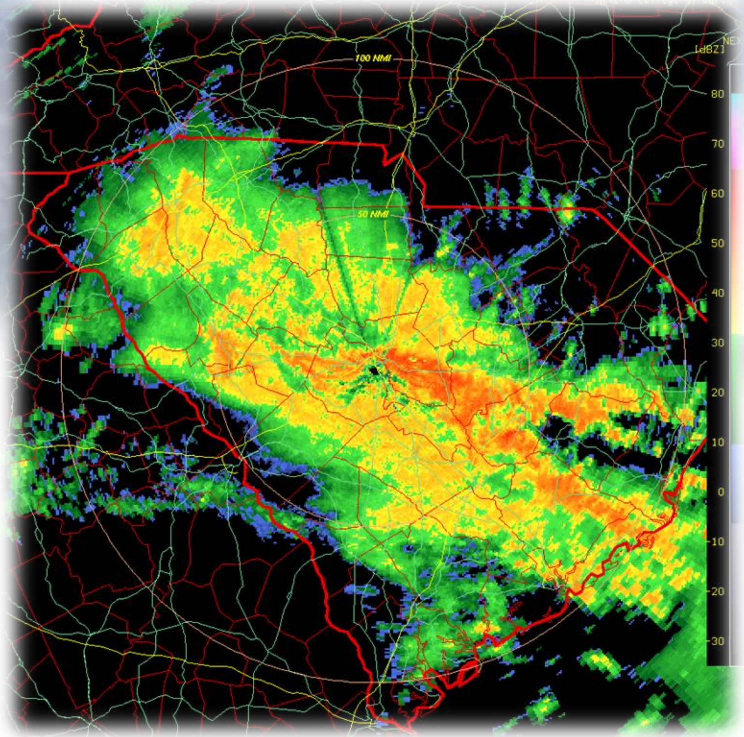
South Carolina's Climate Report Card:

Understanding South Carolina's Climate Trends and Variability



Hope Mizzell,
Melissa Griffin and Leah Moore
SC State Climatology Office

South Carolina State Climatology Office

Serves as the State’s focal point for weather and climate information

•Archive, process, and disseminate South Carolina weather and climate data, to educate on current and emerging weather and climate issues

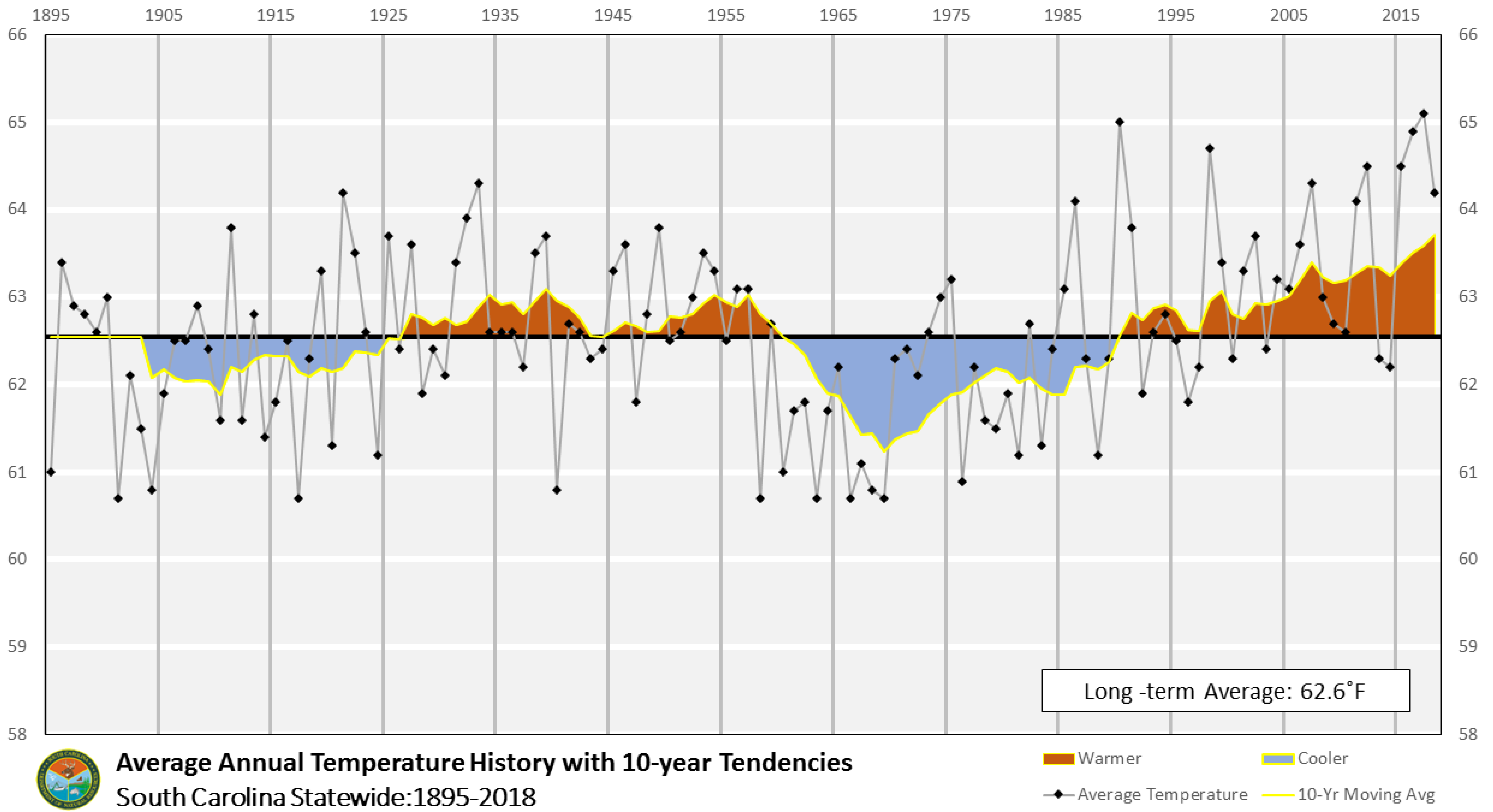
•Assist in forecast interpretation before, during, and after periods of severe weather

