHS observers recruited.



SCONC Staff and Students at NCSU Farm Animal Days 2019



Monitoring and Impact Assessment

The Environment and Climate Observing Network (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 stations in the state such as solar radiation, soil temperature, and soil moisture.

- Last year, 171 site visits were made to perform routine or emergency maintenance covering 25,178 vehicle miles.
- New station installed: The 42nd ECONet station was installed at the Horace Williams Airport in Chapel Hill, NC.
- New primary maintenance provider for the weather station at the famous Grandfather Mountain Swinging Bridge.
- New sensors installed: 23 ECONet stations are now outfitted with black globe thermometers to assist with monitoring heat stress. 13 stations have now been outfitted with air temperature sensors at 9 meters to better detect low level temperature inversions.

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

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Morrill Hall 304

City, State, Zip Code: Fargo, ND 58102

Telephone: 701-231-6577

Website(s): <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/climatesummaries/>. 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

Leelaruban, N, G. P. Padmanabhan, P. Oduor, and F. A. Akyuz. 2018: Uncertainty in Drought Reporting Across Different Spatial Scales. ASCE-EWRI 2018 Congress. Jun 3-7, 2018. Minneapolis, MN.

Extension Publications

Kandel H. and A. Akyüz, M. Ostlie, B. Schatz, K. Bjerke, J. Nielsen, J. Rickertsen, R. Olson, E. Eriksmoen, J. Effertz, A. Kraklau, B. Hanson, T. Hakanson, L. Henry, J. Bergman, G. Pradhan, J. Jacobs, and T. Tjelde. North Dakota Canola Variety Trial Results for 2018 and Selection Guide. 2018. NDSU Extension Services/ ND Ag Experiment Station. A1124-18. October 2018.

Kandel H, A. Akyüz, B. Schatz, M. Ostlie, S. Zwinger, S. Schaubert, J. Rickertsen, B. Hanson, T. Hakanson, L. Henry, J. Bergman, G. Pradhan, T. Stefaniak, H. Worrall, G. Martin. North Dakota Dry Pea Variety Trial Results for 2018 and Selection Guide. 2018. NDSU Extension Publication # A1469-18. October 2018.

Outreach and Education

- Media Interaction
- Professional/Invited Presentations
- Guest Lectures/K-12 Presentations
- Various topics related to climate change, impact and climate outlook for the coming growing seasons were communicated with the target audience through workshops and farm meetings including but not limited to North Dakota Farm Bureau Annual Convention, North Dakota Commodity Groups Meeting, Crop Productions, Diversity Direction and Weed Control meetings.
- 16th Annual Climate Prediction Application Science Workshop that was hosted in Fargo ND. The workshop was organized to bring together a diverse group of climate researchers, information producers, and users to share developments in the research and applications of climate predictions for societal decision-making. A web site was designed to publish all presentation for the public and the stakeholder view: <https://www.ag.ndsu.edu/cpasw>
- Monthly and quarterly state of climate and impact were communicated with the target audience through ND State Climate Office website: <https://www.ndsu.edu/ndsco/climatesummaries/> .
- The Norther Plains drought of 2017 that was concentrated in ND, SD and MT extended into 2018. Weekly drought impact at county level was tabulated and communicated with the state and federal partners. The North Dakota Drought page was updated to disseminate drought information to the target audience weekly throughout the growing season in 2018. A website was developed to communicate the drought development and intensity continuously pushing weekly drought update with the target audience: <https://www.ag.ndsu.edu/drought>
- Master Gardener program to train the workshop participants to utilize weather and climate information for successful gardening.
- Expanding your horizons to attract middle school female students in science and technology.

- North Dakota Science Olympiad state competition was facilitated to administer the meteorology event. 24 middle school teams who won the regionals across the state participated the event.

Education (Teaching):

Classes Taught:

1. Fall 2018: AGRI 115/Wonders of Weather (Class Size: 235)
2. Fall 2018: Soil 217/Introduction to Meteorology and Climatology (Class Size: 54)

Professional Affiliations:

Royal Meteorological Services (Fellow), AMS, AASC (President), WMO Commission for Climatology focus area four (Capacity Development for Climate Services) expert team on communication and outreach.

STATE CLIMATE OFFICE OF OHIO

State Climatologist: Bryan Mark

Assistant State Climatologist: Jim DeGrand

Staff/Service Climatologists: Aaron Wilson, research scientist
Jason Cervenec, Education & Outreach Director
Steven Quiring, Professor
Wes Haines, Technical staff/meteorologist
Jeff Rogers, professor emeritus

Affiliation: The Ohio State University, Department of Geography, Byrd Polar and Climate Research Center (BPCRC), and Department of Extension

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rogers.21@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 Climate Office of Ohio (SCOO) unites 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 Mission: Connecting Climate and People

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 April 1, 2018 to March 31, 2019, the SCOO website has seen 2,601 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 and its Twitter stream has over 68 followers.

Information Services, Products and Tools

Information services: SCOO produces a weekly summary of hydrological conditions across Ohio. These are video productions that review the current status of drought, precipitation receipts, soil moisture, and river levels as well as forecasts in the near, short and long term. These videos are available through the SCOO website, the Byrd Polar and Climate Research Center website.

Office publications: SCOO, along with Ohio Extension, publishes a quarterly climate summary for the State. This is available in pdf format from the SCOO website.

Software tools: SCOO is particularly excited about the release of its web-based decision tool, "FARM" (Field Application Resource Monitor). This app is designed to help ag producers comply with State regulations regarding the timing of application of granular fertilizer or manure with respect to forecasts of precipitation. This app is free and may be used on any device at the FARM website (<https://farm.bpcrc.osu.edu/>). FARM currently has 213 active user accounts.

Research, Projects and Publications

Projects: SCOO played a central role in the development and publication of the Climate Adaptation Plan for the City of Columbus, Ohio. This plan, released in December 2018, is the culmination of 4 years of work on the part of SCOO members Cervenc and Wilson and others at the Byrd Polar and Climate Research Center working in collaboration with elected officials and staff from the City. The plan is available for download from the SCOO and City of Columbus websites.

Other areas of active research include integrated modeling (climate, ecosystem services, economy) to farmer adaptations to climate change and development of the National Soil Moisture Network

Publications: The academic publications authored or co-authored by SCOO members Wilson, Quiring and Mark over the past year are listed on their respective Department or Center websites. Members of the Office are active in their fields of research and continue to publish their findings regularly.

Outreach and Education

Members of SCOO engage in a wide range of outreach and education activities. These include courses taught in the Geography Department at Ohio State University by SCOO members DeGrand, Mark and Quiring. Public talks at various meetings around the state given by SCOO members Wilson, Quiring, Mark and DeGrand. These are too numerous to identify individually. SCOO member Wilson has been particularly active in this regard through his appointment with OSU Extension. Engagements include the following groups: Ag commodities, Kiwanis, Soil and Water Conservation Districts, and Rotary.

Outreach events at the BPCRC planned/coordinated by Cervenc. These are too numerous to identify individually here but a review of BPCRC's Facebook calendar will provide an idea just how engaged the Center is with the academic community at OSU and with Columbus and central Ohio generally.

As part of the North Central Region Water Network's North Central Climate Collaborative, Wilson co-facilitated the Great Lakes Big Rivers Climate Workshop held in Indianapolis, Indiana to help educate and train Extension professionals across the eastern Midwest region on the impacts of a changing climate.

Monitoring and Impact Assessment

SCOO continues to partner with the Ohio Agricultural Research and Development Center (OARDC) in Wooster, OH in the maintenance and expansion of its 13 Ag Weather stations located at research farms around the state. A needs assessment is currently being developed and will provide beneficial information to help guide the development of this network.

Figure: For the third year in a row SCOO sponsored a booth at Ohio's Ag trade show "Farm Science Review".



OKLAHOMA CLIMATOLOGICAL SURVEY



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

Street Address: Oklahoma Climatological Survey
120 David L. Boren Blvd., Suite 2900
City, State, Zip Code: Norman, OK 73072
Phone: 405-325-2541
Fax: 405-325-2550
Website: <http://climate.ok.gov>
Email: ocs@ou.edu

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.

Communication Capabilities

The Mesonet's Marketing team, staffed by members from several other teams, continued to reach out to new advocates and expand the Mesonet's reach via in-person and social media activities. Major events included displays at the two Severe Weather Awareness Expos in Oklahoma City and Tulsa, and the Wildlife Expo in Guthrie. The Mesonet's social media presence on Facebook reached a milestone of 19,000 followers in December 2018, an increase of more than 15,000 over five years. Quarterly and/or Annual Reports for SCIPP and Mesonet can be found on file at the Oklahoma Climatological Survey.

Information Services, Products and Tools

The Mesonet's Climate and Data Services (CDS) team's duties were driven by Oklahoma's weather and climate extremes, as well as customer requests. The year began with severe drought in place across Oklahoma's wheat belt and resulted in severe damage to Oklahoma's winter wheat crop. A substantial amount of time was spent providing input to the U.S. Drought Monitor report. Disparate Drought Monitor depiction requests from surrounding states spurred additional activity securing data from state, county and

local resources. The dry conditions also contributed to perhaps the largest wildfire outbreak in state history in April, with fire complexes burning more than 400,000 acres in the state. The drought and its impacts led to hundreds of information and media requests that were fulfilled by CDS team members. Assistant State Climatologist Monica Mattox returned to her CDS duties following her temporary appointment with the Southern Climate Impacts Planning Program (SCIPP). Monica accomplished an important task with SCIPP as she organized, hosted and spoke at the Oklahoma Drought Plan Advisory Meeting - the first significant step in revamping Oklahoma's outdated drought plan in more than two decades. Al Sutherland, Wes Lee, and State Climatologist Gary McManus produced 49 Mesonet Weather segments for OETA's SUNUP-TV program, airing most Saturday mornings. Gary produced 133 Mesonet Tickers and 12 monthly press releases during 2018.

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 98th Annual Meeting of the American Meteorological Society. Six other Mesonet staff and student employees attended as well. Additionally, Brad chaired the "Network Design and Accuracy" session for the *19th Symposium on Meteorological Observation and Instrumentation* and the conference. Brad performed a major update to the Mesonet Bibliography where he added 219 articles, 89 theses, and 153 dissertations using Mesonet data in their research to the database. This brings the current totals to 955 articles, 204 theses, and 213 dissertations covering 1993-2018. In August, Brad began teaching METR 2603 – Severe and Unusual Weather — where he has a heavy emphasis on utilizing Mesonet data and how it is used in many severe weather aspects.

Outreach and Education

The Mesonet's public safety outreach program, OK-First, had its biggest training year in program history during 2018 with 438 public safety officials receiving training (exceeding the previous high mark of 425 set in 2017). The OK-First program had 694 active members in 2018, spanning a variety of public safety roles. OK-First trains approximately 100 new members each year. Another significant accomplishment was the publication of a journal article in 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 program received a special commendation from the Governor's Office for 20 years of outreach to the public safety community.

K-12 outreach participated in dozens of activities attended by thousands of students and adults. In June, OCS held their sixth Regents camp, "Partly Weather With A Chance Of Fun." Campers were challenged with contouring surface and upper air maps, charting upper air data on skew-T diagrams, and researching weather careers. Students had the opportunity to issue warnings with AWIPS systems provided by NOAA's Warning Decision Training Division. Andrea Melvin traveled to 10 school sites to give career presentations to 8th graders in support of the Oklahoma Regents for Higher Education's GearUP program. This will continue for the duration of the 7-year GearUP grant. The National Weather Festival was held on Oct. 20 with thousands of attendees. Mesonet staff answered questions at the Crawford tower and inside near the OCS front office.

Agricultural outreach underwent a significant change during 2018 with the retirement of longtime Mesonet Extension Specialist Al Sutherland of Oklahoma State in August. Wes Lee, who had been in an assistant role to Al since March, assumed sole responsibility for those duties at that time. The Mesonet's agricultural group was extremely busy during 2018 and didn't miss a beat with the personnel changes. Team members Al, Wes, and Andrea Melvin provided Mesonet booths at numerous meetings and conferences across the state, as well as providing informational talks concerning climate, weather and Mesonet products.

Monitoring and Impact Assessment

During 2018, the Mesonet Calibration Lab and Sensor Development team completed 1505 laboratory calibrations of sensors. Field Technicians made a total of 1259 site visits to Oklahoma Mesonet stations, Little Washita and Fort Cobb ARS stations, repeaters and bases. The Mesonet's Field Operations, Calibration, and Quality Assurance teams resolved 675 trouble tickets and rotation tickets during 2018 in the three networks. The Field team welcomed two new Mesonet technicians onboard during 2018 – Aaron Beckwith and Chris Bieschke. Prior to their addition, technician Kirk Wilson handled maintenance for the entire state, a first for the Oklahoma Mesonet. Kirk was awarded the 2018 OCS Employee of the Year award for his hard work.

OREGON CLIMATE SERVICE

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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. Media in 2018 largely focused on an active fire season, summer drought, and a hot summer. Kathie is one of Oregon State University's most quoted experts in the media. 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. Kathie participated in this trip for the 7th time.

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 helped organize a West Side Water Year drought forum in Lacey, WA with the Office of the Washington State Climatologist and other partners. Kathie coordinates US Drought Monitor inputs with 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. 11 Oregon Counties received a drought declaration from Oregon Governor Kate Brown in 2018.

Research, Projects and Publications

Danielle Moruzzi graduated with a Master's Degree in Atmospheric Sciences in Fall of 2018. Phil and Kathie worked with her on a project that co-developed a drought recovery metric with the state water managers of Oregon, Washington, and Idaho. Kathie is working on manuscript.

Kathie worked with staff from Oregon's federal Congressional delegation to better understand the drought monitor and solicit local input. This culminated in a meeting with Senator Jeff Merkley in DC during the week of the American Geophysical Union meeting.

Outreach and Education

Kathie and Phil give public presentations to various audiences, including state legislative committees and other state agencies. The topics range from climate change impacts, research, drought, and general Oregon climate and weather. Kathie gave an invited talk at a standing room only session at the American Geophysical Union annual meeting on lessons learned from state-level engagement in Oregon.

Kathie has been an active member of AASC, participating on the newly-dissolved value proposition committee.

Monitoring and Impact Assessment

Phil and Kathie co-authored the 4th Oregon Climate Assessment, per the legislation that created the Oregon Climate Change Research Institute. Phil was an author on the Northwest Chapter of the 4th National Climate Assessment.

PENNSYLVANIA STATE CLIMATE OFFICE



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About the Pennsylvania State Climate Office

The Pennsylvania State Climate Office, housed with Penn State's College of Earth and Mineral Sciences, provides support and services to numerous users and clients across the state spanning numerous economic sectors such as agriculture, transportation, and energy. In 2018, 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 2018, over 1100 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 data inventory and display. 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 4-6 requests per week.

Website Analytics:

- The number of visitors to the Climate Office website in 2018 are nearly double the number that visited the site in 2017. In addition, the number of sessions was up nearly 90% compared to 2017. About two-thirds of the visitor base came from Pennsylvania, followed by about five percent of total visitors from the District of Columbia and New Jersey. The extremely wet weather seen during calendar year 2018 was the likely

culprit for some of the increased website traffic.

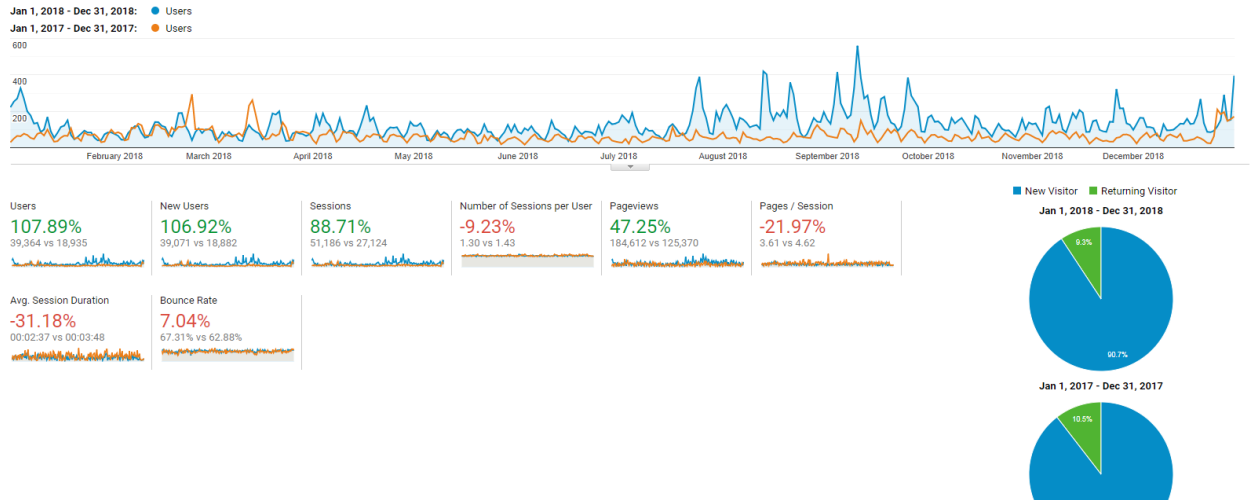


Image courtesy of Google Analytics

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 also available. 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. There are currently about 150 active newsletter subscriptions. The office receives about a dozen data requests per month, with primary users comprised of commercial, educational, and government organizations.

Research, Projects and Publications

- A new study developed by NCEI to gauge use of resources began in late 2017 through 2018. The Pennsylvania State Climate Office participated 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, 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 2018.
- A new statewide mesonet initiative (Keystone Mesonet) was established in June 2018 with assistance of the Pennsylvania Emergency Management Agency (PEMA). A user interface is in development and will be released in the middle of 2019. Additional datasets, such as RAWs and IFLOWS, will be incorporated into this project and archived by the PA Climate Office. An emergency alert system is also in the planning stages to provide real-time weather alerts to users across the state based on mesonet data.

