

A Hotter, Wetter, and More Humid North Carolina

Kathie Dello, Walter Robinson, Ken Kunkel, Jenny Disson, Tom Maycock

This commentary is adapted from the North Carolina Climate Science Report, led by the North Carolina Institute for Climate Studies, drawing from climate science expertise across the state and peer-reviewed research to reach conclusions about the impact of climate change and associated extreme weather on our state.

Introduction

Climate change is already being felt in North Carolina, and it will continue to pose a significant challenge for the foreseeable future for the 10.5 million people who call this state home. The continuing release of heat-trapping gases into the atmosphere as a result of human activity makes for a warmer, wetter, and more humid North Carolina. Scientists from across the state agree that the changes to our climate in this century will be larger than anything experienced in North Carolina's historical past. Climate change will impact our state's economy, environment, and people. Over the next 80 years, the state can expect disruptive sea level rise, increasingly hot nights, more severe droughts, and more days with dangerous heat and extreme rainfall unless the global increase in heat-trapping gases is stopped [1].

We need to build resilience to climate change to ensure a thriving, healthy North Carolina over the next few decades. We need to reduce our fossil fuel use to mitigate the impacts of climate change through the rest of the 21st century.

We see pictures of the polar bear floating on a lonely piece of ice: but make no mistake, climate change affects us here, as people, in our backyard. From Franklin to Nags Head, a warmer, wetter climate will directly affect public health in North Carolina. Our urban communities have challenges with extreme heat in urban heat islands. Our rural communities are struggling with the challenges of outdoor labor in extreme temperatures. Water quality is threatened by extreme precipitation, and water quantity—our drinking water—is at stake on the other side of the coin. Here, we detail the past and projected impacts of climate change on our state.

North Carolina has warmed by about 1°F over the past 120 years. This is less than Earth as a whole, which has warmed by nearly 2°F. The National Oceanic and Atmospheric Administration's National Centers for Environmental Information (NCEI), housed in Asheville,

North Carolina, maintains meticulous climate records for the country and planet—measured throughout what we call recorded history—through the use of thermometers and rain gauges at official sites monitored by trained observers. From these data, we know that even though the state has warmed less than the planet, warming here has accelerated in recent decades. The last decade (2009-2018) beat out the warm 1930s as the warmest decade on record for North Carolina [1]. While this report was being finalized, 2019 was declared North Carolina's warmest year in 125 years of record keeping [2].

Scientists expect the warming to continue in North Carolina through this century, in all seasons. The amount of warming will depend on future emissions of heat-trapping gases. Scientists study future warming using climate models and potential scenarios of how we may continue to use resources and burn fossil fuels (coal, oil, and natural gas). If emissions continue to grow rapidly through the end of the century, North Carolina is projected to warm an additional 6°-10°F by 2100 [1]. Under a scenario in which emissions increase at a slower rate, peak around the middle of the century, and then begin to decrease, the warming will range from 2°-6°F [1]. Emissions are similar in the two scenarios through mid-century, and they suggest a fairly similar amount of warming through about 2050, with the range being slightly greater under the higher emissions scenario [1].

Nights have been getting hotter, but there is no historical trend in hot days. The last five years (2015-2019) have had the warmest overnight low temperatures on record in North Carolina, with 2019 setting the record for the warmest lows in the recorded past [1]. These warm nights affect public health specifically by creating conditions where the body cannot cool down after a high-temperature day.

In the future, both days and nights are likely to get hotter. This increased heat, together with increases in humidity, will present a public health risk. The heat index

Electronically published September 2, 2020.

Address correspondence to Kathie Dello, Suite 130, Research III Building, 1005 Capability Drive, Centennial Campus, Box 7236, North Carolina State University, Raleigh, NC 27695 (kddello@ncsu.edu).

NC Med J. 2020;81(5):307-310. ©2020 by the North Carolina Institute of Medicine and The Duke Endowment. All rights reserved. 0029-2559/2020/81505

is a measure that combines air temperature and relative humidity to get at how the human body experiences these conditions. It is very likely that there will be more days with dangerously high heat index values due to increases in temperature and humidity. In a warmer North Carolina, warmer nights are very likely, and the number of cold days is likely to decrease. Cities tend to be warmer than surrounding rural areas because paved surfaces absorb and retain heat. This is called the urban heat island effect, and it is projected to increase as North Carolina warms and our urban areas grow.

There is no trend in annual precipitation, but extreme rainfall has increased in the recent past, including a new statewide record for precipitation. 2018 was North Carolina's wettest year on record in 125 years of record keeping, partially as a result of Hurricane Florence, which produced the heaviest rainfall in North Carolina history. The 2015-2018 period saw an increase in the number of days with very heavy rain, defined as three inches or more in 24 hours [1]. The official climate station on Mt. Mitchell received 139.94 inches of precipitation in 2018, which set a new statewide precipitation record [1].

Heavy rains from hurricanes and other weather systems will become more frequent and more intense. Annual precip-

itation is also expected to increase. These changes are driven primarily by increases in atmospheric water vapor as the climate warms. Extreme rainfall in North Carolina can result from hurricanes (as experienced in recent years with Dorian, Florence, Matthew, and Michael), from Nor'easters (strong coastal storms with winds from the Northeast), or from other weather systems like thunderstorms [3-6]. Severe thunderstorms are also likely to increase in a warming climate and can cause flash flooding, especially in urban areas.