•Maintain an active research program

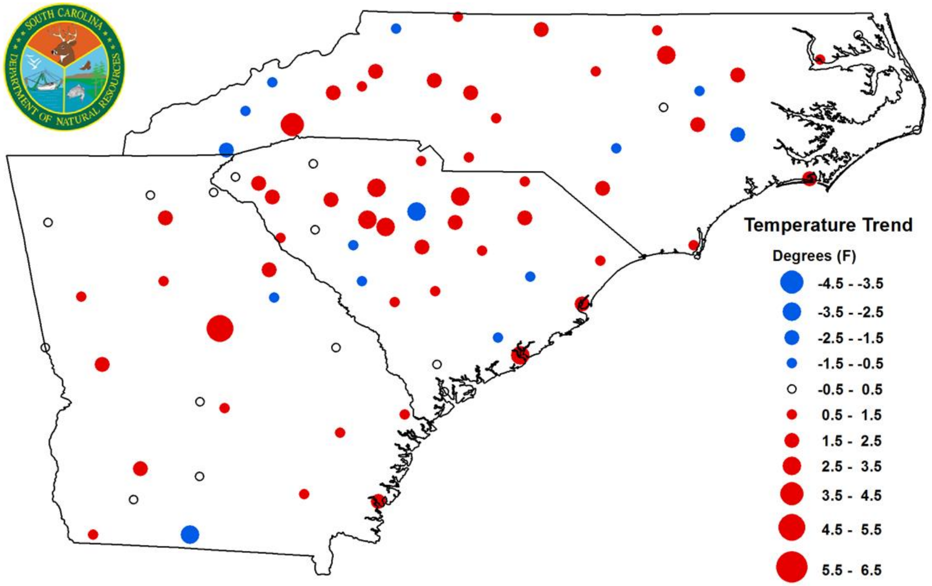
www.dnr.sc/climate/sco

Is the SC Getting Warmer or Colder?

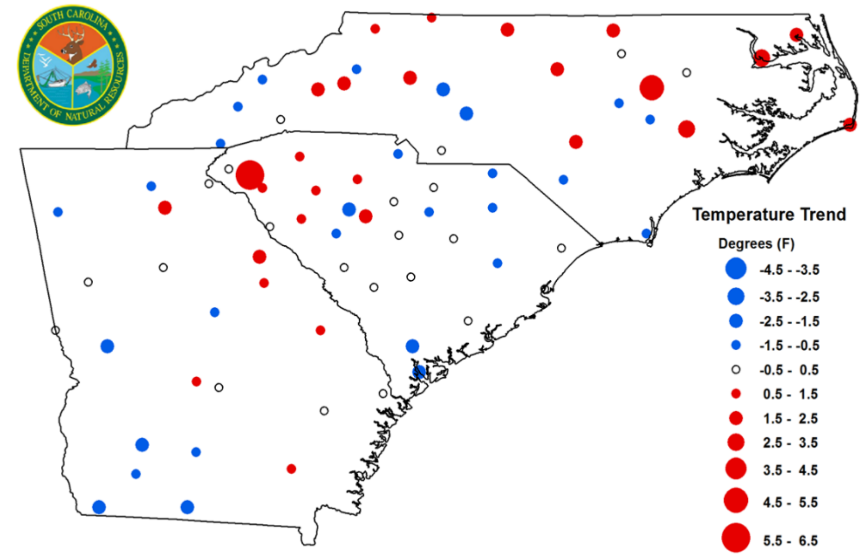
SC Statewide Average Annual Temperature 1895-2018



Winter Maximum Temperature 1901-2015

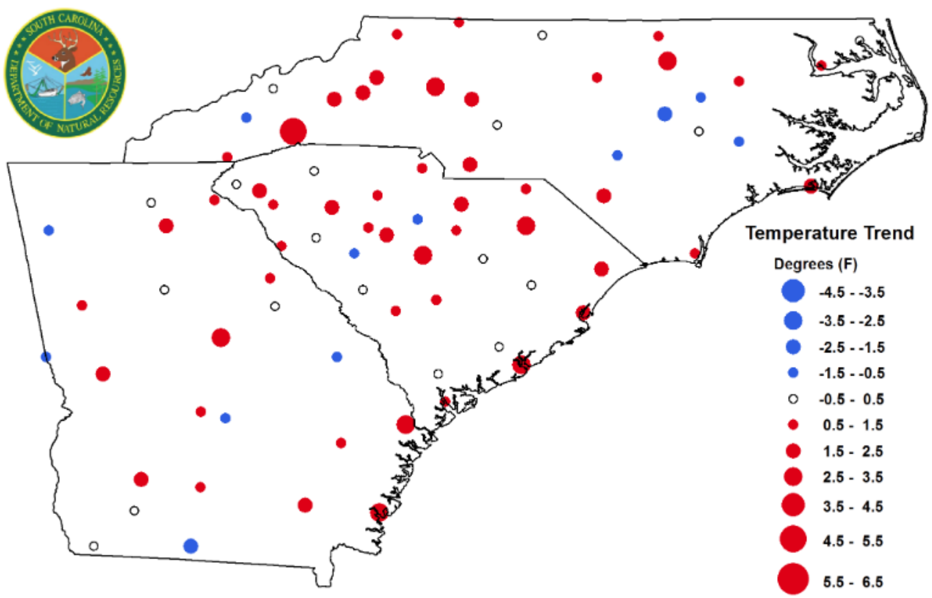


Winter Minimum Temperature 1901-2015

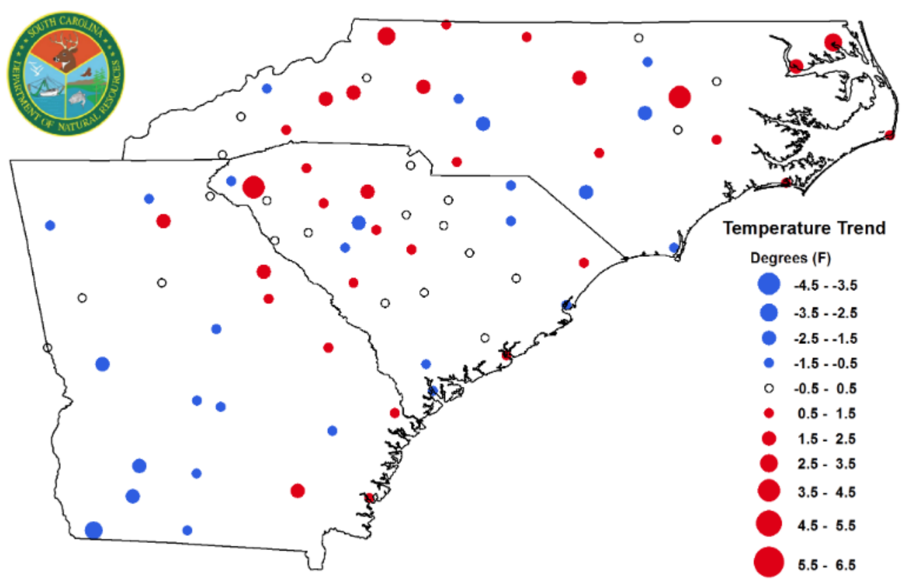


USHCN database developed by NOAA. Stations chosen using criteria:
-length of period of record -% of missing data
-number of station moves and other station changes