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.

The Pennsylvania Climate Roundtable was hosted at PEMA headquarters in August 2018. This allowed state regional stakeholders, government personnel, state agencies, and other interested parties to discuss the new mesonet initiative being completed by the PA Climate Office. In addition, numerous weather and climate tools were presented to the group to provide exposure and familiarity with different weather and climate data sets. A second roundtable may be scheduled at a later date.

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 the Keystone 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.

SOUTH CAROLINA STATE CLIMATOLOGY OFFICE

State Climatologist: Dr. Hope Mizzell
Assistant State Climatologist for Service: Melissa Griffin
Severe Weather Liaison: Mark Malsick
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About the South Carolina State Climate 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. Subscribers increased from 9,172 subscribers in 2017 to 17,811 in 2018.
- SCO staff worked closely with SCDNR Media Outreach staff members to create a YouTube video and other communication materials for the CoCoRaHS march recruiting contest. These communication and outreach materials aided in the SCO's victory. The outreach video can be found here: <https://www.youtube.com/watch?v=sAZNkP-97w>
- The SCO worked on expanding social media presence via Twitter and Facebook and created user-friendly infographics to summarize South Carolina's weather events and monthly climate.

Information Services

- The SCO averaged 20 monthly phone and email requests for climate data.
- Staff assisted SCDNR Law Enforcement, SC Highway Patrol, and County Solicitor Offices with multiple watercraft, vehicle, and criminal investigations.
- 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, along with an easy PDF version, which can be seen here:
<http://dnr.sc.gov/climate/sco/Publications/2018YearReview.pdf>
- The Drought Response Program requires regular correspondence with 33 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 2018, the SC Drought Response Committee was convened 2 times via teleconference. Prior to Hurricane Florence, the SC Drought Response Committee had planned a third teleconference meeting.
- The office finalized a contract with MetStat for the FEMA Hazard Mitigation Grant to create an Extreme Precipitation and Flood Alert System. Work continued throughout the year to create the application, and work on this project will continue into 2018.

Research, Projects and Publications

- 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. CISA and the SCO collaborated to complete the new South Carolina Drought Portal, <http://www.scdrought.com/index.html>. The webpage won the South Carolina State Library Notable Document Award. This year, the South Carolina State Library selected 12 notable state documents from a pool of 3,000 nominated documents, publications, and webpages. This was the SCO's third year in a row winning a Notable State Document award. The office collaborated with the South Carolina Athletics Department and South Carolina Police Department to complete a preliminary heat exposure study for the South Carolina Gamecocks football stadium heat-health hazards.
- Staff continually developed weekly Crop Moisture and Palmer Drought Severity Index maps.
- Staff developed a comprehensive, user-friendly hurricane and tropical storm database of events affecting South Carolina throughout history. The website was completed and is planned for posting on opening day of hurricane season in 2018.

Outreach and Education

- The SCO provided approximately 26 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 *, American Meteorological Society Annual Meeting*, Palmetto Sportsman Classic, State Hurricane Task Force/ NWS
- Coordination quarterly meetings*, SC State Emergency Response Team Hurricane Workshop, monthly SCDNR Board Meetings*, SC Climate Connections Workshops*, SC Association of Hazard Mitigation*, South Carolina Water

Resources Conference*, and the Carolinas Climate Resilience Conference*, among others.

- The SCO completed approximately 35 media interviews throughout the year.
- The SC State Climatology Office, in collaboration with the Carolinas Integrated Science and Assessments (CISA3) and the SC Water Resources Center conducted the second and third in a series of three one-day educational workshops focused on the impacts of extremes on SC's built and natural environments. The workshops were held in Columbia (2/22) with 72 participants, and Charleston (3/22) with 82 participants.
- State Climate Office staff and staff from SCDNR Media Outreach developed a YouTube Video and other campaign material to promote the recruitment of Community Collaborative Rain Hail and Snow Network observers (CoCoRaHS). During the month of March there is a friendly recruiting contest between all 50 states to see who can recruit the most new volunteers during the 31 days of the month. South Carolina won the 2018 March Madness contest recruiting 178 new observers.
- The State Climatologist serves on various committees for stakeholders in South Carolina, such as the Carolinas Integrated Sciences and Assessments Steering Committee, the Coastal Climate Extension Specialist Advisory Committee, and the American Association of State Climatologists Executive Committee. The State Climatologist is serving as Past President of the American Association of State Climatologists for the period July 2018 to June 2019.

Monitoring and Impact Assessment

- SCO recruited 252 new CoCoRaHS volunteers throughout the year. 178 of these observers were recruited during the CoCoRaHS March Madness competition, which South Carolina won in 2018.
- Of the 887 active observers in SC in 2018, 80 observers have been with the program since 2008 (10 years). 57 observers in SC have been with the program since 2013 (5 years). SC averages around 360 daily CoCoRaHS observations.
- The new South Carolina drought portal is continually updated with monitoring data and information for South Carolina stakeholders.
- The office distributed 60 complimentary rain gages to new CoCoRaHS observers through a Harry Hampton grant.
- Staff were activated to the State Emergency Response Center in response to Hurricane Florence from 9/9 – 9/26 in support of State Emergency Response Team operations. Staff also assisted the South Carolina Flood Mitigation Program in flood damage assessments throughout the impacted areas of South Carolina.
- Staff spent significant time consolidating Hurricane Florence 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, CoCoRaHS Network, and local weather observation networks. Staff teamed with MetStat, Inc. Arvada, Colorado to develop total precipitation and return interval maps for the event. Two Open-file Reports and an ArcGIS Online Story Journal were developed.
 - Interactive On-line Story Journal about Tropical Storm Florence in South Carolina
 - <https://scdnr.maps.arcgis.com/apps/MapJournal/index.html?appid=c2d63441bc974cadd52f0bed7528aae1>

- PDF version of the story journal:
<http://dnr.sc.gov/climate/sco/Publications/TropicalStormFlorenceinSC.pdf>
- Two Open-File Reports were produced on Hurricane Florence
 - Florence Quick Report:
http://www.dnr.sc.gov/climate/sco/Publications/FlorenceQuickReport_100518.pdf
 - Florence Synoptic Review:
<http://dnr.sc.gov/climate/sco/Publications/HurricaneFlorenceSynoptic.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 2018 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 Florence flooding summary.
- 5 exercise weather briefs were provided to SCDOT, SCDPS/HP, and SCEMD.
- Staff issued 11 advisories for Hurricane Florence, 4 advisories for Tropical Storm Michael, 1 advisory for Hurricane Oscar, 7 strong thunderstorm/tornado advisories, 20 tropical advisories/updates, 12 winter weather advisories, and 26 pre-event Weather outlooks for SC Emergency Management Division/SC Department of Public Safety/SC Department of Transportation.
- 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, and a 2018 Hurricane Season forecast at the Governor’s Hurricane Season Seminar.

SOUTH DAKOTA STATE CLIMATE OFFICE

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About the South Dakota State Climate Office

Laura Edwards was appointed the state climatologist in January 2017. Since that time, the state climatologist has been located in Aberdeen, SD, at the SDSU Extension Aberdeen Regional Center. The state climatologist is within SDSU Extension and also affiliated with the Department of Agricultural and Biosystems Engineering at SDSU. There were no other staff, students or faculty employed by the state climate office in 2018.

The SD state climatologist focuses primarily on climate and agriculture but reaches to many areas of SDSU Extension's mission. Individuals and groups that were involved in gardening, human physical and mental health, crops and livestock, natural resources, wildland fire, and youth education are among the many collaborations in 2018. In addition, the state climatologist works with many other entities across the state and region such as: National Weather Service Forecast offices, NOAA Regional Climate Services Director, USDA Climate Hubs, SD Drought Task Force, SD Hazard Mitigation Team, State Fire Meteorologist, state agencies, and other colleges and universities.

Communication Capabilities

The SD State Climatologist primarily utilizes the SDSU Extension Communication staff for news releases, Extension articles and newsletters, and publications. The SDSU Extension website underwent a redesign in late 2018, and the former igrow.org is now the new extension.sdstate.edu website.

The state climatologist is among the most active from SDSU Extension on Twitter and Facebook. As of this writing, there are 1241 Twitter followers and 401 Followers on Facebook.

Most weeks, the state fire meteorologist, Dr. Darren Clabo, publishes a fire, climate and fuels update. The state climatologist contributes a weekly climate summary for this report that is distributed via email, website and often on social media.

Information Services, Products, and Tools

As a part of the SDSU Extension Agronomy team, the state climatologist provides weekly internal weather & climate briefings during the growing season. Any articles that are written in relation to agriculture are also published in the Pest & Crop Newsletter, which is produced weekly in the growing season (mid-April to mid-September) and monthly during the off-season.

In conjunction with the SD Mesonet, grant funds supported the development of an online Spray Tool. This tool provides weather information for pesticide applicators who spray fields with herbicide, fungicide and insecticides. Additional thermometers were added to almost every Mesonet station and the online tool was launched in mid-May 2018. It is a mobile website at mesonet.sdstate.edu/spray.

Research, Projects and Publications

In 2018, the State of South Dakota revised their FEMA All-Hazard Plan. In this revision, the state climatologist was involved in identifying impacts of a changing climate to the hazards that may affect the state. This work was approved by FEMA in early 2019 and thus qualified the state for the Enhanced Plan status.

Other research and projects include:

1. Enhancements of inversion detection, in collaboration with SD Mesonet.
2. Continuation of the North Central Climate Collaborative (NC3), a multi-state team of Extension professionals working on climate issues. Representatives from 12 North Central states and their Land Grant Universities are included in NC3.
3. Continued as SD state liaison for the USDA Northern Plains Climate Hub. The state climatologist and other colleagues hosted the Hub's Extension and Outreach team for their annual retreat in Rapid City in September 2018.

Outreach and Education

Three highlights of 2018:

1. As a follow-on to two consecutive years of drought in western and central South Dakota, the state climatologist collaborated with livestock staff in SDSU Extension for a series of workshops in April 2018. The team held six workshops in three days across the region to discuss drought management strategies and minimizing risk following a drought year.
2. In May 2018, the state drought task force held an in-person meeting in Fort Pierre, SD. That afternoon, a half day Climate Forum was planned to share the seasonal climate outlook, wildland fire outlook, USDA Natural Resource Conservation Service drought tools and resources, NOAA River Forecast Center outlooks, and SDSU faculty research on mental health of farmers. It was a success with about 60 attendees in this first, limited invite event. Similar events are likely in the future.
3. The NC3 team assembled two regional workshops for focusing on climate and Extension work. The first, held in Sioux Falls, SD in October 2018, brought nearly 100 people together to learn about climate science and data, what are the climate science beliefs of farmers and Extension professionals in our region, and adaptation and mitigation methods that are being adopted in the northern Great Plains region. The second, held in Indianapolis, IN in December 2018, was a dedicated workshop and session within the One Water conference.

Media outreach is a frequent occurrence in the SD State Climate Office. There were at least 64 radio interviews, and a handful of newspaper and other online media interviews. More than 15 articles were written for the SDSU Extension website. Many of these articles are reproduced in local and regional newspapers and agricultural publications or cited in radio news stories.

Monitoring and Impact Assessment

The State Climatologist leads a regular discussion about drought conditions around the state. This discussion occurs nearly every week while there is drought in the state, which was most of the 2018 calendar year. Collaborators in the drought discussion include the state fire meteorologist, National

Weather Service office representatives, state geologist, staff from the state Department of Environment and Natural Resources, and SDSU staff and faculty. The state climatologist then provides the group consensus recommendation to the US Drought Monitor authors for consideration in each week's map.

The 2017 Northern Plains Drought Assessment, a multi-state collaborative effort through NOAA's National Integrated Drought Information System, continued with writing and editing during 2018 and will be published in 2019.

The state climatologist has close collaboration with the SD Mesonet, as they are both housed within the Department of Agricultural and Biosystems Engineering at SDSU and work within the same office.

OFFICE OF THE STATE CLIMATOLOGIST, TEXAS



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Undergraduate Assistants: Jeramy Dedrick, Brooke Barker (thru May 2018)

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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 an active web presence through utilization of a webpage (<http://climatexas.tamu.edu>), Facebook site (ClimaTexas), and Twitter account (@climatexas). The webpage and social media accounts were created to provide a range of sources for information delivery to citizens of Texas and those around the world.

The Climate Office joined Facebook in 2014 with a small user following. Over the past four years, we have seen a steady increase in follower count and user engagement. At the end of 2018, the ClimaTexas Facebook boasted 960 follower subscriptions, a 200 follower increase during the last three years, as well as 970 page likes. 63 postings were made on the ClimaTexas page in 2018 that reached 36,000 people, with 180 total shares and 330 total likes. On average, 350 people regularly observe or engage with our posts. Updates of Texas drought conditions and record-breaking weather events regularly garner the largest engagement, with the most popular post receiving 10,300 views, 30 likes, and 50 shares.

Twitter has become one of the main sources for quick and efficient information dissemination to the general public. Since our account creation in September 2016, @climatexas has been on par with this communication evolution. The account follows a small number of users that are mainly Texas National Weather Service offices, NOAA and affiliated services, as well as other verified meteorological and climate accounts. The account concluded its first year with 30 followers, increasing to 180 in 2017, and over 300 ending 2018. @climatexas is frequently used for sharing Texas drought, weather, and climate

information, in addition to tweets from verified accounts that mention our work or are related to the previously mentioned topics. During 2018, our tweets had a total impression count of 122,000 users that were liked or retweeted over 300 times. Tweets that pertained to extreme climatic events, including intense heat waves, record-breaking seasonal rainfall, and the one-year remembrance of Hurricane Harvey amassed the largest engagements throughout 2018.

The Climate Office webpage underwent wholesale revision in 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 frequent updates on the key aspects of climate that are pertinent to Texas citizens.

Information Services, Products and Tools

The Climate Office does not generate climate data on its own. Instead, it serves as a clearinghouse for connecting climate data needs with climate resources. During 2018, the Office received and satisfied 22 data requests via email and phone. 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.

Texas 2036 has funded the OSC to produce analyses of weather and climate historic trends and projections out to the year 2036. This will be the first official set of climate projections from the OSC. The Texas State Climatologist is a member of the Predictions, Predictability, and Applications Interface Panel of the US CLIVAR program. As a panel member, he helps federal agencies engaged in applied climate research to identify research priorities and helps facilitate opportunities for collaboration among climate scientists.

Outreach and Education

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 2018, the State Climatologist made invited presentations to or for the following organizations: Texas A&M AgriLife Extension, Barton Springs Edwards Aquifer Conservation District, Petroleum Accountants' Society of San Antonio, Texas and Southwestern Cattle Raisers' Association, Citizens Environmental Coalition, Houston Geological Society, Southeast Texas Clean Air & Water, Insurance Council of Texas, National Integrated Drought Information System, City of Dallas, Texas Land Trust Council, and Citizens' Climate Lobby. Issues of frequent interest were climate change and impacts on extreme rainfall and flooding.

The State Climatologist fulfilled 93 interview requests and 23 information requests from members of the press in the United States and Canada. He also contributed to ten press releases.

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.

The State Climatologist was a coauthor of the Southern Great Plains chapter of the Fourth National Climate Assessment and was a contributor to the Our Changing Climate chapter.