Increased flooding, due largely to sea level rise, will disrupt coastal and low-lying communities. By the end of the century, these areas will experience high tide flooding nearly every day and a substantial increase in the chance of flooding from coastal storms. The ocean is rising because melting glaciers add more water to the ocean and because sea water increases in volume when it warms. Sea levels are rising faster on the northern coast of North Carolina than on the southern coast, but by the end of the century all of the state's coast will experience disruptive coastal flooding [1]. Under the higher emissions scenarios, flooding events that are currently rare will become much more likely.

Hurricanes will be wetter and are likely to be more intense, though it is unknown whether the number of hurricanes

making landfall in North Carolina will change. Atmospheric water vapor is the fuel for hurricanes. Increased water vapor in a warmer climate will favor hurricanes that are more intense and that will produce more extreme rainfall.

Severe droughts will become more intense, and this will increase the risk of wildfires. Rising temperatures and the resulting increase in evaporation will accelerate the rate at which soils dry out. Thus, naturally occurring droughts in North Carolina will be more severe. The state's worst ever drought in 2007 led to water restrictions in municipalities [7]; some had less than a 100-day supply of water available for residents. Large agricultural losses were experienced by producers. In 2016, Western North Carolina experienced drought and wildfires. It is expected that severe drought impacts will become more frequent in a warmer North Carolina.

North Carolina's climate is changing rapidly. By warming the planet, we shift our long-term averages (climate), as well as our day-to-day weather. A couple degrees of warming can mean that rainfall is more intense, nights are warmer, and days are hotter. On the other side of the coin, warmer temperatures and prolonged dry periods mean that droughts

will be more severe. The state must plan for both sides of the coin—too much water, and not enough. Ultimately, we need to reduce our reliance on fossil fuels as an energy source and build resilience to climate change in the near term. No part of this state will be spared from the impacts of climate change, but there is still time to act. **NCMJ**

Kathie Dello, PhD director/state climatologist, North Carolina State Climate Office, North Carolina State University, Raleigh, North Carolina.

Walter Robinson, PhD professor, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina.

Ken Kunkel, PhD senior scientist, North Carolina Institute for Climate Studies, North Carolina State University, Asheville, North Carolina.

Jenny Disen, MS corporate relationships and partnerships lead, North Carolina Institute for Climate Studies, North Carolina State University, Asheville, North Carolina.

Tom Maycock, MLA science public information officer, North Carolina Institute for Climate Studies, North Carolina State University, Asheville, North Carolina.

Acknowledgments

This commentary is adapted from the plain language summary of the North Carolina Climate Science Report, the first report of its kind for the state of North Carolina. The North Carolina Climate Science Report (NCCSR), led by the North Carolina Institute for Climate Studies, draws from climate science expertise across the state, as well as from

peer-reviewed science, to reach conclusions about the impact of climate change and associated extreme weather on our state. It has been thoroughly reviewed by subject matter experts. The full report can be accessed at <https://ncics.org/programs/nccsr/>.

Potential conflicts of interest. The author reports no conflicts of interest.

References

1. Kunkel, Easterling, Ballinger, et al. North Carolina Climate Science Report. Asheville, NC: North Carolina Institute for Climate Studies; 2020. https://ncics.org/wp-content/uploads/2020/06/NC_Climate_Science_Report_FullReport_Final_revised_May2020.pdf. Published May 2020. Accessed July 27, 2020.
2. Dello K, Davis C. Q&A: Our Record Warmest Year in 2019. North Carolina Climate Office website. <https://climate.ncsu.edu/climateblog?id=308>. Published January 8, 2020. Accessed July 27, 2020.
3. Davis C. Rapid Reaction: Dorian Drenches and Damages the Coast. North Carolina Climate Office website. <http://152.14.35.147/climateblog?id=293>. Published September 9, 2019. Accessed July 27, 2020.
4. Davis C. Rapid Reaction: Record Rainfall and Flooding Follow Florence. North Carolina Climate Office website. <http://152.14.35.147/climateblog?id=266>. Published September 18, 2018. Accessed July 27, 2020.
5. Davis C. Rapid Reaction: Michael Whips Up Winds and Widespread Damage. North Carolina Climate Office website. <http://152.14.35.147/climateblog?id=268>. Published October 12, 2018. Accessed July 27, 2020.
6. Davis C. Rapid Reaction: Matthew's Mark on NC Includes Heavy Rain, Flooding. North Carolina Climate Office website. <http://152.14.35.147/climateblog?id=215>. Published October 10, 2016. Accessed July 27, 2020.
7. Boyles R. 2007 Drought: Lessons Learned & Issues. Presentation at: 6th Annual One Medicine Symposium; December, 2008; Durham, NC. <http://www.ncagr.gov/oep/Veterinary/noms/2008/Boyles%20-%20Drought%20Panel%20-%20Climate%20Change.pdf>. Accessed July 27, 2020.