Spring Maximum Temperature 1901-2015

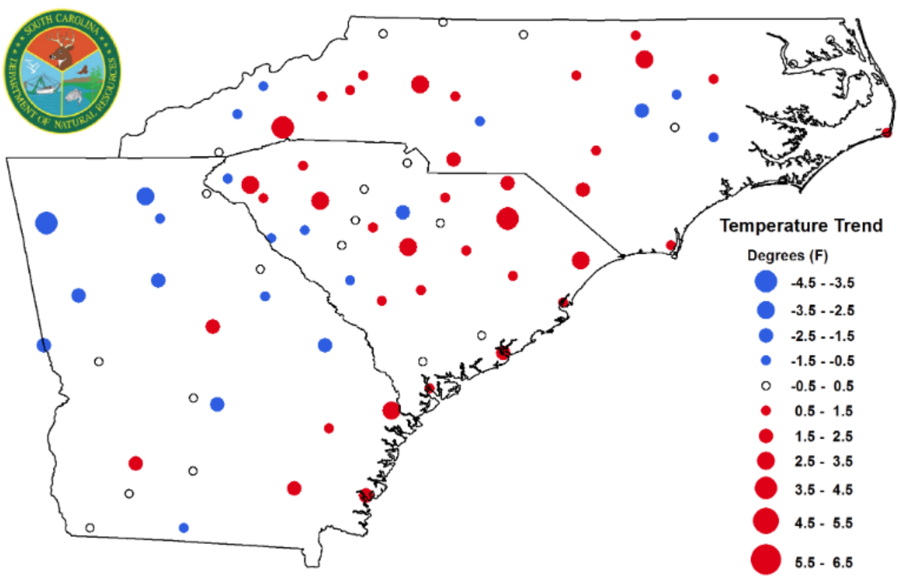


Spring Minimum Temperature 1901-2015

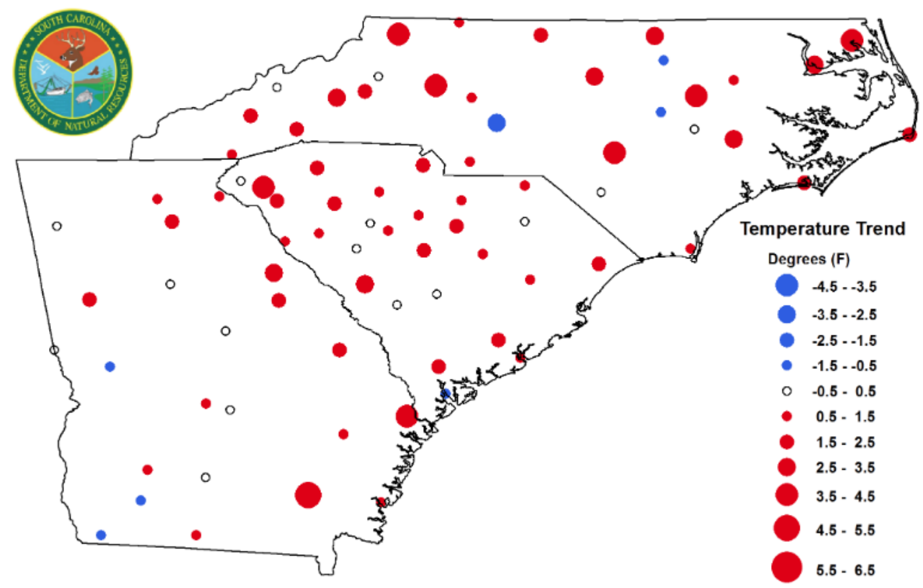


USHCN database developed by NOAA. Stations chosen using criteria:
-length of period of record -% of missing data
-number of station moves and other station changes