UTAH CLIMATE CENTER

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Assistant State Climatologist: Dr. S-Y Wang
Staff/Service Climatologists: Dr. Jon Meyer

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About the Utah State Climate Office

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

- Long-term means of April 1 snow water equivalent (SWE) observations projected onto the 4-km grid mesh
- Winter Precipitation
- Inversion Forecast
- The Utah Climate Center's Snow Forecast for the state of Utah
- The Utah Climate Center's First Fall Freeze Forecast for Cache Valley and surrounding areas
- The Great Salt Lake Annual Level Prediction

Research, Projects and Publications

Pokharel, B., S.-Y. Wang, J. D. D. Meyer, R. Gillies, and Y.-H. Lin, 2018: Climate of [weakly-forced yet high-impact convective storms](#) throughout the Ohio River Valley and Mid-Atlantic United States. *Climate Dynamics*, DOI: [10.1007/s00382-018-4472-0](https://doi.org/10.1007/s00382-018-4472-0)

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

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., 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*, doi: 10.1007/s00382-018-4198-z

Outreach, Media and Education

- Sept. 26, 2018 - Career Day Presentation: Becoming a climatologist and observing the weather
 - ~350 High School students
 - Thanksgiving Point Eco Challenge event held in Lehi, Utah. Presented to high school students learning about STEM careers. Weather demonstration and experiments
- Dec. 3, 2018 - School Visit: Utah's Ever-Changing Weather
 - 800 Middle School students
 - Adele C Young Intermediate Middle School. Five groups of 125-140 6th graders. Presentation on weather fronts and storm systems with demonstrations on observing weather instruments.
- Nov. 9, 2018 - Class visit to Climate Center: Observing weather at the Utah Climate Center
 - 150 students
 - Ellis Elementary students visited Climate Center (3 groups of ~50 students). Presentation on extreme weather and demonstration of instruments
- Sept 17, 2018 - Guest Lecture/Class Visit Changes in Utah's Climate
 - 20 Students
 - Physical Geography Lab visited Climate Center to learn about Utah's climate patterns, research conducted at USU and the tools the UCC offers.
- May 11, 2018 - School Visit: Observing weather at the Utah Climate Center
 - 150 elementary students
 - Bridger Elementary students visited climate center for presentation on extreme weather and observing weather instruments.
- May 8, 2018 - School Visit: Observing weather at the Utah Climate Center
 - 75 students
 - Visited Preston, Idaho middle school to present on climate science and Utah's climate cycles. Presentation on weather observing instruments
- March 7, 2018 - School Visit: Observing weather at the Utah Climate Center
 - 200 students
 - Visit to Ellis Elementary students using CoCoRaHS gauges to learn about weather patterns. Presented on extreme weather and how weather is measured.
- Feb 21, 2018 - School visit: Observing weather at the Utah Climate Center
 - 80 elementary students

- Edith Bowen Lab School elementary students visited UCC to learn about weather extremes, Utah's weather cycles and how weather is observed along with interactive demonstration with instrumentation.
- Mar 17, 2018 - Guest Lecture: Climate Change in the Western U.S.
 - 30 undergraduate students
 - Guest lecture for Layne Coppock's course ENVS 3330
- Dec 5, 2018 - Cache Valley Daily
 - Online Story
 - Inversion Season
- Oct 18, 2018 - Cache Valley Daily
 - Online Story
 - Drought Condition and expectations through the upcoming winter
- Oct 4, 2018 - Park Record
 - Newspaper
 - <https://www.parkrecord.com/opinion/for-the-record-oct-6/>
- Sep 23, 2018 - Logan Herald Journal
 - https://www.hjnews.com/opinion/columns/editor-s-corner-predicting-the-coming-winter-with-science-folklore/article_77e0daf8-3f99-5442-b112-7c829d470667.html
- Aug 4, 2018 - Logan Herald Journal
 - https://www.hjnews.com/news/local/smoke-persists-in-cache-valley-skies/article_5733a807-9b28-5880-8200-f07a1954837e.html
- Mar 13, 2018 - Salt Lake Tribune
 - <https://www.sltrib.com/news/environment/2018/03/13/utah-governor-asks-residents-to-pray-for-snow-but-this-winter-is-still-among-the-five-driest-in-states-history-and-thats-the-good-news/>
- Feb 20, 2018 - KSL TV
 - <http://ksltv.com/391485/utah-gradually-getting-less-snow-more-rain-climatologists-say/>
- Feb 7, 2018 - Logan Herald Journal
 - https://news.hjnews.com/allaccess/experts-low-snowfall-this-winter-precursor-to-utah-s-future/article_582532be-7ced-5072-bbcb-1411315def8f.html
- Dec 3, 2017 - KUTV
 - Interview with Sterling Poulson: We're working on a story for next week about the changing climate in Utah. With it being such a dry November, we'd like to discuss if this is the new normal, are seasons now pushing later than usual, what are the projections for this trend over the next several decades? Can you show us the projections and the history of the temps and precipitation from the past ten years or so showing this pattern?

Monitoring and Impact Assessment

<https://climate.usu.edu/mchd/index.php>

<https://climate.usu.edu/traps/>

VERMONT STATE CLIMATE OFFICE

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state.climatologist@uvm.edu (queries)



About the Vermont State Climate Office

The Vermont State Climate Office (VTSCO) received its ARSCO recognition in June 2005. The office is housed within the Department of Geography at the University of Vermont (UVM) & State Agricultural College, a land-grant institution that emphasizes outreach as one of its core missions. The VTSCO is located in a laboratory setting donated by the Geography department. National Science Foundation (NSF) and NOAA Climate Database Modernization Program (CDMP)-funded equipment, archival publications and documents are housed there, with adequate facilities for the undergraduate and graduate assistants.

The core mission of the VTSCO is to provide climate research and services to Vermonters and other constituents (university researchers, policy makers, state agencies, legal firms or school children) in a timely and efficient manner. This is facilitated via a dedicated website and e-mail address.

With the loss of the VTSCO graduate research assistant in AY 2010, undergraduate interns have provided assistance since then. A NOAA PACE (Postdocs Applying Climate Expertise) postdoctoral fellow, Dr. Evan Oswald, was also affiliated with the VSCO for the period 2013-2015.

Communications Capabilities

- The VTSCO website (<http://www.uvm.edu/~vtstclim>) continued to serve as the portal for disseminating information and research.
- AMS (American Meteorological Society) Applied Climatology Committee member - national liaison to the NOAA Regional Climate Centers and the American Association of State Climatologists
- Provided free data, expert opinions and recommendations via the telephone, facsimile, electronic mail and regular mail

Information Services Products and Tools

Handled 23 email requests. These ranged widely and included: Vermont State Agencies working wind energy and annual snowfall updates; town planning updates; specific town weather data requests; professional opinion about weather and climate tools and zones for planting; data for use in classes; and students seeking career advice following graduation.

Research, Projects and Publications

- Lead author of the Northeast chapter of the Fourth National Climate Assessment.
Dupigny-Giroux, L.A., E.L. Mccray, M.D. Lemcke-Stampone, G.A. Hodgkins, E.E. Lentz, K.E. Mills, E.D. Lane, R. Miller, D.Y. Hollinger, W.D. Solecki, G.A. Wellenius, P.E. Sheffield, A.B. MacDonald, and C. Caldwell, 2018: Northeast. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.CH18
- *peer reviewed by scientists at 13 US federal agencies & the National Academies of Science, Engineering and Medicine.*
- *invited briefings given to the New England Federal Partners (13 federal agencies); EPA Region 1; National Weather Service Climate Focal Point members; International Joint Commission.*
- Oswald, E.M. Pontius, J., Schaberg, P., Rayback, S.A., Wilmot, S.H. and Dupigny-Giroux, L.-A., (2018) “The complex relationship between climate and sugar maple health: climate change implications for a key northern hardwood species, *Forest Ecology and Management*, doi.org/10.1016/j.foreco.2018.04.014.
- Dupigny-Giroux, Lesley-Ann; Cole*, Amanda. (2018) “Climate Literacy and Education.” In *Oxford Bibliographies in Geography*. Ed. Barney Warf. New York: Oxford University Press, DOI: 10.1093/obo/9780199874002-0191.

Outreach and Education

- 3 invited presentation on climate and climate change to a) 20th Annual Science Immersion Workshop for Journalists: Global Impacts: Climate Change and Extreme Weather at the University of Rhode Island; b) Osher Lifelong Learning Institute (OLLI) at UVM Distinguished Lecture Series and; c) AMICA Officer Breakfast Leadership Series, AMICA Corporate Headquarters, Lincoln Rhode Island.
- Fourth National Climate Assessment activities:
 - poster presentation at the American Geophysical Union meeting (Washington D.C.)
 - invited panelist at the AASC meeting (Nebraska City, NE)
 - 12 print, radio and television interviews, including 3 Public Radio stations in New England and 2 national affiliates.
- Continued the activities of the Vermont Weather and Climate Research group.

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 within (and part of) the Department of Environmental Sciences. The AASC has designated it the State Climate Office for Virginia, and it is recognized as such by NOAA. 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. This information is regularly provided to government (Federal, state, and local), education, industry, the media and individuals. Its on-line, *Climate Advisories* feature climate research and 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 (VOIP) phone, fax, email and videoconferencing capabilities with high-speed network service, and ready access to the UVa's extensive network development, software and programming services. The office maintains a web site devoted to 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 on PBS, public access channels, and agricultural networks. This collection is archived on YouTube.

The office frequently provides interviews to print, radio, television and web-based media, including taped and live broadcasts and regular radio call-in shows. The University also makes informational webcasts, podcasts, and general news releases. The office has been involved in a number of legal cases, including the provision of 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 relationships between weather 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 seasons 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 During 2018:

- 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 each of 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 and decision making 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 timing for objectively defined seasons across the US.

OFFICE OF THE WASHINGTON STATE CLIMATOLOGIST



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Assistant State Climatologist: Karin Bumbaco, MS
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About the Office of the WA State Climatologist

This report summarizes the Office of the Washington State Climatologist (OWSC) activities during the 2018 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 357 “likes” on Facebook and 701 followers on Twitter.

Information Services, Products and Tools

We completed an update and redesign of our most popular web-based tool in 2018, hiring a part-time assistant (University of Washington atmospheric science graduate, Matt Rogers) to co-lead the effort. Built in Tableau, our PNW Temperature, Precipitation, and Snow Water Equivalent Trend Analysis Tool now allows trends for multiple stations to be viewed at once and indicates whether each linear trend is significant at the 95% confidence level for user-specified time periods (>30 years): <http://www.climate.washington.edu/trends/>. The tool uses NOAA's USHCN dataset and NOAA's climate division data. It includes stations in WA, OR, ID, and western MT, but could be easily replicated for other regions of the country if other state climate offices are interested.

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 150 of these data requests, which varied greatly in topic from inquiries about specific weather events (e.g., summer dry spell, summer wildfire smoke) to requests for ENSO and seasonal forecasts. The 150 requests are substantially greater than the 90 requests fulfilled in 2017. We suspect that this increase is due to our better reporting mechanisms, as a result of our participation in the AASC/NCEI User Engagement Project, rather than an increase in visibility for OWSC. On the other hand, 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 588 subscribers, about 30 of which were new subscribers in the last year.

Research, Projects and Publications

As mentioned above, OWSC participated in the NCEI/SCO User Engagement Project for 2018, where we recorded detailed notes on our data requests, presentations, and media inquiries. When relevant, we noted the NCEI and Regional Climate Center products that were used to fill those requests to help those partners understand their reach. This proved to be a useful, win-win project, with both OWSC and our partners having an increased understanding of the requests fulfilled during the year.

As previously reported, OWSC worked with the WA State Department of Ecology to update the state's drought plan from 2016 through 2018. The plan is still in review and is listed as follows:

Publications

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

Contributing authors to:

PSEMP Marine Waters Workgroup, 2018. Puget Sound marine waters: 2017 overview. S.K. Moore, R. Wold, K. Stark, J. Bos, P. Williams, N. Hamel, S. Kim, A. Brown, C. Krembs, and J. Newton (Eds).
URL: www.psp.wa.gov/PSmarinewatersoverview.php

Outreach and Education

OWSC has continued outreach and education activities over the 2018 calendar year, including presentations in conferences, guest lectures, talks to the general public, and outreach activities. Some examples include:

- NIDIS Bi-Monthly Webinar (current PNW climate conditions)
- Dept. of Ecology's Water Resources Advisory Committee (2018 water year review)
- Keynote Speaker for Northwest Hydropower Association (historical water supply and climate change projections)
- OR-WA Water Year 2018 Recap and 2019 Outlook meeting (climate recap and outlook)
- NW Avalanche Center Annual meeting (fall and winter forecast and new forecast methods)

In addition to the types of presentations listed above, OWSC performed a half-day training to about 40 staff at WA's Dept. of Health representing a broad range of program areas (zoonotic disease, drinking water, shellfish safety, wastewater, environmental epidemiologists, etc.). We provided an introduction to types of weather and climate networks available in WA state, examples of public health usage of weather data, and did a hands-on exercise where participants practiced gathering weather and climate data on their own for a hypothetical norovirus outbreak scenario. Overall, continuing engagement with the Dept. of Health was the overall goal.

Media requests are also a part of the office's regular involvement with the public. In 2018, an unusually dry summer and widespread impacts from wildfire smoke throughout the state caused some increased media interest during the summer months. Over the past year, OWSC was interviewed approximately 60 times by radio, TV, and print journalists. Some examples include:

- National Geographic (normal summer weather and wildfire smoke)
- KING5 News (ENSO and winter weather)
- Wall Street Journal (ocean temperatures and history of "blob")
- Q13 Fox (snowpack and water supply)
- Seattle Times (editorial on snowpack trends in WA)

Monitoring and Impact Assessment

As mentioned in previous reports, OWSC has been a participating member of the Water Supply Availability Committee (WSAC) to support the state agencies in monitoring drought. OWSC continued to provide monitoring and forecast information to the WSAC in 2018.

OWSC lead weekly discussions with partners to provide recommendations for the US Drought Monitor map in 2018, beginning in June 2018 through the end of the calendar year, when there were drought conditions present in the state.

WEST VIRGINIA STATE CLIMATE OFFICE

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About the West Virginia State Climate Office

Prior to 2008, the West Virginia State Climate Office (WVSCO) was located at West Virginia State University. Until that time, West Virginia State University was the only university with a meteorology program in the state. However, that program was discontinued and Marshall University began to develop a meteorology program under the direction of Dr. Kevin Law. In 2008, the WVSCO moved to Marshall University where Dr. Law was named State Climatologist. The mission of the 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 and government agencies have contacted the office. The WVSCO has also provided legal counsel and drafted reports to be used in trials.

Communication Capabilities

The WVSCO maintains communications via its website through the Marshall University Department of Geography.

Information Services, Products and Tools

The WVSCO continues to remain active with the CoCoRaHS network and participated in new recruiting activities. The office has also provided legal consultation and expertise when needed.

Research, Projects and Publications

The office presented research on West Virginia Tornado Climatology at the Southeast Division of the Association of American Geographers meeting in Johnson City, TN. The research is planned to be submitted for publication in Southeastern Geographer.

Outreach and Education

The WVSCO assists in climatic education and has participated in various events around the state including career and science fairs at elementary schools and invited speaking engagements in the community.

Monitoring and Impact Assessment

A state record precipitation COOP station in WV is a possibility for 2018. Consultation has begun with the responsible National Weather Service office and a State Climate Extremes Committee may be formed to examine the validity of the station.

2018 Weather and Climate in Review

Temperatures fluctuated across West Virginia throughout 2018, but the year will long be remembered for being extremely wet. The entire year exhibited positive departures precipitation departures. Figure 1 shows January-March precipitation departures averaging between 3-5" above normal across the state. Spring values (Figure 2) were slightly less but dramatically increased in fall (Figure 3). Precipitation was 7-13" above normal over much of the state due to the remnants of some tropical systems. October to December values (Figure 4) were above normal too, albeit much less than the previous three months. Charleston broke their record for the most precipitation in a year with 66.56".

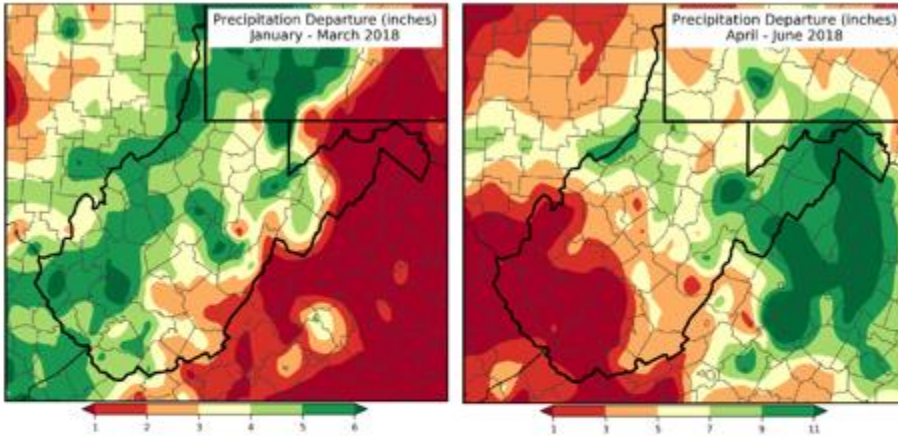


Figure 1: January – March
Precipitation Departure (in).

Figure 2: April – June
Precipitation Departure (in).

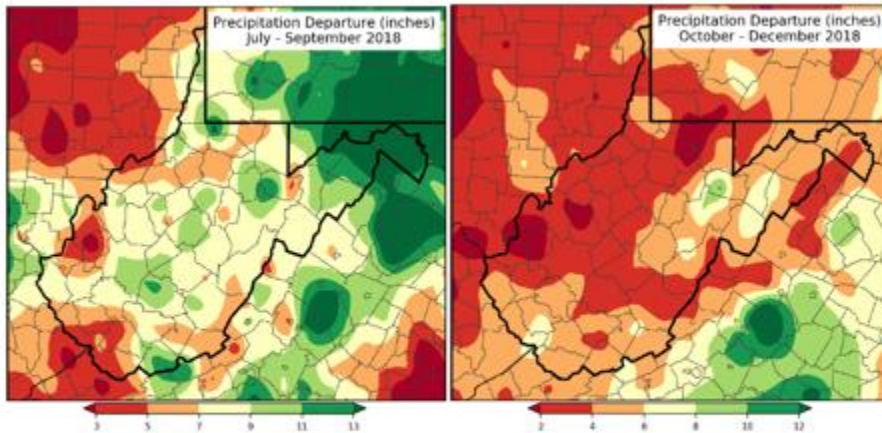


Figure 3: July – September
Precipitation Departure (in).

Figure 4: October – December
Precipitation Departure (in).

WYOMING STATE CLIMATE OFFICE

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Websites: <http://www.wrds.uwyo.edu> http://www.wrds.uwyo.edu/sco/climate_office.html
<http://library.wrds.uwyo.edu> <http://waterplan.state.wy.us>
<http://wwdc.state.wy.us> <http://wyofloods.wrds.uwyo.edu>

Social Media:

Facebook: WyomingClimateWater, WyomingCoCoRaHS

Twitter: @WyomingClimateWater, @WyomingCoCoRaHS

YouTube: WyomingWaterClimate

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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 1966 and in the following year the Wyoming Legislature set in motion the Water Planning efforts which WRDS became involved. More than 50 years later, one of our primary functions continues to be to support the State's Water Planning Program. The WRDS/SCO is housed within the Department of Civil and Architectural Engineering at the University of Wyoming and is funded primarily via the Wyoming Water Development Office.

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.

Communication Capabilities

WRDS/SCO is housed on the University of Wyoming campus which allowed us to take early advantage of the available high-speed network infrastructure through which we continue to serve our various products online. WRDS/SCO has had an online presence predating the World Wide Web and later, after its creation, became one its early adopters (one of the "pre-1995 sites"). 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 State Coordinator for CoCoRaHS (the Community, Collaborative, Rain, Hail, & Snow Network), Facebook and Twitter channels have been created to enhance this outreach effort with about 250 and 90 followers respectively. The WRDS/SCO itself has over 1160 followers on its Facebook page. The number of Twitter followers is 85+ which is more than a 70% increase over last year. Growth is slow at times but steady.