Summer Maximum Temperature 1901-2015



Summer Minimum Temperature 1901-2015



USHCN database developed by NOAA. Stations chosen using criteria:
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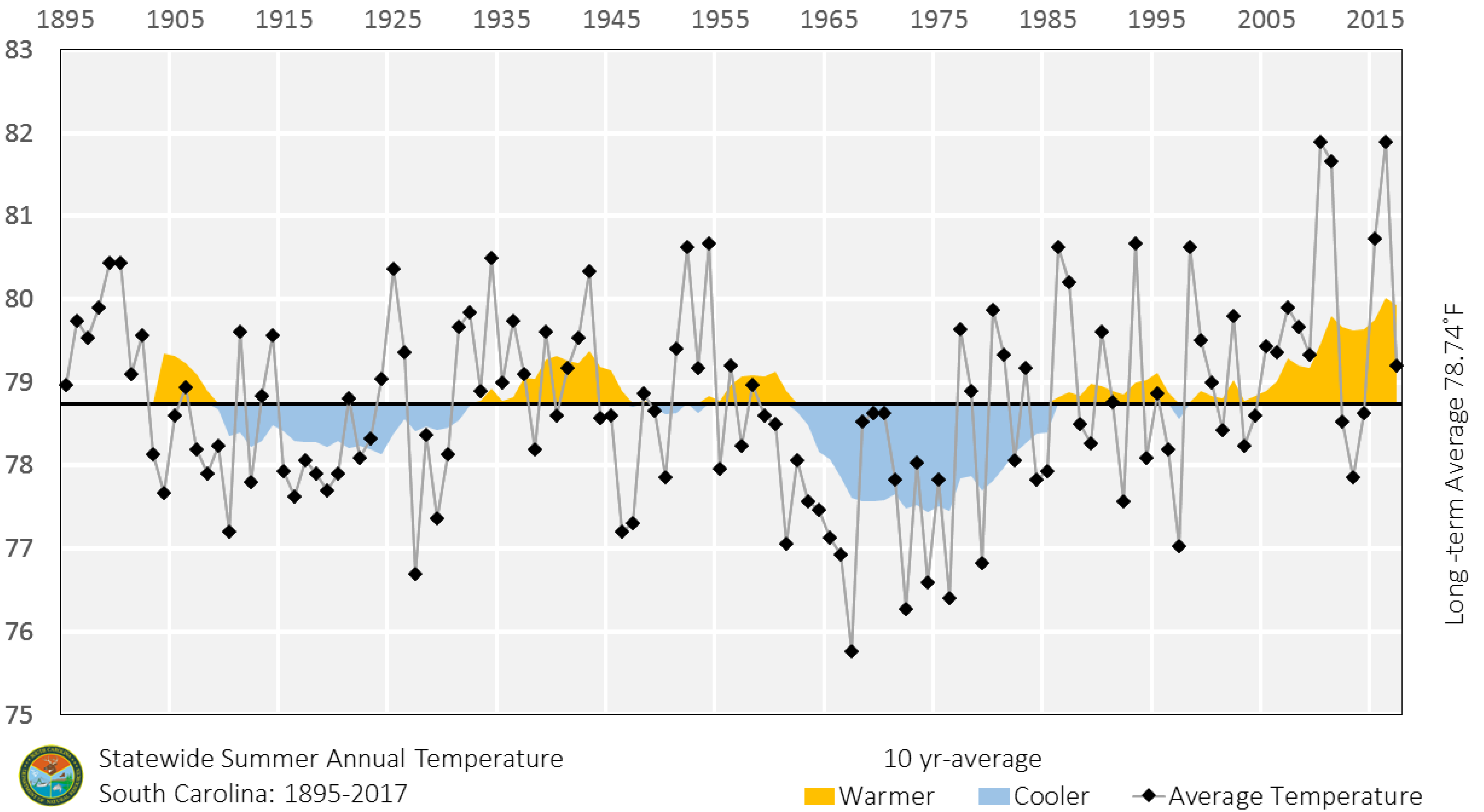
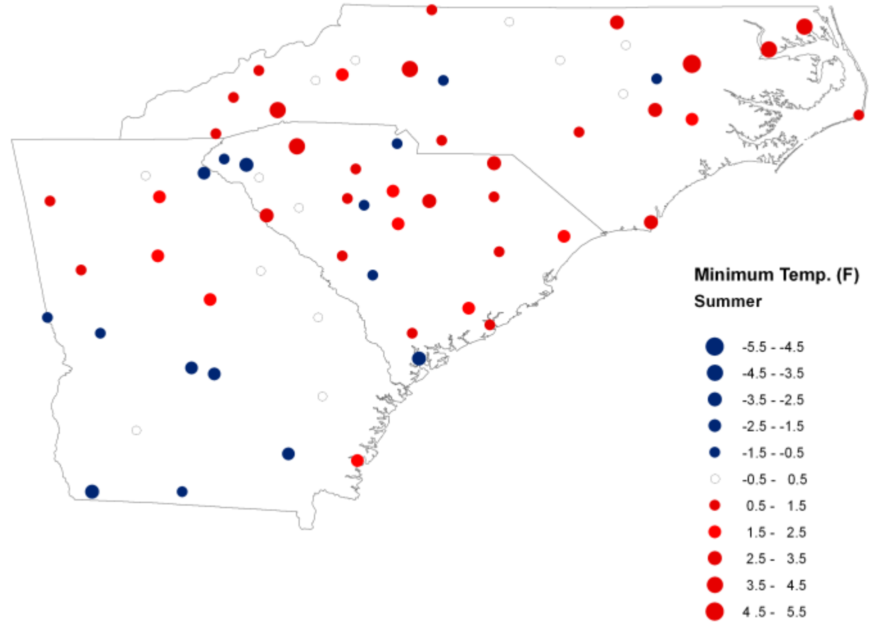
-number of station moves and other station changes

SC Statewide Average Summer Temperature
1895-2017

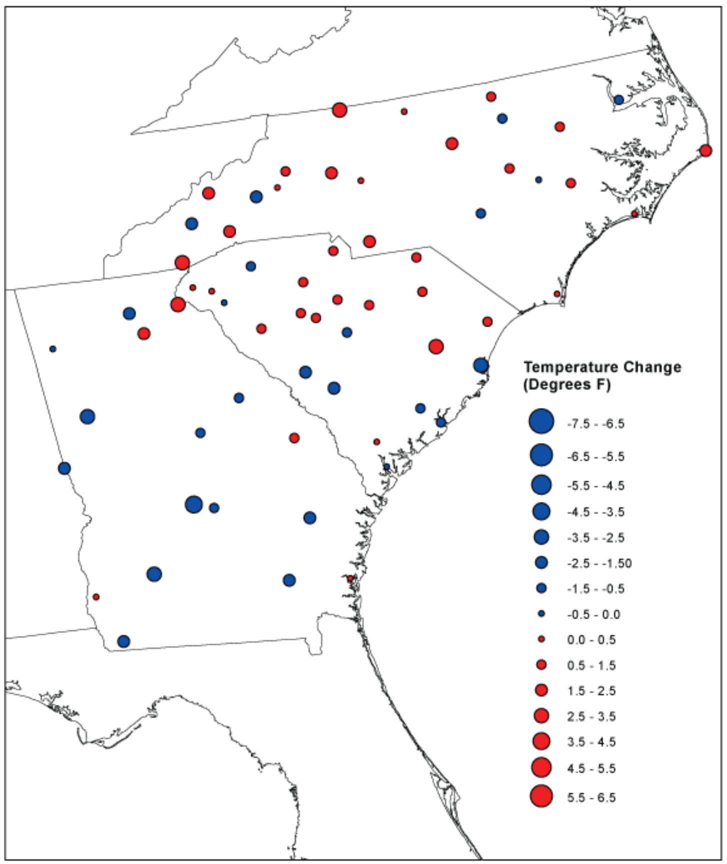


Summer Minimum Temperature Comparison 1901 - 2015

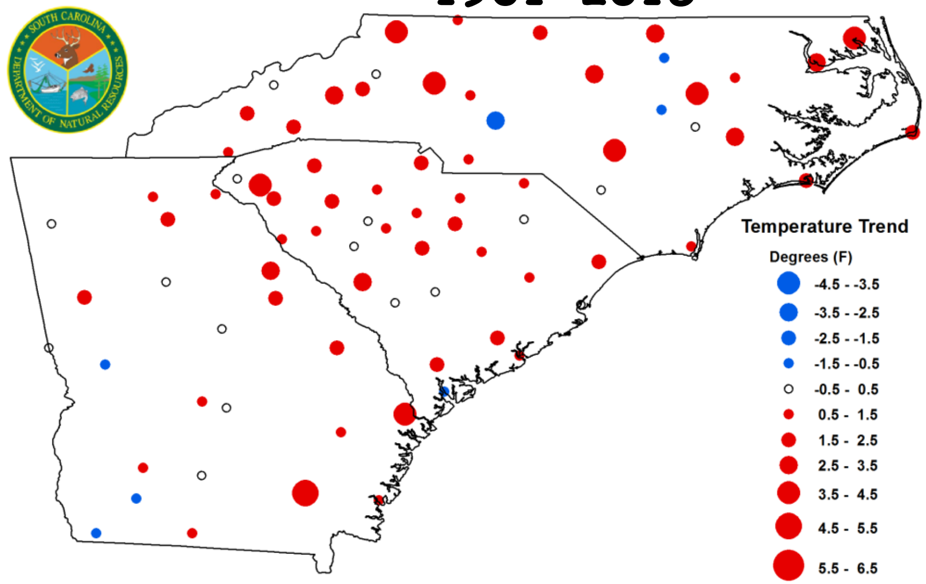
1901-2010



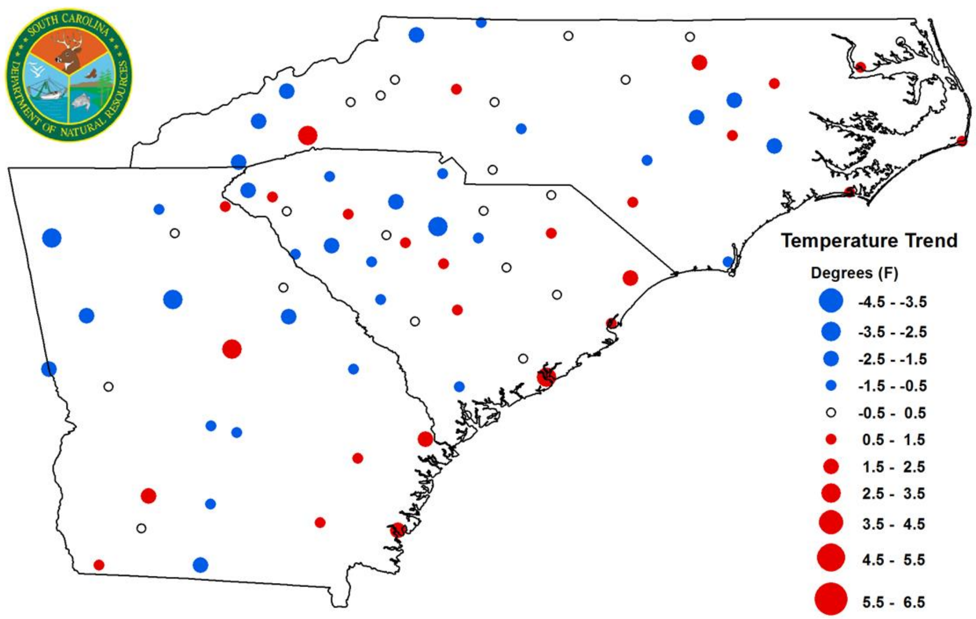
1901-2005



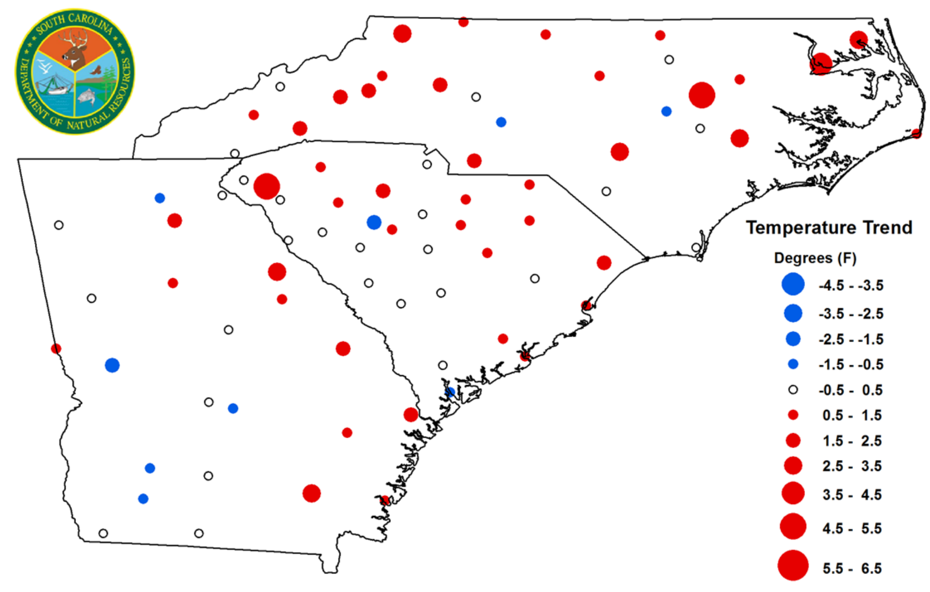
1901-2015



Fall Maximum Temperature 1901-2015



Fall Minimum Temperature 1901-2015



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South Carolina State Climatology Office

AASC AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

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The State Climatology Office (SCO) has represented the State in all climatological and meteorological matters within and outside South Carolina since its creation in 1986 in accordance with Chapter 25, Title 49, of the South Carolina Code of Laws. The Office provides a unique service to the State by archiving and distributing climatological data to State agencies, educational and research institutions, and private citizens; much of the data is provided at no cost, or for a nominal fee. The State Climatology Office is a division within the South Carolina Department of Natural Resources.

Hurricane Florence - Preliminary Open File Report

SOUTH CAROLINA NOTABLE STATE DOCUMENTS AWARD **August 21, 2017 Solar Eclipse**

Interactive Journal of Hurricane Matthew, October 8, 2016

SOUTH CAROLINA NOTABLE STATE DOCUMENTS AWARD **Interactive Journal of the October 2015 Historic Rain and Flooding**