We use these platforms primarily as a means of announcing events, new products, or noteworthy climate/water related news with mixed results. We have found that information-laden posts often do not have the impact that a single timely and catching image does. A meeting announcement may garner 100-200 views but a simple picture of a snow-ruler stuck in the snow showing 9.5” snowfall from the recent blizzard captured almost 4000 views. Judging from the number of referrers from Facebook, the platform falls short of expectations and we are exploring ways to improve that.

WRDS/SCO enjoys having a high number of repeat users who access our sites directly. Direct access (i.e., from bookmarks) is, in fact, the highest percentage of our referrers. While this user loyalty is good, we strive to continue increasing our number of users and, to do this, people need to be able to find us. We are continually optimizing our products to achieve higher rankings in search engines. Along with this comes having pages that are accessible to a wide range of users on various devices, and we continue to transition to fully responsive web pages to provide a viewing experience that is just as fulfilling on a smart-phone as it is on a desktop computer.

Information Services, Products and Tools

The WRDS/SCO still receives a few hundred traditional data requests per year. The bulk of these are now by email with a lesser percentage being made by phone. We did still receive two hardcopy letters in 2018 requesting climate information.

Active or direct requests like these have steadily declined since 1997 while the passive type of data request (where the user chooses from products already online) continues to go up. We expect this to continue as we increase our product presence online.

While we lost a position in 2018 due to State budget cuts, our functions and activities have increased. One result of the position loss is that we have consolidated our hardcopy Library and have begun to transition it to a digital-only presence. Although we are sorting the physical collection into parts that we will still retain in-house, this will be only a fraction of the overall collection. Documents that we have the ability and permission to will be digitized and served online through the Digital Documents section of our website. We continue to receive about 20 new Water Development Project Reports a year and these are placed online and linked to our Water and Climate Atlas map server.

Digitization of historical water diversion records for the Wyoming State Engineer’s Office continues. These data are often consumed by State Water Plan studies for determining water availability in a given River Basin or watershed.

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.

Below represents presentations and publications for CY 2018.

- Bergantino, A.R. (2018). [Wyoming Climate Summary - Water Year 2018](#), Water Resources Data System/State Climate Office, Laramie, WY, 37 pp.
- Bergantino, A.R. (2018). The Climate of Wyoming, in *Navigating Drought in Wyoming (B-1395)*, Brian Sebade, (Ed.) University of Wyoming Extension, Laramie, WY, June 2018
- Bergantino, A.R. (2018). Just like precipitation, measuring moisture takes many forms, in *Navigating Drought in Wyoming (B-1395)*, B-1395, Brian Sebade, (Ed.) University of Wyoming Extension, Laramie, WY, June 2018
- Nicholson, C.M. and Hatch, R., (2018). From Drifts to Dams: Following Wyoming’s Water Resources through Story Maps, Presented at GIS in the Rockies Conference, Denver, CO, September 2018.
- Nicholson, C., J.J. Shinker, V.M. Hanway, and S. Zavala, 2018., The Influence of Atmospheric Circulation on Abnormal Snowpack Melt-Out Events and Drought in Wyoming. *Journal of American Water Resources Association*. 1-17. <https://doi.org/10.1111/1752-1688.12697>.
- Hatch, R., and C. Nicholson, 2018. From Drifts to Dams: Following Wyoming’s Water Resources through Story Maps. Presented at the 2018 GIS in the Rockies Conference, Denver, CO.
- Hatch, R., Nicholson, C.M., & Bergantino, A.R. (2018). [Explore Wyoming's Climate, Snowpack, and Water Information Using the Wyoming Water and Climate Atlas](#). Presented at Elevations Geospatial Summit, Saratoga, WY, May 2018.
- Sharma, V., Nicholson, C.M., Bergantino, A.R., Cowley, J., Hess, B.W., & Tanaka, J. (2018). [Wyoming Agricultural Climate Network \(WACNet\)](#), in *Field Days Bulletin*: University of Wyoming, Wyoming Agricultural Experiment Station, p. 52-53.

Outreach and Education

WRDS/SCO participated in several conferences over the past year during which we displayed 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 via 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. Some of the conferences, meetings, etc. attended in 2018 include:

- Western States Water Council WIMS workshop, Pasadena CA: Jan 16-18
- High Plains Organic Farming Conference, Cheyenne WY: Feb 28
- Popo Agie Conservation District Expo, Lander WY: April 14
- WyGEO Meeting, Saratoga WY: May 2-4
- GIS In the Rockies, Denver CO: September 19-20
- Colorado River Basin Drought Contingency Planning Meetings, Baggs, Rock Springs, and Pinedale, WY: October 9-11
- WyGEO Meeting, Douglas WY: October 17-19
- Wyoming Water Association, Laramie WY: October 24-26
- Wyoming Association of Conservation Districts, Evanston WY: Nov. 14-16

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.

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.

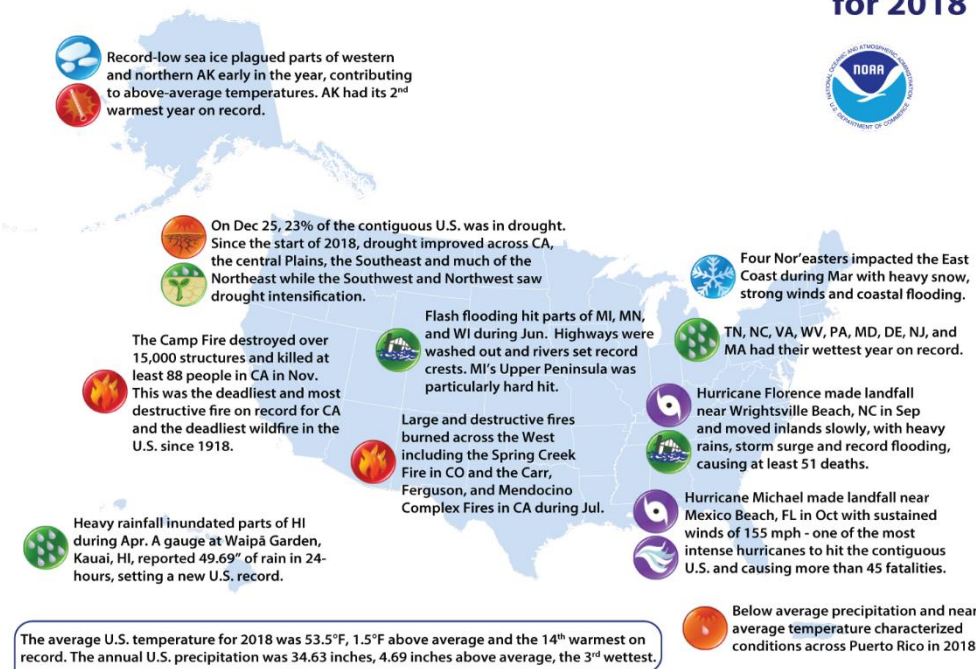
WRDS/SCO along with the State Engineer's Office (SEO) is participating in the Upper Missouri River Basin Monitoring Program. This program is an outgrowth of the 2011 floods along the Missouri River and a call for additional monitoring to assist with spring run-off forecasts. There is legislation in Congress to provide funds for improvements to the current monitoring network, which includes funds for more soil moisture equipment and better equipment to measure snow (weighing gages, optical snow sensors, etc.) WRDS will be working with the SEO and University of Wyoming AG Extension Office to assist them with upgrades to their current stations. WRDS/SCO personnel will be serving on the Data Management Plan, Affected Stakeholders, and University Governance Committees.

In 2018 WRDS/SCO started taking part in the National Mesonet Program to provide data from 19 of the 25 stations in the Wyoming Agricultural and Climate Network (WACNet). We anticipate disseminating data from the remaining six stations in 2019 with hopes of adding stations and instrumentation.

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.

NOAA 2018 United States Climate Summary

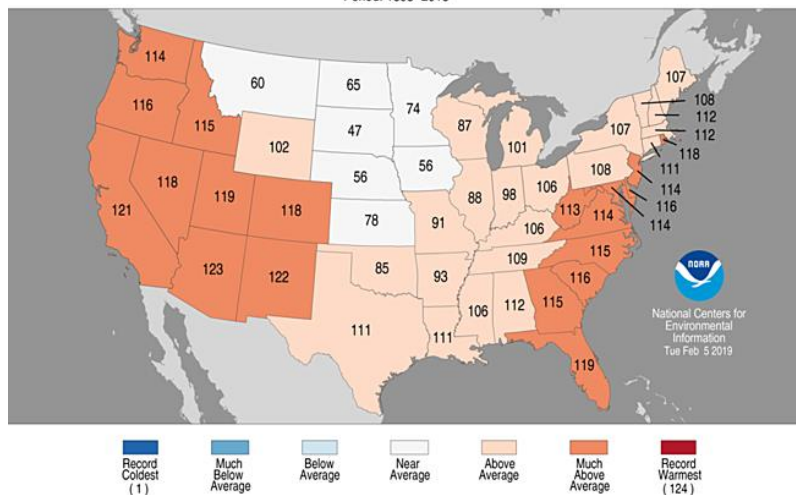
U.S. Selected Significant Climate Anomalies and Events for 2018



Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>

Annual Temperature and Precipitation Analysis

Statewide Average Temperature Ranks January–December 2018 Period: 1895–2018



Based on preliminary analysis, the average annual temperature for the contiguous U.S. was 53.5°F, 1.5°F above the 20th century average. This was the 14th warmest year on record and the 22nd consecutive warmer-than-average year for the U.S. (1997 through 2018). 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

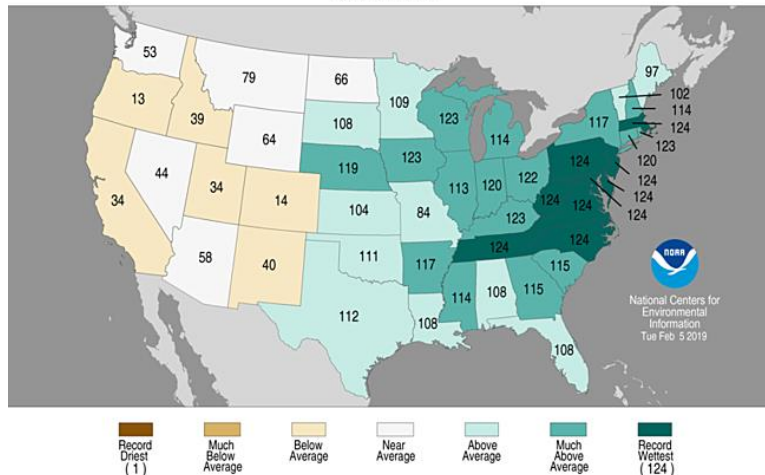
of 1.5°F per century. Nationally, the [average minimum \(low\) temperature](#) was 42.0°F, the seventh warmest on record, while the [average maximum \(high\) temperature](#) was 65.1°F, which is warmer than average.

This was the coolest year since 2014 and the first year in the last four where the annual temperature for [some states](#) was near average. No state ranked record warm for the first time since 2009. Arizona ranked second warmest, New Mexico, third and California was fourth warmest. Fourteen states in the West and Southwest as well as the Southeast and Mid-Atlantic states had annual temperatures which ranked among the 10 warmest on record. [Alaska](#) had its second warmest year on record in 2018. Much of the year was characterized by above average to near-record temperatures, often record breaking.

Statewide Precipitation Ranks

January–December 2018

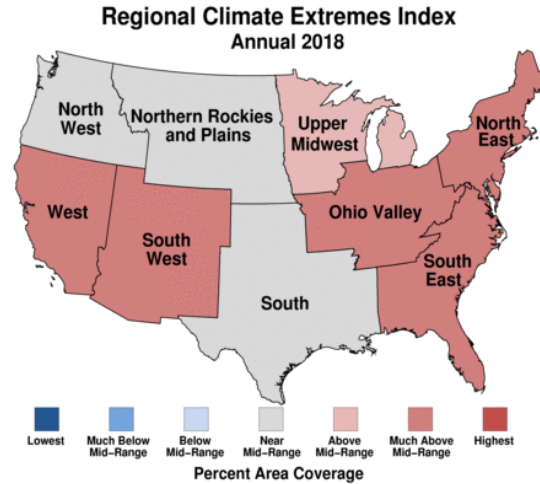
Period: 1895–2018



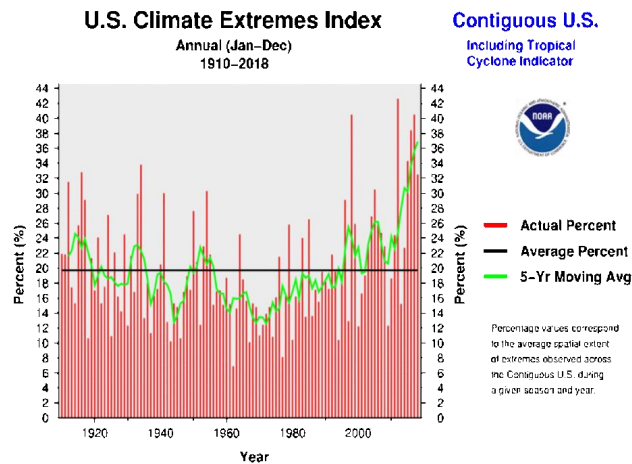
The [contiguous U.S. average annual precipitation](#) was 34.63 inches, which is 4.69 inches above the long-term average. This made 2018 the 3rd wettest year on record for the nation, and the sixth consecutive year with above-average precipitation. Since 1895, precipitation across the CONUS has increased at an average rate of 1.81 inches per century.

It was an above-average year for precipitation from the Great Plains to the Atlantic Coast. Nine states had their wettest annual period on record including: [Tennessee](#), [North Carolina](#), [Virginia](#), [West Virginia](#), [Maryland](#), [Delaware](#), [Pennsylvania](#) and [Massachusetts](#). Below-average precipitation was observed in parts of the Southwest, West and Pacific Northwest. Several locations along the North Carolina coast and the southern Appalachians observed annual precipitation totals of [100 inches or more](#) for the first time in their observational history. Stations in several states along the East Coast set all-time single-station annual precipitation records for their states, according to preliminary data. These apparent records will be investigated by the [State Climate Extremes Committee](#) in the coming weeks. A persistent wet pattern across the Southeast coupled with tropical precipitation contributed to the above average and record precipitation observed during 2018. One of the largest contributors to the annual totals included the record widespread rainfall, which occurred across parts of North Carolina, South Carolina and Virginia associated with Hurricane Florence in September. Florence moved inland, slowly, bringing heavy and steady rains across a large swath of the region, with many reports of between two and three feet of rainfall.

According to the [U.S. Drought Monitor](#), drought extent peaked at 39.6% of the contiguous United States in early February 2018. Drought became less intense across much of California by the end of 2018 and was eliminated across parts of the central Plains, Southeast and much of the Northeast. In the Southwest and Northwest, drought intensified as 2018 progressed.



Climate Extremes Index



The U.S. Climate Extremes Index (USCEI) for 2018, when taking into account landfalling tropical cyclones was 66% above average, and ranked as the eighth highest annual USCEI in the 109-year record. When excluding the tropical cyclone component, the USCEI remained 66% above average and ranked as the ninth highest on record. On the national scale, extremes in warm minimum temperatures (fifth highest) and days with precipitation (highest) contributed to the elevated USCEI. Note, each of these components only look at the contiguous United States. Regionally, the USCEI was the second highest for the Southwest and fifth highest for the Southeast.

2018 Regional Center Summaries

Northeast Region



Northeast Regional Climate Center

2018 averaged out to be 47.3 degrees F (8.5 degrees C) for the Northeast, which is near normal. The annual average temperature for eight of the region's twelve states averaged out to be within 0.5 degrees F (0.3 degrees C) of normal. Temperatures for all states ranged from -0.3 degrees F (0.2 degrees C) below normal in New Hampshire to 1.7 degrees F (0.9 degrees C) above normal in Delaware. The Northeast had its third warmest February since 1895 with an average temperature of 32.1 degrees F (0.1 degrees C), 5.9 degrees F (3.3 degrees C) above normal. It was the warmest February on record for Connecticut, Massachusetts, and Rhode Island, as well for as five major climate sites. From February 20 to 21, twenty major climate sites had their all-time warmest February day on record. In fact, for 15 sites, it was the all-time warmest winter day on record. Colder than normal temperatures on April 15 caused Concord, New Hampshire, to have its latest high temperature of 32 degrees F (0 degrees C) or colder. West Virginia had its warmest May on record, as did six major climate sites. July was record warm for Burlington, Vermont, and Caribou, Maine. With an average temperature of 71.4 degrees F (21.9 degrees C), 3.3 degrees F (1.8 degrees C) above normal, the Northeast had its second warmest August since record keeping began. It was the warmest August on record for Connecticut, Delaware, Massachusetts, New Hampshire, and Rhode Island. Five major climate sites also had their warmest August on record. Rhode Island had its warmest summer on record, as did Caribou, Maine. The Northeast had its third warmest September on record with an average temperature of 64.9 degrees F (18.3 degrees C), 4.3 degrees F (2.4 degrees C) above normal. September was record warm for Delaware, Maryland, and West Virginia. Elkins, West Virginia, and Atlantic City, New Jersey had their warmest September on record, while Erie, Pennsylvania, had its greatest number of September days with a high of at least 90 degrees F (32 degrees C). On October 8, Erie, Pennsylvania, tied its all-time warmest October temperature on record with a high of 89 degrees F (32 degrees C). With low temperatures ranging from 70 degrees F (21 degrees C) to 72 degrees F (22 degrees C) on October 9, Rochester, New York; Erie, Pennsylvania; and Syracuse, New York, set/tied their all-time warmest minimum temperature records for October. On November 2, Atlantic City, New Jersey, had its highest minimum temperature for November with a low of 66 degrees F (19 degrees C). An unseasonably cold air mass settled over the Northeast during the Thanksgiving holiday (November 22 to 24), with temperatures up to 35 degrees F (19 degrees C) below normal. In the coldest areas, low temperatures were below 0 degrees F (-18 degrees C) and high temperatures were in the single digits (degrees F). These were some of the all-time coldest November temperatures on record for the Northeast. Six major climate sites recorded their all-time coldest temperatures on record for November. In addition, six sites had their all-time lowest maximum temperatures for November on record. It was the coldest Thanksgiving Day on record for Buffalo and Rochester, New York.

The Northeast had one of its wettest years on record receiving 57.35 inches (145.67 cm) of precipitation, 129 percent of normal. 2018 also ranked among the wettest years on record for Connecticut, Delaware, Maryland, New Jersey, Pennsylvania, Rhode Island, and West Virginia. Precipitation for all states ranged from 99 percent of normal in Vermont to 157 percent of normal in Maryland. In addition, eight major climate sites had their wettest year on record. On January 23, Caribou, Maine, had its largest one-day precipitation total for January with 1.72 inches (43.69 mm) of precipitation. Pennsylvania and West Virginia had their wettest February on record, as did six major climate sites. It was a record wet May for Maryland. Pennsylvania had its wettest July since recordkeeping began. Four major climate sites also had

their wettest July on record. August was record wet for Concord, New Hampshire. It was the wettest summer on record for Pennsylvania, as well as for Dulles Airport, Virginia, and Williamsport, Pennsylvania. With 6.62 inches (168.15 mm) of precipitation, 169 percent of normal, the Northeast had its third wettest September since 1895. West Virginia had its wettest September on record, as did five major climate sites. The Northeast had its third wettest November on record with 6.17 inches (156.72 mm) of precipitation, 161 percent of normal. Delaware, Maryland, and Massachusetts had their wettest November on record. Seven major climate sites also had their wettest November on record. On November 2, Allentown, Pennsylvania, had its wettest November day on record with 3.45 inches (87.63 mm) of precipitation. The Northeast had a record wet autumn, receiving 17.21 inches (437.13 mm) of precipitation, 148 percent of normal. Maryland, New Jersey, Rhode Island, and West Virginia had their wettest autumn on record, as did ten major climate sites.

According to the U.S. Drought Monitor released on January 4, 2018, 5 percent of the Northeast was in a moderate drought and 19 percent of the region was abnormally dry. During the month, drought and abnormal dryness lingered or slightly expanded. By month's end, conditions worsened in parts of Maryland, leading to the introduction of severe drought. Below-normal streamflow and groundwater levels were reported in some areas, especially those experiencing severe drought. The U.S. Drought Monitor released on February 1 showed 5 percent of the Northeast was in a severe or moderate drought and 21 percent of the region was abnormally dry. Above-normal precipitation throughout February drastically improved drought conditions, leaving just 2 percent of the Northeast abnormally dry and a small area of moderate drought in Maryland (based on the U.S. Drought Monitor released on March 1). Dry conditions persisted but improved in Maryland during March, with the U.S. Drought Monitor released on April 5 showing less than 1 percent of the Northeast in a drought and 1 percent as abnormally dry. Dryness lingered in Maryland through most of April, with the U.S. Drought Monitor released on May 3 indicating 2 percent of the Northeast was abnormally dry. By late May, dryness had eased in Maryland, but New England began to dry out and abnormal dryness was introduced. The U.S. Drought Monitor released on May 31 showed 1 percent of the Northeast as abnormally dry. A water ban was enacted in Northampton, Massachusetts, on June 15 as a result of the increasingly dry conditions throughout the area. Dry conditions also prompted over 75 Public Water Suppliers to enforce varying degrees of water bans in other locations throughout Massachusetts. Dryness expanded to include New York by mid-June, and moderate drought was introduced in northern New England by late June. The U.S. Drought Monitor released on July 5 showed 6 percent of the Northeast in a moderate drought and 27 percent of the region as abnormally dry. Reduced harvests and heat stress caused problems for growers in parts of northern New England. During July, drought and abnormal dryness eased in some parts of New York and New England but expanded in other parts of these states, with the U.S. Drought Monitor released on August 2 showing 9 percent of the Northeast in a moderate drought and 18 percent of the region as abnormally dry. During August, dry conditions lingered but improved across New York and New England. By month's end, 7 percent of the Northeast was in a moderate drought and 13 percent was abnormally dry (based on the U.S. Drought Monitor released on August 30). In September, conditions worsened in northern New England and northern New York, with the introduction of severe drought, but dryness eased in southern New England. Farmers in northern New York reported decreased hay and pasture production. In Aroostook County, Maine, dry conditions contributed to a hay shortage and allowed bedstraw, an invasive plant species, to flourish, reducing the number of acres of hay for some farmers. Springs and private wells continued to run dry in parts of northern Vermont. Water levels at two dams on the Lamolle River were too low to make electricity. Companies that drill, deepen, or replenish wells saw increased business. The U.S. Drought Monitor released on October 4 showed 5 percent of the Northeast in a severe or moderate drought and 17 percent of the region as abnormally dry. Dryness lingered but improved during October, with the U.S. Drought Monitor released on October 30 showing 2 percent of the Northeast in a severe or moderate drought and 9 percent of the region as abnormally dry. While rainfall during the month allowed dry conditions to slowly ease, streamflow and groundwater levels remained below normal in parts of northern New York and northern New England. Drought eased

by mid-November but abnormal dryness lingered through the rest of November and all of December. The U.S. Drought Monitor released on December 27 showed 4 percent of the Northeast as abnormally dry.

From January 3 to 5, a nor'easter dropped up to 24 inches (61 cm) of snow on the Northeast, mainly coastal areas from southern Maryland to northern Maine. The storm produced snowfall rates of up to 3 inches (8 cm) per hour, and thundersnow was reported in several locations. Thirteen major climate sites set daily snowfall records, with a few sites ranking their daily snow total among their top five greatest for January. Strong winds of up to 76 mph (34 m/s) produced blizzard conditions in parts of New England and southeastern New York. More than 5,000 flights were cancelled nationwide, mostly in the Northeast. Kennedy and LaGuardia airports suspended operations, with Kennedy Airport being closed for around 20 hours. There were also power outages in the region. In addition, parts of coastal New England experienced high water levels and significant flooding. Boston, Massachusetts, had its highest tide on record (since 1921) and Portland, Maine, had its third highest tide on record (since 1912). Storm reports indicated that some areas were inundated by up to five feet (1.5 m) of water, with numerous impassable roads and flooded basements.

An active weather pattern brought four major storms to the Northeast in March. On March 2, a snowstorm impacted much of central New York. Areas west of Albany, New York received up to 40 inches (101.6 cm) of snow, mainly in Schoharie County. Strong winds associated with the storm downed trees and power lines, which caused over 83,000 customers to lose power. Although much of the snow from this storm fell in New York, wind gusts greater than 90 miles per hour (40 m/s) were reported in southeastern Massachusetts, particularly areas near Barnstable and Nantucket, Massachusetts. A few days later on March 7, a nor'easter brought heavy, wet snow to eastern New York, northern New Jersey, and much of New England. Locations in western Massachusetts and southern Vermont received the most snow, with Woodford, Vermont reporting 36 inches (91.4 cm) of snow from this storm. Flooded streets led to road closures in Duxbury, Massachusetts, and many other coastal areas. The wind gusts from the storm also caused over 320,000 customers to lose power. Just a few days after that storm, another nor'easter moved through the region on March 13, impacting eastern New England. Penobscot, Maine received 30 inches (76.2 cm) of snow from this storm. Blizzard conditions were reported in Boston, Massachusetts, with winds gusting over 40 miles per hour (18 m/s), as well as in other locations along coastal Massachusetts and Rhode Island. Boston, Massachusetts and Worcester, Massachusetts ranked this storm as their largest one-day March snowfalls on record. A week later on March 21, another nor'easter moved through the Northeast, with the greatest snowfall totals reported in New York, New Jersey, Pennsylvania, and Maryland. This nor'easter closed schools in New York City and many surrounding areas, and also caused more than 5,000 flights to be cancelled. Patchogue, New York recorded 20.1 inches (51.1 cm) of snow. The snowfall pushed Islip, New York's monthly total into record territory. The site picked up 31.9 inches (81.0 cm) of snow this March, beating the previous record of 23.3 inches (59.2 cm) set back in March 1967. The four nor'easters during the month of March impacted many within the Northeast and led to numerous school cancellations, accidents, and travel delays throughout much of the region. These storms contributed to Islip, New York; Kennedy Airport, New York; and Worcester, Massachusetts, having their snowiest spring on record.

Several heavy rain events led to flash flooding during late spring and summer. Torrential rain on May 27 caused catastrophic flooding in Ellicott City, Maryland, where estimates show the Patapsco River rose 17.8 feet (5.4 m) in less than two hours. In total, over nine inches (228.6 mm) of rain were reported near Catonsville, Maryland. The National Weather Service issued a flash flood emergency, its most severe flood alert. As Ellicott City was just finishing rebuilding from a similar flood event in 2017, this year's flood heavily damaged buildings and houses along the city's Main Street, and caused more than \$20 million in damage. Parts of the region received heavy rain in late July. For instance, Dunkirk, Maryland, received 16.55 inches (420.4 mm) of rain over the span of five days, ending on July 26. The heavy rain

caused several waterways to quickly rise. For example, on July 24, Swatara Creek in Pennsylvania rose to 17 feet (5.2 m), which is 15 feet (4.6 m) above its usual height. Significant flooding occurred, with evacuations, water rescues, road damage, and compromised home foundations reported. Knoebel's and Hershey Park in Pennsylvania had to close park operations for a period of time. A stagnant weather pattern in mid-August provided plenty of tropical moisture to slow-moving storms over the region. Receiving more rain in a day than what usually comes in a month, several areas in New York and New Jersey experienced significant flooding. From August 13 to 14, Lakewood, New Jersey, received 8.01 inches (203.5 mm) of rain. In nearby Brick, New Jersey, over 100 homes were evacuated due to flash flooding. In central New York, a similar sequence of events occurred during that same time frame. Hector, New York, recorded 6.38 inches (162.1 mm) of rain from August 13 to 14, then received another 5.15 inches (130.8 mm) during a 24-hour stretch ending August 15. The storms caused a mandatory boil water order to be in effect for nine days and resulted in the cancellation of the Phish Festival in Watkins Glen, New York, due to the unavailability of clean drinking water for the 30,000 people that were expected to attend. In both coastal New Jersey and central New York, the extreme rainfall led to road closures, damaged homes, and water rescues.

October was an active month for tornadoes in the Northeast. On October 2, a rare tornado outbreak occurred in Pennsylvania when 14 tornadoes touched down in the state. This was the state's largest single-day tornado outbreak since June 2, 1998. Pennsylvania averages only 15 tornadoes for an entire year, and from 1950 to 2018, the state had only recorded a total of 13 October tornadoes. The tornadoes downed hundreds of trees and caused structural damage. Golf ball-sized hail also accompanied some of the storms. The same storm system also produced three tornadoes in southeastern New York and two in Connecticut. On October 20, another tornado touched down in New York. On October 23, four tornadoes touched down in southern New England—one in Rhode Island and three in Massachusetts. The tornado on the 23rd was the latest tornado in the calendar year for Rhode Island. The most recent October tornado in Massachusetts was in 1970. Severe weather struck again on October 29 when a tornado touched down in Connecticut and another touched down in New York, adding to the October tornado count in those states.

An early season winter storm from November 15 to 16 dropped mixed precipitation and up to 18 inches (46 cm) of snow on the region. Newark, New Jersey, and Kennedy Airport, New York, had their greatest 1-day snowfall for November, with 6.4 inches (16 cm) and 4.8 inches (12 cm), respectively. The storm also made it Kennedy Airport's snowiest November on record. For Central Park, New York, and Newark, it was the earliest 6+ inch (15 cm) snowstorm on record. Thundersnow occurred in southern New England. The storm caused major travel disruptions. News reports indicated there were numerous accidents, commuters and students that were stranded for hours, and thousands of delayed and cancelled flights.

For more information, please go to the [Northeast Regional Climate Center Home Page](#).

Midwest Region



Annual averaged temperatures in the Midwest were near normal. The entire region was within 2 degrees F (1 C) of normal when averaged over the entire year. There were however periods of both warm and cold that offset each other. April was the 2nd coolest on record (1895-2018) while May set the record as warmest for the region. Other months were quite warm (Jun ranked 13th warmest and September ranked 15th warmest) or cool (November ranked 11th coolest) as well. There were notable swings in temperature across the region in 2018. Spring saw a sudden jump from cold in April to warm in May and fall had a similar sudden transition from warmth in September and the first 10 days of October to cold in the rest of October and November. There were also big swings of temperature in January, July, and December in 2018. Statewide temperatures set records in three months. April had new record cold in Iowa and Wisconsin. May had record warmth in Illinois, Indiana, Kentucky, Missouri, and Ohio. Ohio set another record for warmth in September. There were numerous other top-10 rankings for states including top-10 warmth in February (Kentucky and Ohio), May (all nine Midwest states), June (Iowa and Missouri), August (Michigan), and September (Illinois, Indiana, Kentucky, and Ohio). Top-10 statewide rankings on the cool side occurred in April (all nine Midwest states) and November (Illinois and Missouri).

Precipitation was record breaking on the wet side in 2018. The Midwest as a whole was just wetter than 1993 (using preliminary data for December) with an average of 42.88 inches (1089 mm) across the region. Statewide totals ranked among the wettest in their histories (1895-2018) with Iowa, Kentucky and Wisconsin ranking 2nd wettest, Ohio 3rd, Indiana 5th, Michigan 11th, and Minnesota 17th. Only Missouri had below-normal annual precipitation falling 0.27 inches (7 mm) short of normal. Statewide values ranked among the wettest in several months including February, June, August, September, October, and November. Missouri also had a top-10 driest month in April. More than 120 stations in the region set new annual precipitation records (minimum of 30 years period of record) with dozens of those stations having periods of record exceeding 100 years. Some of the bigger cities that set such records in 2018 were Louisville and Lexington in Kentucky, Columbus in Ohio, Waterloo in Iowa, and Green Bay in Wisconsin. Each of these cities had period of record of at least 124 years.

Drought in the Midwest began 2018 with just under 10 percent of the region in drought. In the summer drought expanded and intensified, particularly in Missouri and southern Iowa but also in Michigan, peaking in mid-August before being completely eradicated by the end of 2018. At its peak in August, nearly 20 percent of the region was in drought, with more than 8 percent in severe drought and 0.77 percent in exceptional drought (the highest category). More than 43 percent of the region was classified in drought or abnormally dry in mid-August but by the end of the year there was no drought and less than 1 percent of the region was classified as abnormally dry which was the lowest percentage since May of 2018.

Flooding was a problem in the region for a good part of 2018. Flooding started in February and continued to pop up as a problem throughout the year as heavy rains fell, particularly in two large areas: northern Iowa to southern Wisconsin and into neighboring areas and also in the Ohio River Valley. During the year, at least 14 fatalities were attributed to flooding or flash flooding in the Midwest. Property damages were estimated at more than \$300 million through September with data for the last three months still pending. Crop damages in Iowa and Wisconsin alone topped \$17 million.

Severe weather in the Midwest was not typical with very little in April, near the climatological peak, and yet with tornadoes in both January and December. The December 1st tornado outbreak in Illinois set a new state record with 28 tornadoes. There were about 500 homes damaged and 22 injuries in the EF-3 tornado that struck Taylorville, Illinois on the 1st. There was also a deadly tornado near Aurora, Missouri the previous day. Another significant severe weather event was the sinking of a duck boat in the Ozarks of Missouri on July 19th. The duck boat was being used to give a tour on the lake when a severe thunderstorm whipped up large waves and sank the boat.

Spring planting, especially in the northern half of the region, was delayed due to wet and cold conditions in March and then cold and snowy conditions in April. Wet fields in the fall also affected harvest in many areas with fields too wet, and in some cases with standing water, to allow tractors into the fields.

Winter weather struck in April in the north bringing records snows to Iowa, Minnesota, and Wisconsin. The storm had snow totals of more than 2 feet (61 cm) in many locations. Green Bay, Wisconsin set a record for its snowiest April on record 36.7 inches (93 cm) which also ranked as the 2nd snowiest month all-time (December 2008). A blizzard hit on the Thanksgiving weekend in late November snarling air and ground traffic from Kansas City to Chicago.

For further details on the weather and climate events in the Midwest, see the weekly and monthly reports at the [Midwest Climate Watch page](#).