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- South Carolina Temperature and Precipitation Trends 1901-2015
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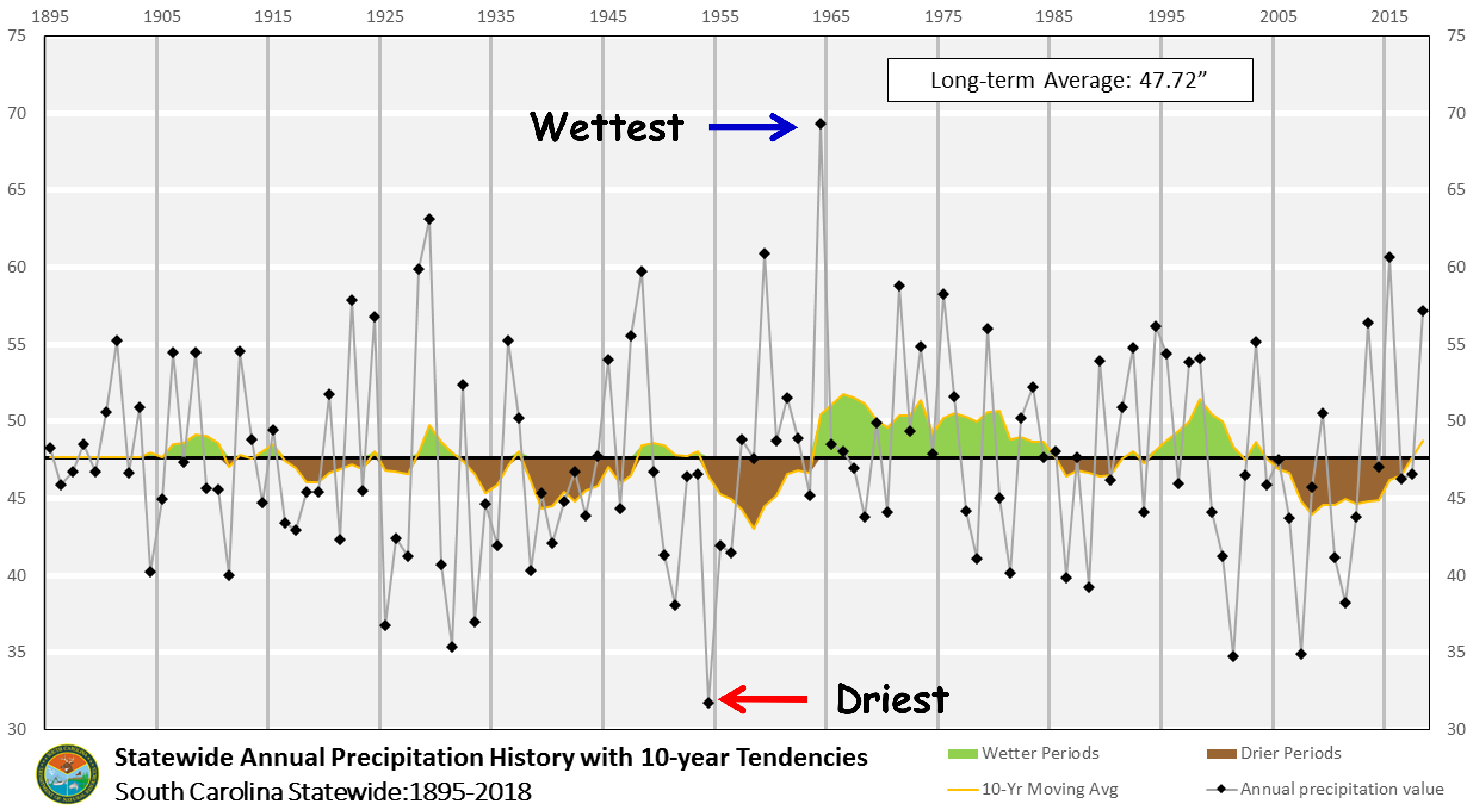
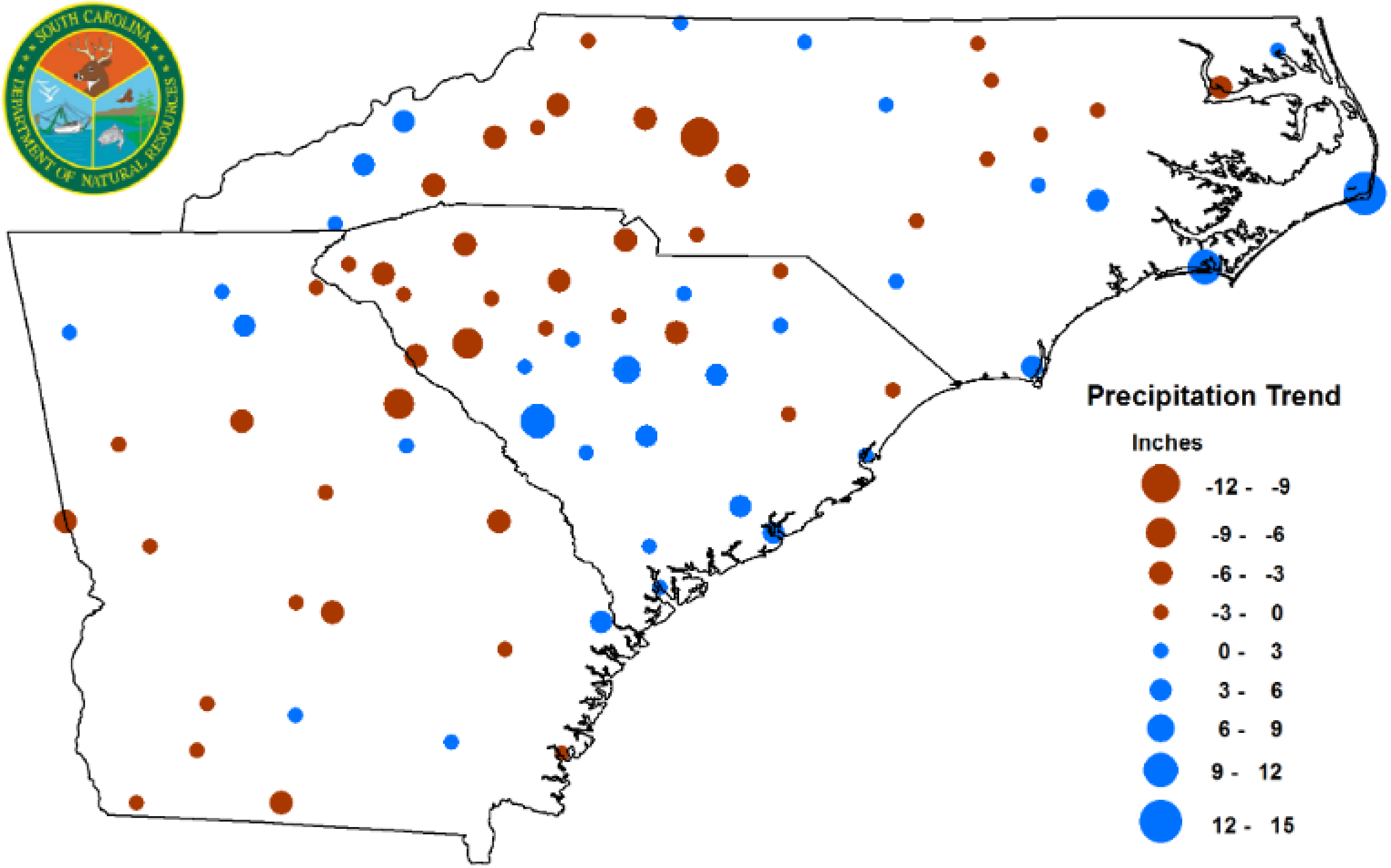
Is it Wetter or Drier?