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 across the Southeast were warmer than normal in 2018, except for a few small and isolated pockets in Alabama, Florida, Georgia and the Carolinas. The majority of the region was 1-2 degrees F (0.6 to 1.1 degrees C) warmer than normal, although a few stations in Alabama and Florida reported annual temperatures that were more than 3 degrees F (1.7 degrees C) above normal. Nine long-term stations (records of 50 years or longer) reported mean temperatures that were in the top three warmest on record, including Key West, FL (1874-2018; 3rd warmest), Tampa, FL (1890-2018; 3rd warmest), Cape Hatteras, NC (1895-2018; 2nd warmest), and Greenville, SC (1958-2018; 3rd warmest). The only long-term station that reported a maximum temperature ranked in the top three warmest was Plant City, FL (1949-2018; 2nd warmest), while two stations reported maximum temperatures in the lowest three, including Covington, VA (1963-2018; 1st coldest) and Juncos, PR (1949-2018; 3rd coldest). By comparison, there were 44 long-term stations with minimum temperatures in the top three warmest, and none in the lowest three, including Asheville, NC (1894-2018; 1st warmest), Cedartown, GA (1942-2018; 1st warmest), and Louisa, VA (1920-2018; tied for 1st warmest). Temperatures varied significant across the region from month to month. In January, several long-term stations in the Carolinas and Virginia observed or tied their highest or second highest count of January days with a maximum temperature of 32 degrees F (0 degrees C) or less, including Greensboro, NC (1903-2018; 8 days), Williamsburg 2 N, VA (1952-2018; 7 days), New Bern, NC (1949-2018; 6 days), and Florence, SC (1948-2018; 4 days) (Extreme #1). After the cold start to the year, February roared in with 70 percent of the long-term stations reporting mean temperatures that were at least 8 degrees F (4.4 degrees C) warmer than normal. Every state in the region observed its warmest February on record except Virginia, which recorded its second warmest February (Extreme #2). The months of March through August were variable across the region but did not set many records for either warm or cold conditions. By late August, however, a strong ridge of high pressure began to dominate much of the Southeast, bringing record heat to the region, which lasted from late August until mid-October, when temperatures finally cooled off. Many mainland stations reported one of their warmest Septembers on record, including Shelby, NC (1936-2018; 1st warmest), Asheville, NC (1892-2018; 1st warmest), Tarpon Springs, FL (1894-2018; 1st warmest), Gainesville, FL (1890-2018; 1st warmest), and Atlanta, GA (1878-2018; 2nd warmest). Tampa, FL (1890- 2018) reported a monthly average temperature of 85.9 degrees F (29.9 degrees C), which broke the old monthly temperature record for any month previously held by June 1998 with a temperature of 85.6 degrees F (29.8 degrees C). Seven stations reported a temperature of 100 degrees F (37.8 degrees C) during the month; the 100-degree F (37.8 degrees C) reading in Macon, GA was the first September 100-degree F reading since September 8, 1990 (Extreme #3). Humidity was also very high in September, with a number of inland airport stations reported new records for the number of hours with a dew point temperature of 65 degrees F (18.3 degrees C) or higher, including Charlotte, NC, Greenville-Spartanburg, SC and Asheville, NC, which reported more than 500 additional hours of very humid conditions above their previous records. In early October, many stations reported temperatures greater than 90 F (32.3 C); a number of

National Weather Service offices noted that these were the latest occurrences of over 90 F in any year for their locations. The year ended with a colder than normal November, especially in the northwestern part of the region, and a warmer than normal December. Several stations in eastern Virginia and North Carolina reported a record number of days in 2018 with maximum temperatures at or above 85 degrees F (29.4 degrees C), including Cape Hatteras, NC (1893-2018; 103 days), Wilmington, NC (1870-2018; 130 days), Charleston, SC (1938-2018; 157 days) and Savannah, GA (1871-2018; 170 days). Numerous stations along the East Coast reported a record-setting number of days with a minimum temperature at or above 70 degrees F (21.1 degrees C), including Gainesville, FL (1890-2018; 144 days), Birmingham, AL (1895-2018; 110 days), Atlanta, GA (1878-2018; 115 days), and Richmond, VA (1887-2018; 73 days). The coldest temperature of the year at any station in the Southeast was -14 degrees F (-26 degrees C) observed at Wakefield, VA on January 7 and the warmest temperature of the year was 105 degrees F (41 degrees C) observed at the University of South Carolina in Columbia, SC on July 11.

Annual precipitation across the Southeast was well above normal in most areas of the region, with some small pockets of drier than normal precipitation. January through March was generally dry across the region, as wetter conditions generally prevailed for the rest of the year, especially the months of April through July and December. The driest areas of the Southeast were located along the East Coast of Florida, with deficits as much as 15.6 inches (396 mm) at Melbourne, FL (1936-2018; 7th driest) (Extreme #4). Puerto Rico also experienced drier than normal conditions, with San Juan, PR receiving 4.3 inches (109 mm) less than normal. Drought expanded in both of those locations at the end of 2018. Drier than normal conditions were also observed in southeastern Georgia and South Carolina, where a moderate drought developed earlier in the year before wetter conditions late in the year ended the drought. The rest of the region experienced wetter than normal conditions, particularly areas affected by tropical systems Gordon, Florence and Michael. In Florida, the Big Bend area stretching west along the Panhandle experienced precipitation amounts as much as 20 inches (508 mm) wetter than normal. Pensacola, FL (1879-2018; 4th wettest) received 90.01 inches (2286 mm), which was 24.7 inches (627 mm) above normal and Tallahassee (1892-2018; 9th wettest) received 79.86 inches (2028 mm), which was 20.6 inches (523 mm) wetter than normal. Farther north, precipitation amounts were even higher, especially areas affected by Hurricane Florence. Much of North Carolina and Virginia, as well as the District of Columbia, northern Georgia, and northwestern South Carolina received precipitation amounts that were more than 20 inches (508 mm) higher than normal. Wilmington, NC (1869-2018; 1st wettest) received 102.40 inches (2601 mm) of rain, which was 44.79 inches (1138 mm) wetter than normal. While Hurricane Florence contributed to this rainfall total, Wilmington was so wet in 2018 that they would have set their all-time precipitation record even without the rainfall from Florence (Extreme #5), Jocassee, SC (123.45 inches or 3136 mm), Montebello, VA (104.70 inches or 2659 mm), Sperryville, VA (86.08 or 2186 mm) and Mount Mitchell, NC (139.94 inches or 3554 mm) all set potential new state records for annual precipitation, which will have to be evaluated for accuracy by State Climate Extremes committees (Extreme #6). Numerous locations in North Carolina and Virginia set their all-time record high precipitation in 2018, including Washington, DC (1979-2019; 66.29 inches or 1684 mm), Lynchburg, VA (1892-2018; 65.7 inches or 1669 mm), Morganton, NC (1900-2018; 76.46 inches or 1942 mm), and Carrollton, GA (1945-2018; 73.86 inches or 1876 mm). An additional 36 long-term stations observed precipitation that was ranked 2nd or 3rd wettest, including Atlanta, GA (1878-2018; 70.03 inches or 1779 mm; 2nd wettest), Cape Hatteras, NC (1895-2018; 90.07 inches or 2287 mm; 2nd wettest), and Walhalla, SC (1917-2018; 84.38 in or 2143 mm; 2nd wettest). A number of stations also set records for the number of days with measurable rain, including Pensacola, FL (1880-2018; 156 days), Anniston, AL (1939-2018; 141 days), Toccoa, GA (1899-2018; 161 days), and Lexington, VA (1899-2018; 157 days). Measurable snowfall was recorded in every state across the region during January, with two winter storms producing some of the greatest monthly accumulations in portions of south-central and southeastern Virginia, central and eastern North Carolina, and coastal South Carolina. Portions of northern Florida and southern Georgia observed their first winter storm since December 1989, a span of over 28 years. With a tenth of an inch (2.5 mm) of snow recorded on the 3rd, Tallahassee, FL (1893-2018) observed its first measurable

snowfall during the month of January and its greatest 1-day snowfall since December 1989. In southeastern Georgia, Alma (1949-2018) observed its greatest 1-day snowfall for January and its second greatest 1-day snowfall for any month on record, with an accumulation of 3.0 inches. Charleston, SC (1939-2018) observed its greatest 1-day snowfall for January and its third greatest 1-day snowfall for any month on record, with an accumulation of 5.3 inches (135 mm). On February 11, several long-term stations in central and western Virginia observed their wettest February day on record, including Wise 1 SE (1956-2018; 3.74 inches, 95 mm), Appomattox (1938-2018; 2.73 inches, 69.3 mm), and Buckingham (1895-2018; 2.71 inches, 68.8 mm). Well-above-normal snowfall was recorded across portions of North Carolina and Virginia during March, with some of the greatest monthly totals including 36.0 inches (914 mm) on Mt. Mitchell, NC (19.6 inches or 498 mm above average) and 25.2 inches (640 mm) at Burkes Garden, VA (17.8 inches or 452 mm above average). On March 24th and 25th, another winter storm produced 3 to more than 12 inches (76.2 to more than 305 mm) of snowfall across portions of northwestern North Carolina and southwestern Virginia, including 16.3 inches (414 mm) near Long Spur, 16.2 inches (411 mm) near Pilot, and 14.0 inches (356 mm) near Dublin. In addition, 15.0 and 12 inches (381 and 305 mm) of snow fell at Burkes Garden, VA (1896-2018) and Pulaski 2 E, VA (1922-2018), respectively, breaking the greatest 1-day snowfall on record for March and surpassing daily snowfall totals that were recorded during the 'Storm of the Century' in March 1993. On May 24, Talbotton, GA (1893-2018) and Thomaston 4 SE, GA (1956-2018) observed their second and fifth highest 1-day precipitation total for any month on record, with 8.57 and 5.42 inches (218 and 138 mm), respectively. From May 15th through June 1st, Athens, GA (1857-2018) observed its longest streak of 18 consecutive days with measurable precipitation, surpassing its previous record in June 1963 by 4 days. In spite of a rainy summer, the period from mid-August to early September was one of the driest on record for parts of northern Georgia, most of South Carolina, and some stations in North Carolina. In September, Hurricane Florence brought torrential rain to North and South Carolina. The highest rainfall amount from Florence in North and South Carolina was 35.93 inches (913 mm) northwest of Elizabethtown and 23.63 inches (600 mm) west of Loris, respectively. These will likely become new record hurricane rainfalls for those two states. Most of southeastern North Carolina and parts of northeastern South Carolina received rain in excess of a 1000-year return period. Snow was observed unusually early in the season in the Washington D. C. area on November 15, as a developing low-pressure system moved up the East Coast. This resulted in the first measurable snow that occurred there in November in the last 22 years. Reagan International Airport received 1.4 inches (35 mm) and Dulles International Airport received 3.0 inches (76 mm). The snow, which was mixed with sleet and freezing rain, snarled traffic and closed schools. December also brought the first major snowstorm of the year to the Southeast. A low-pressure system skirted the Gulf and Atlantic coasts on December 8-10, as a high pressure to the north provided a source of cold air. Mount Mitchell, NC reported 32 inches (812 mm), Jefferson, NC received 20 inches (508 mm), and Boone, NC recorded 15 inches (381 mm) of snow in the storm. Many sites receive more than a foot of snow, which is close to the annual average snowfall for those locations.

Four tropical systems (Tropical Storm Alberto, Tropical Storm Gordon, Hurricane Florence and Hurricane Michael) passed through the Southeast in 2018, bringing heavy rain and inland flooding, high winds, tornadoes, storm surge, and other significant impacts to parts of the region. Alberto formed as a subtropical depression over the northwestern Caribbean Sea, became a subtropical storm over the southeastern Gulf of Mexico, and then transformed into a tropical storm before making landfall along the coast of the Florida Panhandle on May 28. Alberto produced heavy rainfall and flooding across the southern and central Appalachian Mountains, which took the lives of eight people in North Carolina and Virginia. Heavy rainfall fell over the Florida peninsula over a multi-day period as Alberto moved northward across the eastern Gulf of Mexico, with a maximum six-day total of 11.80 inches reported at Taylor Creek on the northern shore of Lake Okechobee from 25-30 May. Maximum rainfall totals of 12.30 inches were reported near Helen in northeastern Georgia, 12.21 inches near Jonas Ridge in western North Carolina, and 5.48 inches near Lewis Mountain Camp in Virginia. The heavy rains caused flooding of several rivers, especially across western North Carolina. Tropical Storm Gordon moved inland along

the Florida Panhandle on September 4, bringing heavy rain to Pensacola, FL and northwest into much of Alabama. Pensacola, FL received 18.25 inches (464 mm) of rain for the month, 12.27 inches (312 mm) wetter than normal; of that, 6.40 inches (163 mm) fell on September 5 alone as a feeder band from Gordon brought hours of rain to the station. The rainfall total from Gordon in Pensacola was 12.73 inches (323 mm). In Alabama, the highest rainfall from Gordon was 8.53 inches (217 mm) north of Bay Minette in the southeast part of the state. The strongest winds from Tropical Storm Gordon were reported at Dauphin Island, AL (74 mph; 33 m/s), Mobile, AL (57 mph; 25 m/s), and Pensacola, FL (52 mph; 23 m/s) on September 4, as the center of circulation approached the coast. Hurricane Florence (Extreme #7) approached the North Carolina coast on September 13 as a strong hurricane but weakened to a Category 1 storm before making landfall on the 14th, and the most severe impacts of the storm came from the 10-foot storm surge followed by the extreme impacts of more than 30 inches (762 mm) of rain across a large portion of southeastern North Carolina. At one point, more than a dozen river gauges in North Carolina alone had reached major flood stage, and portions of I-40 and I-95 were both closed due to the flooding. In New Bern, NC, storm surge from Florence damaged or destroyed more than 4,300 homes and 300 businesses, resulting in a loss of \$100 million in combined residential and commercial damage. The North Carolina Division of Public Safety reported that 5,214 people and 1,067 animals were rescued from the high waters. Hurricane Michael (Extreme #8) made landfall near Mexico Beach, FL on October 10 as a Category 4 hurricane, and moved northeast across the Florida panhandle and southwest Georgia. It was still a hurricane when it was south of Macon in central Georgia on the 11th. Widespread damage occurred from Michael as the center of circulation passed over the Southeast. Hurricane Michael attained peak winds of 155 mph (69.3 m/s), as it made landfall near Mexico Beach, FL on October 10, becoming the first system to do so in the region as a Category 4 hurricane. A maximum wind gust of 129 mph (57.7 m/s) was measured at Tyndall Air Force Base near the point of landfall. Catastrophic damage occurred along the Florida coast at Mexico Beach and Panama Beach due to the extreme winds and storm surge. The 9 to 14 feet (2.7 to 4.3 m), storm surge wiped out nearly every structure along the coast near the point of landfall. The highest gust reported in Georgia was 115 mph (51.4 m/s) by a University of Georgia weather station at the Donalsonville airport. Michael moved rapidly across South and North Carolina and parts of Virginia, as it began its transition to an extra-tropical cyclone. At least 60 deaths were attributed to Michael in the United States alone. Utility companies estimated that over 3.1 million people were affected by loss of power due to the storm, with a peak outage of 1.6 million customers early in the morning of October 12.

There were 3,621 reports of severe weather in 2018 across the region, which is 122 percent of the average of 2,948 for the period from 2000-2017. A third of the reports (1,220, compared to an average of 721) came from June alone. The total number of tornadoes confirmed in 2018 was 167, which is 109 percent of the average value of 153 from 2000-2017. All but three of the tornadoes were rated EF-2 or lower. The season got off to a slow start in January and February, with less than half of the average number of severe reports occurring in each of those months. The number of reports in January (20, with one tornado and the rest damaging winds) was the lowest number in that month since 2004. In spite of the low total number of severe weather reports, February had 13 confirmed tornadoes, almost double the average number (7). On March 4th through the 7th, a powerful cyclone situated over the Northwest Atlantic Ocean generated exceptionally large swells with waves of 25 to 30 feet in height along the coastline of Puerto Rico and the U.S. Virgin Islands, which are located about 1,500 miles away. Coastal flooding caused significant beach erosion and damaged numerous structures along the northern and western coast of Puerto Rico. The largest hail reported in the Southeast in 2018 occurred in March and April. Hail accounted for nearly 45 percent (99 of 227) of the severe weather reports during March, including nine reports of 2-inch (i.e., hen egg-sized) or larger hailstones. On March 19th, extremely large hail with diameters ranging from 2.75 inches (baseball-sized) to more than 4 inches (softball-sized) caused extensive damage and destruction to homes, businesses, and vehicles across Cullman County, AL. An exceptionally large hailstone found in the community of Walter measured 5.38 inches (137 mm) in diameter, with a circumference of 13.75 inches (349 mm) and a weight of 9.8 ounces (0.26 kg) (Extreme #9). This is officially the largest

hailstone on record for the state of Alabama, surpassing the old record of 4.5 inches (114 mm). On March 19th, an EF-3 tornado tracked over 35 miles from Calhoun County in northeastern Alabama to Haralson County in northwestern Georgia, with a maximum path width exceeding one mile and four reported injuries. The greatest damage occurred in the city of Jacksonville, AL, where many homes were rendered uninhabitable and several buildings on the campus of Jacksonville State University sustained major damage. In April, three reports of large hail were recorded, including 3-inch (tea cup-sized) hail in St. Johns County, FL on the 10th and 2.75-inch (baseball-sized) hail in Gaston County, NC on the 15th. In June, about 95 percent (1,154 of 1,220) of the severe weather reports during the month were for strong thunderstorm winds, and nearly half (556 of 1,154) of these reports occurred in Georgia and South Carolina. Some of the highest thunderstorm wind gusts that were recorded during the month included 70 mph at Shaw Air Force Base near Sumter, SC and 69 mph at North Perry Airport near Hollywood, FL. Thunderstorm winds were responsible for 2 fatalities and 9 injuries in Alabama and Georgia, with most of these casualties caused by falling trees. On April 15, an EF-3 tornado tracked across portions of three counties in central Virginia, including the western portion of Lynchburg. Hundreds of trees were snapped or uprooted, and dozens of homes sustained major damage or destruction along its 25.8-mile (42 km) path, with at least 12 reported injuries. On June 28th, a southward-moving derecho produced a 300-mile (190-km) swath of wind damage, extending from northern Alabama and northwestern Georgia to the Gulf of Mexico along the Florida Panhandle. Some of the highest measured wind gusts included 58 mph at Birmingham-Shuttlesworth International Airport, AL and 52 mph at Tuscaloosa Regional Airport, AL, and Falcon Field in Peachtree City, GA. Hundreds of trees were blown down across these areas, with 1 fatality and 2 injuries caused by trees falling onto moving vehicles in central Alabama. In Madison County, AL, straight-line winds estimated at 100 mph snapped a 300-yard-wide swath of trees near the town of Gurley. A total of 231,000 customers lost power in Alabama following the derecho. Twelve people were injured at Traditions Park near Hayden AL on August 16, when a large tent collapsed on a crowd of approximately 150 people. The tent collapse occurred even though winds were estimated to be below severe limits and no other damage was reported in the vicinity. On December 2, an EF-3 tornado caused four injuries at Kings Bay Naval Base in Camden County, GA along the coast. A docked Coast Guard vessel reported a wind gust of 144 mph from the storm, as it passed near the coast.