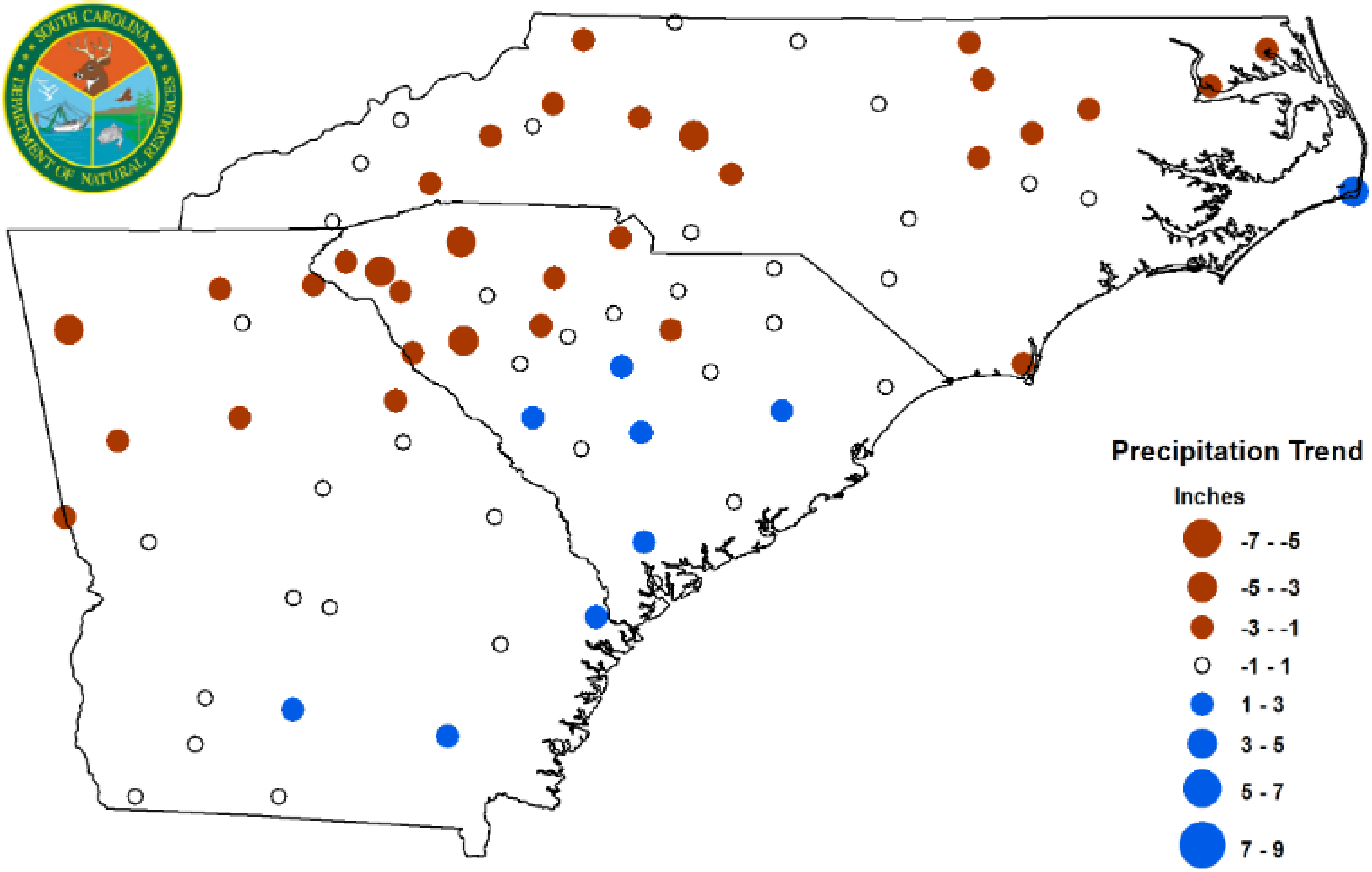
SC Annual Precipitation Trend
1895-2018



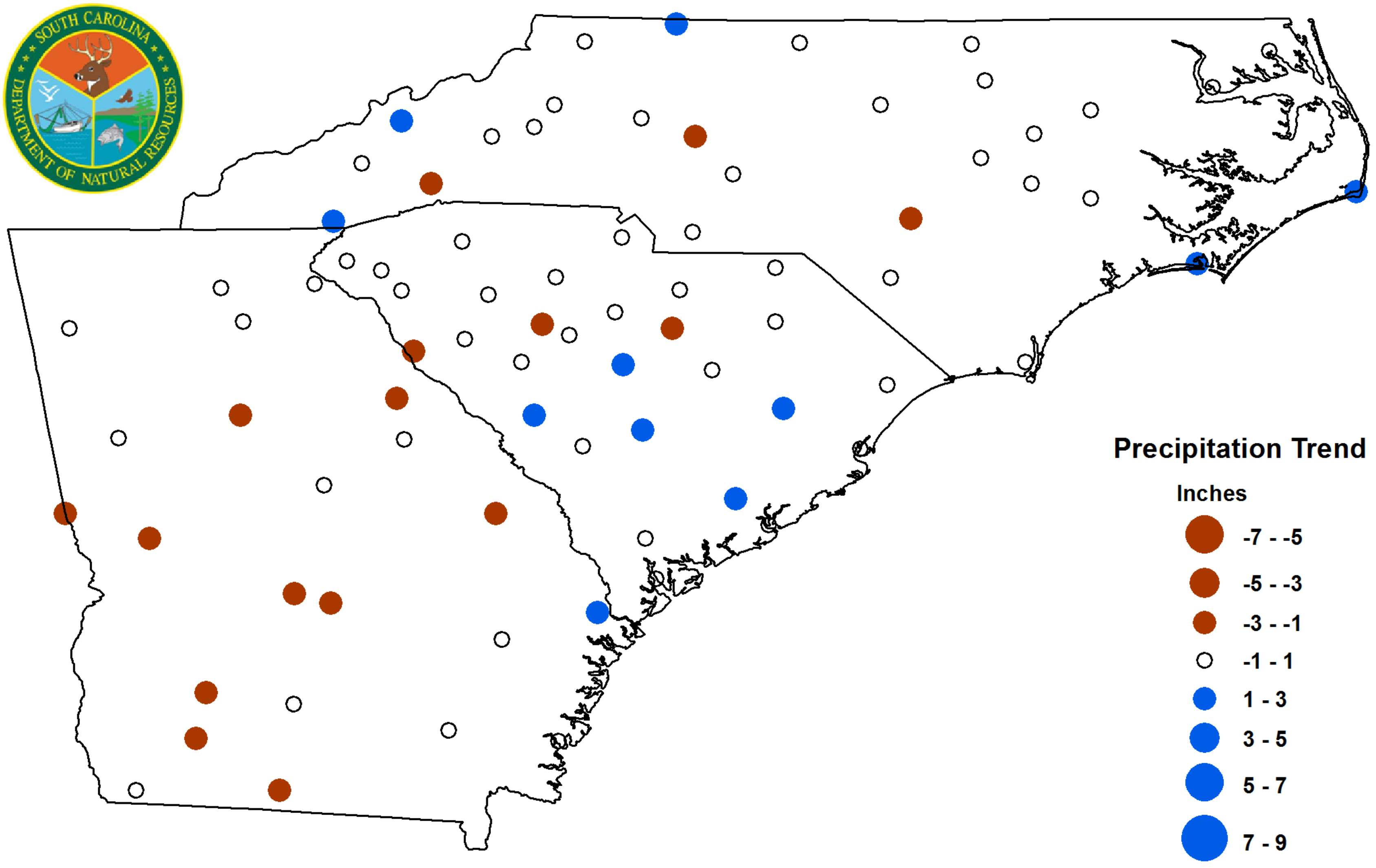
Annual Precipitation
1901-2015