2018 began with a broad area of moderate drought (D1) and abnormally dry conditions (D0) covering significant parts of every state in the region except for the Florida peninsula and the coastal plains of North and South Carolina. During January, drought expanded and worsened due to relatively dry conditions, particularly in southwestern Georgia, southeastern Alabama, and parts of the Florida panhandle. Severe drought (D2) spread to northern Alabama and Georgia and covered the entire Florida panhandle during that time. Near the end of January, 80 percent of the region was covered by drought or abnormally dry conditions, and an area of extreme drought (D3) was identified in central Alabama on January 30 before wetter conditions improved soil moisture in that area, eliminating the worst drought conditions. In contrast, heavier rain in the Carolinas and Virginia reduced drought conditions in those areas. Colder than normal temperatures in January caused minor damage to citrus crops, Vidalia onions and other vegetables, and stunted the growth of winter grains and pastures. However, it provided ample chill hours for fruit crops like nuts and peaches and built up cold tolerance in citrus orchards as well as killing off insect pests that had survived the previous two warmer winters. By mid-February, heavier precipitation eliminated all severe drought (D2) from the region, in spite of record-setting warm conditions. The very warm conditions (as much as 10 degrees F or 5.5 degrees C) led to early blooming of fruit trees and blueberries, making them vulnerable to frost. Heavier rain in the month caused problems for farmers in Alabama, Georgia, North Carolina and Virginia who were delayed in preparation of fields for planting due to the wet soil. The February warmth did contribute to the development of new regions of severe (D2) drought beginning in early March in southeastern Georgia and in early April in southern Florida, regions that were missed by the rain that soaked Alabama and northwestern Georgia as well as North and South Carolina and Virginia. These moderate drought areas persisted until mid-May, when a wet spell across the region removed all drought and most abnormally dry conditions from the region. Colder and drier conditions in March and April caused further delays in field preparation and planting of

row crops and led to several episodes of sub-freezing temperatures, which damaged blossoming fruit in several states (Extreme #10). About 10 to 50 percent of the flowering blossoms on peach trees in northern and central Georgia were lost to excessively cold temperatures. However, 2018's yield was higher than the past two years because the early frosts did less damage this year compared to the two previous winters. Moderate damage to the blueberry crop in southern Georgia was also reported, particularly in farms lacking frost protection. Dry conditions in early May improved field conditions for farmers, allowing them to catch up with planting and field work and reducing disease pressure. However, the rain that occurred later in the month caused flooding which damaged livestock pastures in southern Florida and drowned newly planted crops in low-lying areas. Wet conditions in June and July continued to cause problems for agricultural producers by delaying needed spraying of agricultural chemicals like fungicides, which were sorely needed in the humid conditions. For the rest of the year, drought conditions covered a much lower percentage of the region, mainly in coastal Georgia and southern South Carolina. Impacts on agriculture in the fall were dominated by the effects of the tropical systems, which passed through the Southeast. Tropical Storm Gordon caused losses for cotton, pecan and peanut farmers in southeastern Alabama and western Florida. Hurricane Florence, which dropped excessive rains over parts of North and South Carolina, caused significant impacts to vegetable production and flooded out numerous hog farms and chicken houses. In South Carolina, agricultural losses alone were estimated to surpass \$125 million, including an estimated loss of 75 percent of the cotton crop (\$56 million). In North Carolina, estimated losses to agriculture alone top \$1.1 billion. Losses to row crops such as corn, soybeans and tobacco were estimated at \$987 million, including 50 to 100 percent of unharvested tobacco. Other losses include \$70 million to commercial forests, \$30 million for lawn and landscaping, \$27 million for vegetables and horticultural crops, and \$23 million for livestock. The storm killed an estimated 5,500 hogs and 4.1 million chickens and turkeys. In all, the damage from Hurricane Florence was estimated at \$18 billion. In October, Hurricane Michael caused tremendous damage to timber and decimated the Georgia cotton crop, which was just beginning to be harvested. Numerous pecan orchards, some of which had been planted nearly a century ago, were destroyed by the high winds. Georgia was the worst hit state in the Southeast, with an estimated \$4 billion in agricultural losses. Losses in Alabama were estimated at \$204 million, led by losses in cotton at \$108 million. Florida's agricultural losses were estimated at \$1 to 2 billion, including the loss of over 3 million acres of timber valued at \$1.3 billion and crop losses of \$158 million. Cotton along the path of the storm in Florida was considered nearly a total loss. Peanuts fared better than other crops since they were still in the ground in many fields. A new region of moderate drought (D1) developed in southern Florida in early November and was expanding at year's end. By the end of the year, the Florida drought covered 21 percent of the state, including the eastern half of the Florida peninsula stretching from the Everglades to Cape Canaveral. The dry conditions impacted planting of vegetables in that area and reduced the growth of pastures, leading to increased feeding of hay to livestock. In Puerto Rico, no abnormally dry conditions were observed in January through May, but returned to the island during the second half of the year. No drought was observed in Puerto Rico until the very end of the year when a small area of moderate drought (D1) developed in the central part of the island.

For more information, please go to the [Southeast Regional Climate Center Home Page](#).

High Plains Region



2018 was a tale of extremes across the High Plains, as the region experienced both sides of the temperature and precipitation spectrums. In northern and eastern areas of the High Plains, it was cool and wet, which brought a variety of positive and negative impacts. For instance, this pattern was welcome in the Northern Plains where long-term drought conditions improved dramatically, but the constant wetness brought flooding and challenges to agriculture. In western areas of the High Plains, drought persisted throughout the year, causing a devastating fire season, low water supplies, recreation and tourism revenue loss, and damage to crops and pastures. Thankfully, winter came early this year in this part of the region, and mountain snowpack got off to a promising start. Winter conditions in 2018 were partially influenced by a weak La Niña, which contributed to the cold conditions in the Northern Plains, as well as the high snowpack in the Northern Rockies and the low snowpack in the Southern Rockies.

Despite unfavorable conditions for agriculture in the region, row crops did especially well. For instance, Nebraska and South Dakota had record-high corn and soybean yields. Although cold and wet conditions brought about a late start to the growing season, the warmth of May and June helped Growing Degree Days (GDDs) accumulate very quickly, allowing for rapid progress in crop growth. Corn matured early and was less impacted than soybeans by the unfavorable harvest conditions during the fall. Additionally, early crop maturation reduced the risk for damaging fall freezes. Soybean harvest was very slow in the High Plains; in fact, it was the slowest soybean harvest on record nationwide, a record that goes back to 1995. The winter wheat crop struggled in Kansas and Colorado during winter 2018-19 due to a number of factors, including the presence of drought conditions and the lack of snow cover during cold air outbreaks. As of the end of the year, this season's crop was faring much better in Colorado, thanks to timely precipitation. However, approximately 65 percent of the winter wheat crop in Kansas was planted late due to wet conditions, and it was not faring well.

Temperatures were below normal for the year across the northern part of the High Plains region, while temperatures were above normal in Colorado and southern Wyoming. The period January-April was very cold for the Northern Plains. However, temperatures turned around dramatically in May, as May and June were especially warm. The warmth was beneficial for crop progress because the cold start to the growing season caused crop growth to fall behind, while the warmth of May and June allowed crop growth to progress quickly. In fact, it was so warm in May and June that corn matured early in some places. Below-normal temperatures returned in July, and in the Northern Plains, cooler temperatures stuck around until December. On the other hand, above-normal temperatures dominated the year throughout Colorado and southern Wyoming until October.

The following locations had notable temperature records during 2018:

- Aberdeen, South Dakota: Lowest April temperature on record at -6.0 degrees F (-21.1 degrees C), April 4 (period of record 1893-2019)
- Pierre, South Dakota: Lowest April temperature on record at 0.0 degrees F (-17.8 degrees C), April 4 (period of record 1933-2019)
- Concordia, Kansas: Lowest April temperature on record at 12.0 degrees F (-11.1 degrees C), April 7 (period of record 1885-2019)
- Dodge City, Kansas: Most number of days with temperatures reaching 90.0 degrees F (32.2 degrees C) in May (15) (period of record 1874-2019)

- Salina, Kansas: Most number of days with temperatures reaching 90.0 degrees F (32.2 degrees C) in May (15) (period of record 1948-2019)
- Denver, Colorado: Tied for highest June temperature on record at 105.0 degrees F (40.6 degrees C), June 28 (period of record 1872-2019)

It was a wet year for a large part of the High Plains, especially throughout southern South Dakota, Nebraska, and Kansas. The excessive wetness resulted in the wettest year on record for several locations, creating flooding issues and delays during the growing season. On the contrary, it was a dry year for Colorado and southern Wyoming, where drought was present throughout most of the year. While precipitation varied across the region each month, October and December were most notable for being wet, particularly in Nebraska and Kansas. While it was consistently dry across Colorado and areas of Wyoming throughout the year, there were no months that were particularly notable for widespread dryness.

The snowpack was plentiful in the Upper Missouri Basin during the 2018-18 season, which contributed to high runoff and streamflows in the spring. However, Colorado snowpack was abysmal, causing a shortened ski season and concerns over water supply. As for Plains snowpack, snowfall was plentiful in the Northern Plains, particularly in South Dakota and Nebraska. The following locations ranked in the top 10 for snowiest season (July 2018-June 2019): North Platte, NE (5th snowiest), Sioux Falls, SD (5th snowiest), Pierre, SD (10th snowiest), and Rapid City, SD (10th snowiest). Snowfall was scarce throughout Colorado and parts of Kansas, however. Locations ranking in the top 10 for least snowiest season included: Alamosa, CO (least snowiest), Dodge City, KS (3rd least snowiest), Pueblo, CO (4th least snowiest), Denver, CO (5th least snowiest), and Grand Junction, CO (tied for 5th least snowiest). This season's snowpack started off quite well across the High Plains, thanks to cool temperatures and early-season snowfall.

Due to a cold and snowy start to spring, the severe weather season got off to a slow start but ramped up after the late-spring warmup. Numerous hail events damaged crops throughout the region, and some unusual events occurred as well. For instance, in June, a tornado touched down near Gillette, Wyoming and destroyed numerous structures, snapped trees and utility poles, and caused two injuries. This tornado was rated an EF-3 on the Enhanced Fujita Scale. According to records from the National Centers for Environmental Information (NCEI), the last time a tornado of this strength was reported in Wyoming was 1987. Also in June, strong winds kicked up dirt and dust over dry areas of northeastern South Dakota and produced a dust storm, reducing visibilities and causing traffic issues and damage to vegetation.

The following locations had notable precipitation records during 2018:

- Wichita, Kansas: Longest streak of no measurable snow at 393 days, ended January 14 (period of record 1888-2019)
- Wichita, Kansas: Longest streak of no measurable snow at 393 days, ended January 14 (period of record 1888-2019)
- Omaha, Nebraska: 2nd highest 2-day total precipitation of 8.33 inches (212 mm) in any month, August 14-15 (period of record 1871-2019)
- Wichita, Kansas: Earliest measurable snow of 0.7 inches (2 cm), October 14 (period of record 1888-2019)

The big story regarding drought in the region in 2018 was the improvement of conditions in the Northern Plains and the development and intensification of drought in Colorado, Wyoming, and Kansas. According to the U.S. Drought Monitor, over the course of the year the area in the High Plains experiencing drought or abnormal dryness (D0-D4) decreased from approximately 81 percent to 32 percent. However, areas experiencing moderate to exceptional drought (D1-D4) only decreased from 28 percent to 18 percent.

The Northern Plains drought, which plagued the region in 2018, improved significantly during 2018 thanks to the wet conditions that dominated for much of the year. By the end of December, the only drought that remained was moderate drought (D1) in north-central North Dakota.

On the other hand, drought intensified in Colorado, southern Wyoming, and portions of Kansas during the first three-quarters of the year. In Kansas, drought developed in southwestern and northeastern areas of the state, prompting the governor to make drought declarations in multiple counties. Fortunately, heavy rainfall provided drought relief during the summer to southwestern Kansas and southeastern Colorado, and heavy rains in the fall alleviated drought in northeastern Kansas. Drought remained in Colorado, however, despite some improvements due to a good start to the water year and the mountain snowpack season. While the drought caused many impacts, perhaps the most notable was the devastating fire season across Colorado.

Noteworthy Events:

- **Cold Start to the Year:** The High Plains had a very cold start to the year, with monthly temperatures averaging below normal for a large portion of the region through April. The early spring cold delayed planting, particularly in the Northern Plains, as soils remained frozen. Ultimately, the High Plains was the only region in the U.S. with below-normal temperatures for the year.
- **Heavy Rainfall:** It was a wet year for much of the High Plains, with several locations in South Dakota, Nebraska, and Kansas having their wettest or near-wettest year on record. Locations such as Brookings, South Dakota and Manhattan, Kansas experienced impactful urban flooding events, and melting snow caused flooding along the Big Sioux River in eastern South Dakota, impacting the Flandreau Indian Reservation. However, heavy rains helped improve long-term drought conditions throughout the Northern Plains.
- **High Runoff in the Upper Missouri Basin:** A strong snowpack year followed by heavy spring rains and a rapid warmup in May ultimately led to the 3rd highest runoff ever recorded in the Upper Missouri Basin, according to the U.S. Army Corps of Engineers. High runoff prompted the Corps to slowly evacuate stored floodwaters throughout the summer and fall, causing flows downstream to run high, especially in South Dakota and Nebraska.
- **Colorado/Kansas Drought:** Drought developed and intensified rapidly during the year throughout Colorado and portions of Kansas, damaging crops and compromising water supplies. While wet conditions during the summer and fall alleviated the drought in Kansas, drought remained in Colorado, which had its warmest and 2nd driest water year on record (October 2018-September 2018). It was a devastating fire season across the state, with the most notable being the Spring Creek Fire, which burned 100,000+ acres and was the 3rd largest wildfire in Colorado history.
- **Crop Damage from Hailstorms:** The cold temperatures at the beginning of spring brought about a slow start to the severe weather season. However, by June, severe weather ramped up across the region, mostly in the form of damaging hail events. For instance, during the last week of June, two hailstorms decimated corn and soybean fields in South Dakota between Rapid City and Pierre, leaving hail scars on the landscape.
- **Unfavorable Conditions for Planting/Harvesting:** Cold conditions in the spring and wet conditions throughout the growing season created unfavorable conditions for planting and harvesting. April brought frigid temperatures and snowstorms, delaying planting. Wet conditions in the fall, including early snowstorms in October, significantly slowed harvest progress. Nationwide, it was the slowest soybean harvest on record, dating back to 1995.

For more information, please go to the [High Plains Regional Climate Center Home Page](#).

Southern Region



The year 2018 proved to be a warm year for the Southern Region. Temperatures were consistently above normal throughout most of the year. There were four months where all six states averaged above normal temperatures. These months were May, June, July, and September. There were also three months where all six states averaged below normal temperatures. These months were January, April, and November. For the year there were areas in all six states that averaged between 2 to 3 degrees F (1.11 to 1.67 degrees C) above normal, and small areas in Texas and Louisiana averaged 3 to 4 degrees F (1.67 to 2.22 degrees C) above normal. There were scattered areas of below normal temperatures across Texas, Oklahoma, Arkansas, Louisiana, and Mississippi, with a couple of areas in Texas that averaged 1 to 2 degrees F (0.56 to 1.11 degrees C) below normal. All state rankings are based on the period spanning 1895-2018. The 2018 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. The year started drier than normal for all six states, immediately followed by every state except for Texas reporting a top-10 wettest February on record. March and April were around normal, with most states reporting wetter than normal conditions. However, the period from May through July saw states experiencing drier than normal conditions. In August, the pattern shifted, and most states reported wetter than normal conditions to close out the year. There were two months where all six states reported wetter than normal conditions (February and September) and one month where all six states reported drier than normal conditions (January). While no state reported a top-10 driest month on record, three states (Arkansas, Tennessee, and Texas) recorded a wettest month on record. By the end of the year, the area experiencing drought or abnormally dry conditions decreased from just under 69 percent of the region down to just over 12 percent of the region. All state rankings are based on the period spanning 1895-2018.

Severe Weather and Impacts:

- Winter was warmer and wetter than normal for the Southern Region. Every state experienced a wetter than normal winter, with Arkansas reporting its fourth-wettest winter on record. Temperatures were warmer than normal for every state except for Arkansas, which reported a slightly cooler than normal winter. December 2017 was predominantly warmer than normal, with only Tennessee reporting cooler than normal temperatures, but precipitation varied. Arkansas, Mississippi, and Texas were wetter than normal, while Louisiana, Oklahoma, and Tennessee were drier than normal. As a result, the region as a whole was slightly drier than normal. January was cooler and drier than normal across all six states. February saw the region experience its wettest February on record, as every state except for Texas experienced a top-10 wettest February on record. Arkansas and Tennessee reported their wettest February on record, Mississippi reported their second-wettest February on record, Oklahoma reported their fourth-wettest February on record, and Louisiana reported their seventh-wettest February on record. Temperatures were warmer than normal across much of the region, with only Oklahoma reported a cooler than normal

February. Tennessee reported their third-warmest February on record, while Louisiana and Mississippi both reported their fourth-wettest February on record. All state rankings are based on the period spanning 1895-2018.

- Spring was warmer and drier than normal for the Southern Region. Every state experienced warmer than normal temperatures, with Texas recording their ninth-warmest spring on record. Every state except Tennessee reported drier than normal conditions. March was mainly warmer and wetter than normal, with Tennessee reporting cooler than normal temperatures and Oklahoma reporting drier than normal conditions. April was much cooler than normal, with every state except Texas reporting a top-5 coldest April on record and the region as a whole reporting their fourth-coldest April on record. Oklahoma reported their second-coldest, Arkansas and Mississippi reported their third-coldest, Tennessee reported their fourth-coldest, and Louisiana reported their fifth-coldest April on record. Precipitation was predominately wetter than normal, with Oklahoma and Texas reporting drier than normal conditions. May saw a shift in these conditions, as every state was much warmer than normal and every state except Tennessee was drier than normal. Arkansas and Oklahoma recorded their warmest May on record, as did the region as a whole. Tennessee and Texas recorded their second-warmest May on record, while Louisiana and Mississippi recorded their third and fourth-wettest May on record, respectively. All state rankings are based on the period spanning 1895-2018.
- Summer was warmer and drier than normal for the Southern Region. Every state reported warmer than normal temperatures, with Texas reporting their fifth warmest summer on record. Precipitation was wetter than normal for most states, with Louisiana and Texas reporting drier than normal conditions. June was warmer than normal for every state. The region recorded their tenth-driest June on record, while Texas (third-warmest), Louisiana (eighth-warmest), Arkansas (ninth-warmest), and Oklahoma (tenth-warmest) each reported a top-10 warmest June on record. Precipitation was predominantly drier than normal, with only Tennessee reporting wetter than normal conditions. July followed a similar pattern, with each state reporting warmer than normal temperatures and each state except for one (Oklahoma) reporting drier than normal conditions. August saw each state but one (Louisiana) report wetter than normal conditions, while every state but two (Arkansas and Oklahoma) reported warmer than normal temperatures. Arkansas reported their eighth-wettest August on record. All state rankings are based on the period spanning 1895-2018.
- Autumn was wetter and slightly warmer than normal for the Southern Region. The region reported their fifth-wettest autumn on record as Louisiana (ninth-wettest), Oklahoma (ninth-wettest), Tennessee (ninth-wettest) and Texas (first-wettest) each recorded a top-10 wettest autumn on record. Temperatures varied spatially, as three states (Louisiana, Mississippi, and Tennessee) reported warmer than normal conditions while the other three states (Arkansas, Oklahoma, and Texas) reported cooler than normal conditions. September saw each state in the region report warmer than normal and wetter than normal conditions. With respect to temperature, Tennessee (sixth-warmest), Mississippi (seventh-warmest), and Louisiana (tenth-warmest) each recorded a top-10 warmest September on record. With respect to precipitation, Texas (first-wettest), Tennessee (third-wettest), Louisiana (tenth-wettest), and Mississippi (tenth-wettest) each recorded a top-10 wettest September on record, and the region as a whole recorded their third-wettest September on record. October was predominantly wetter and warmer than normal. Every state except one (Mississippi) reported wetter than normal conditions, with Texas recording their second consecutive wettest month on record and Oklahoma (seventh-wettest) record a top-10 wettest October on record. Temperatures were warmer than normal across every state but two (Oklahoma and Texas). November saw a shift in temperatures as every state reported cooler than normal conditions, with Arkansas (seventh-coldest) and Oklahoma (ninth-

coldest) recording a top-10 coldest November on record. Precipitation was still mainly wetter than normal, with Oklahoma and Texas reporting drier than normal conditions.

- Drought conditions exhibited a cyclical pattern throughout the Southern Region during 2018. Almost 70 percent of the region was experiencing drought or abnormally dry conditions at the beginning of the year. These conditions deteriorated through winter until almost 85 percent of the region was experiencing drought or abnormally dry conditions by the beginning of February. Spring saw a decrease in the area experiencing drought or abnormally dry conditions, but areas experiencing exceptional drought increased, with a peak of just over 5.5 percent areal coverage in early May. Due to the drier than normal condition in late spring and much of summer, drought and abnormally dry conditions spread, peaking in early August when over 70 percent of the region was experiencing at least abnormally dry conditions. When August and much of autumn saw wetter than normal conditions, drought improved across the region to the point where, by late November, less than 3 percent of the region was experiencing drought or abnormally dry conditions. However, drought conditions would slightly deteriorate through December, and by the end of the year, just over 12 percent of the region was experiencing mainly abnormally dry conditions. Overall, from the beginning of the year to the end of the year, the region saw marked improvement in drought conditions, but it was not a continuous process.
- There were approximately 3,925 severe weather reports throughout the Southern Region for 2018, with 283 tornado reports, 1,000 hail reports, and 2,642 wind reports. Louisiana had the most tornado reports (86) while Texas had the most hail (508) and wind (589) reports. Texas had the most severe weather reports total (1149) while Louisiana had the least (380).

For more information, please go to the [Southern Regional Climate Center Home Page](#).

Western Region



Average temperatures in 2018 were slightly above normal in the Pacific Northwest, cooler than normal in the inland Northwest, and well above normal across the Southwest. Montana and northern Wyoming observed much wetter than normal conditions. With the exception of a few areas in Arizona and the northern Great Basin, the Southwest was drier than normal. Oregon also reported below normal precipitation.

Cooler than normal temperatures dominated along the northern tier of the region in the first few months of 2018 and again in the autumn season, resulting in below normal annual temperatures. In north-central Montana, Havre reported an average temperature of 43.4 F (6.4 C), 2.5 F (1.4 C) above normal and the 10th coolest calendar year since records began in 1961. Outside of Montana, northern Idaho, and northern Wyoming, temperatures were slightly to well above normal. Many locations in the Southwest reported top-10 warmest calendar years. Average temperature in Las Vegas, Nevada, was 72.2 F (22.3 C), 2.5 F (1.4 C) above normal and the 2nd warmest since records began in 1948. Further south, Tucson, Arizona, had its 4th warmest year in a 73-year record at 71.8 F (22.1 C), 2.4 F (1.3 C) above normal.

Above normal precipitation was observed throughout Montana as well as southern Arizona and parts of the western Great Basin. Billings, Montana, reported its 7th wettest year in an 84-year record at 19.01 in, 139% of normal. Reno, Nevada, reported 9.26 in (235 mm), 125% of normal. Further south, Tucson, Arizona logged 13.44 in, 116% of normal. Elsewhere, drier than normal conditions dominated, especially in western Oregon and the Four Corners area. Eugene, Oregon, had one of its bottom-10 driest years on record at 27.86 in, 60% of normal. In northwestern New Mexico, Farmington reported 4.32 in (110 mm), 39% of normal the 2nd driest year since records began in 1941. This year began with 9% of the West in severe or worse drought according to the US Drought Monitor but expanded to 27% by year's end. The areas seeing the greatest change were the Four Corners region and Oregon. Drought conditions present during the preceding five years persisted throughout 2018 in southern California due to below normal precipitation and above normal temperatures in the area. Drought conditions improved this year across eastern Montana as well as the southern portions of Arizona and New Mexico.

Snowpack was well below normal during January and February in the Sierra Nevada, Cascades, and southern Rocky Mountains. At the end of February, snowpack was less than 60% of normal in nearly all basins in this region. However, an active storm track in March featuring several atmospheric rivers delivered above normal precipitation to a wide swath of the West stretching from central California northeastward to western Montana. These storms increased snowpack in the Sierra Nevada; April 1 values (typically peak of snowpack) exceeded 75% of normal in nearly all Sierra Basins. In contrast, well above normal snowpack developed early in the season in the northern Cascades, Inland Northwest, and northern Rockies and increased or maintained through the season. April 1 snowpack was 106% of normal averaged across the Pacific Northwest basins, and 115% of normal for the Missouri River basin. The Upper Colorado reported 74% of normal. The above normal snowpack in the Northwest led snowmelt flooding in these areas in the spring. The snow season beginning late 2018 ended the calendar year >75% of normal across the West.

Calendar year temperatures were above normal across Alaska, with the greatest departures from normal in the northern and western portions of the state with temperatures closer to normal in the Southeast. In the northwestern part of the state, Kotzebue reported its 2nd warmest year since records began in 1897 29.5 F (-1.4 C), 6.8 F (3.8 C) above normal; temperatures were above normal for every month of 2018. Precipitation was near normal in the western part of the state and slightly to well above normal in the North Slope, Interior, and Southcentral regions. Drier than normal conditions dominated in the Southeast, leading to development of moderate drought conditions over the course of the year. Ketchikan logged 106.59 in (2707 mm) for the year, 75% of normal. Further south, several hurricanes as well as cool season storms in early 2018 contributed to wetter than normal conditions across much of Hawaii. Hilo reported its 3rd wettest year since records began in 1949 at 176.36 in (4479 mm), 139% of normal. Further northwest in the state, Lihue, Kauai recorded 51.95 in (1319 mm) and 140% of normal, the 14th wettest in a 69-year record. Large areas of the state saw improvements through the course of the year. At year's end, abnormally dry to moderate drought conditions were present on the leeward side of all Hawaiian Islands.

Significant Events of 2018:

- January 9: Deadly post-wildfire debris flow in Montecito, California: Soils were burned at moderate to high severity during December's Thomas Fire in the mountains above the communities of Montecito and Carpinteria. This resulted in water repellent soil conditions that produce much higher runoff rates than unburned areas. A band of intense precipitation in an otherwise moderate storm produced rain rates as high as 0.6 in (15 mm) in 5 minutes. Runoff from this intense precipitation scoured ash, boulders, soil, and burned vegetation from the steep channels, producing a debris flow that killed 21 people and destroyed over 100 homes.
- January and February: Low snowpack impacts on Sierra Nevada, New Mexico, Colorado Ski Resorts: Vail Resorts, a large resort operator, reported that visitation and retail sales are down approximately 10% this season through the first week of January. Many resorts have scaled back operations due to the low snowpack and have not been able to open all terrain. In northern New Mexico, Taos has only 25 of 111 runs open at the end of January. The lack of snow throughout February caused downhill and cross-country ski areas to close early or fail to open for the season. On February 21 the Yosemite Ski and Snowboard Area in the Sierra Nevada determined there would not be is enough snow to open the resort during the 2018-18 season. Throughout February, Royal Gorge Cross Country Ski Area near Lake Tahoe, the largest cross-country resort in North America, was unable to open due to a lack of snow. Shasta Ski Park in northern California had to temporarily close due to a lack of snow and warm weather. Ski Apache in New Mexico has only recorded 37 inches of snow for the season and a local business noted sales are down 75%.
- April 14-15: Heavy rainfall caused major flooding and landslides on the island of Kauai, Hawaii: A rain gauge in Waipa on Kauai's North Shore reported 49.69 in (1262 mm) of rain in a 24-hour period. This total is under consideration for the United States 24-hour rainfall record. The heavy precipitation resulted in landslides that closed the Kuhio Highway, the main roadway along the North Shore. Floodwaters damaged or destroyed homes, businesses, and roads and hundreds of people had to be rescued. Many people are cut off from their jobs or cannot work due to business closure and decrease in tourism following the event.
- April-November: Wildfire impacts across the West: April, May: Early start to fire season in Arizona, Utah: Dry winter and early spring conditions as well as above normal temperatures and high winds supported an early start to Arizona's primary fire season, which typically begins in late May. The Tinder Fire was ignited on April 27, destroyed 33 homes and burned over 16,000 acres (6475 hectares). In southwestern Utah, officials declared the fire season as beginning on May 16, two weeks earlier than is usual. A dry

winter and spring combined with windy conditions have dried out vegetation, creating fire hazard. July: In northern California, the Carr Fire was ignited on July 23 and burned over 230,000 acres (93,000 ha) and destroyed over 1600 structures and caused 8 deaths. In southwestern Oregon, the Taylor Creek Fire was started by lightning on July 15 and has burned over 53,000 acres (21,000 ha). By the end of July, the Washington State Department of Natural Resources had responded to over 900 fires in 2018, compared to 853 in all of 2018. However, most of these fires were contained while relatively small. August: The Mendocino Complex Fire in northern California became the largest in the state's history at over 451,000 acres (182,5000 hectares). In northern Nevada, the Sugarloaf Fire was ignited by a lightning strike on August 17 and burned over 232,000 acres (93,900 hectares). September: In northern California, the Delta fire started on September 5 and burned over 60,000 acres (24,281 hectares) and destroyed 20 structures. In northeast Nevada the Range 2 Fire began on September 30th in the Ruby Mountains and has burned over 9,000 acres (3,642 hectares). The Lamoille Canyon area of the Ruby Mountains is a popular tourist destination for camping, hiking, fishing, and other outdoor activities and remains closed until further notice. November: Devastating wildfires in California: The Camp Fire in Butte County, northern California, was ignited November 8 and became, by far, the most destructive wildfire in California history. The fire impacted the town of Paradise, resulting in 85 deaths and 18,804 structures destroyed. During the same wind event, in southern California, the Woolsey Fire burned over 96,000 acres (39,000 ha), destroyed 1,500 structures, and resulted in three deaths. Air quality impacts: Smoke from the various wildfires this year reduced air quality throughout large areas of the West, with notable impacts in central and northern California, western Nevada, and southern Oregon. In some cases, such as during November's Camp Fire, periods of poor air quality were prolonged and impacted heavily populated areas (San Francisco Bay Area).

- Mid-April through May: Snowmelt flooding in northern/central Montana, Northwest: In April, floodwaters washed out roads, inundated fields, and prompted evacuations from threatened homes. The Governor declared a flood emergency in seven counties. In May, with a period of above normal temperatures and, in some cases, compounded by above normal May precipitation, resulted in further flooding and prompted Montana's governor to declare a statewide flood emergency. In Missoula, over 60 homes were evacuated along the Clark Fork River, which reached major flood stage for the first time since 1981. North-central Washington also experienced snowmelt flooding in May, notably along the Okanogan River. On May 10, the Washington governor declared a State of Emergency for 20 central and eastern Washington counties.
- July Mid-month: Monsoon-related flash flooding in Southwest: Flash floods damaged homes and farmland in central and southern Utah. On July 13th, thunderstorms resulted in debris flows and derailling of a freight train, leading to multiple hours of road closure on US Highway 95 near the California-Nevada border. Roughly 20 homes were damaged by flash floods on July 15 in the small town of San Antonio, New Mexico.
- August 22-26: Hurricane Lane impacts Hawaii: Hurricane Lane weakened to a Category 3 or less as it approached and tracked southwest of the state. Lane caused flooding across the Hawaii as well as landslides, washed out roads, widespread road closures, and downed powerlines due to high winds. Strong winds caused a brush fire to spread rapidly near Lahaina, Maui, damaging or destroying over 20 homes.
- September All Month: Widespread drought impacts agriculture in Utah: For the first time in ten years an emergency meeting of the Utah Drought Review and Reporting Committee was called to investigate the potential need for an emergency declaration across the state. Many farmers in southern Utah have run out of surface water. Pasture and range conditions are some of the worst in the country with 71% of the grazable land in poor or very poor condition according to the Climate Prediction Center.

- October 1-3: Thunderstorms associated with remnants of Hurricane Rosa cause flooding, damage in Arizona: At least two people died in Arizona due to flash flooding associated with this storm. A 30-ft section of Highway 89 near Cameron, Arizona collapsed, resulting in one death. The collapse prompted the Navajo Nation to declare a state of emergency, as the highway serves several of its communities.
- Early October: Hurricane Walaka impacts Northwestern Hawaiian Islands: Category 5 Hurricane Walaka resulted in the submersion of a small, uninhabited sandy island known as East Island. The area is part of Papahānaumokuākea Marine National Monument and serves as a refuge for endangered species.

For more information, please go to the [Western Regional Climate Center Home Page](#).

All regional climate center summaries were taken from NOAA National Centers for Environmental Information, State of the Climate: National Climate Report for Annual 2018, published online January 2019, retrieved on March 4, 2019 from: <https://www.ncdc.noaa.gov/sotc/national/201813>

2018 Current AASC State Climatologists/ Directors

State	State Climatologist/ Director
Alabama	John R. Christy
Alaska	Martin Stuefer
Arizona	Dr. Nancy J. Selover
California	Michael Anderson
Colorado	Russ Schumacher
Delaware	Daniel J. Leathers
Georgia	Dr. Bill Murphey
Hawaii	Dr. Pao-Shin Chu
Idaho	Dr. Russell J. Qualls
Illinois	Dr. James Angel (retired Dec. 2018)
Iowa	Dr. Justin Glisan
Kansas	Dr. Xiaomao Lin
Kentucky	Dr. Stuart A. Foster
Louisiana	Barry Keim
Maine	Dr. Sean D. Birkel
Michigan	Jeff Andresen
Minnesota	Luigi Romolo
Mississippi	Dr. Michael Brown
Missouri	Dr. Patrick Guinan
Nebraska	Dr. Martha D. Shulski
Nevada	Dr. Douglas P. Boyle
New Hampshire	Mary Stampone
New Jersey	Dr. David A. Robinson
New Mexico	Dr. Dave DuBois
North Dakota	Adnan Akyuz
Ohio	Bryan Mark
Oklahoma	Dr. Kevin Kloesel
Oregon	Dr. Philip Mote
Pennsylvania	Kyle Imhoff
South Carolina	Dr. Hope Mizzell
Texas	John Nielsen-Gammon
Utah	Dr. Robert R. Gillies
Vermont	Dr. Lesley-Ann Dupigny-Giroux
Virginia	Philip J. Stenger
Washington	Dr. Nicholas Bond
West Virginia	Dr. Kevin Law
Wyoming	Dr. Chris Nicholson