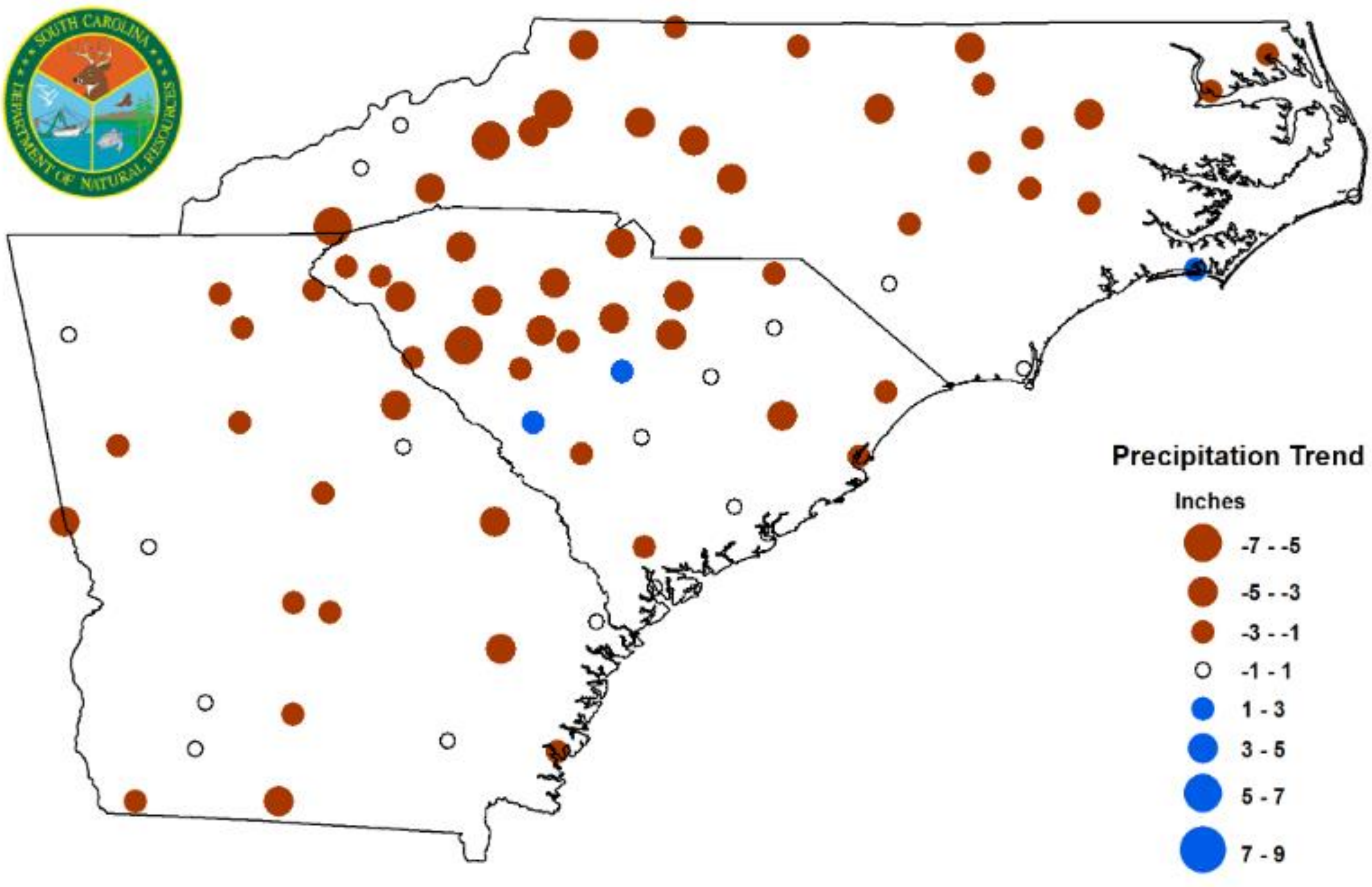
Winter Precipitation
1901-2015



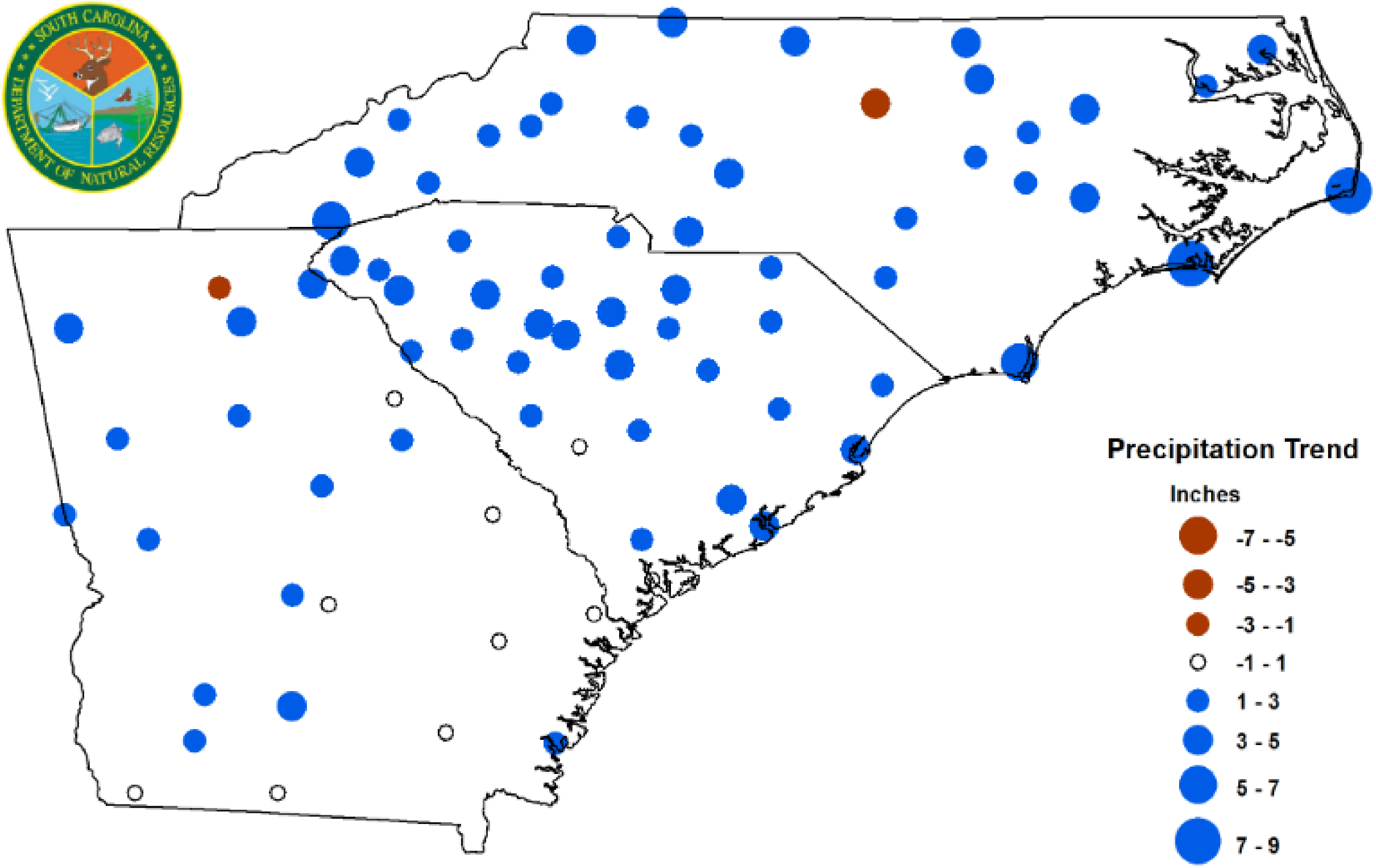
Spring Precipitation
1901-2015



Summer Precipitation
1901-2015

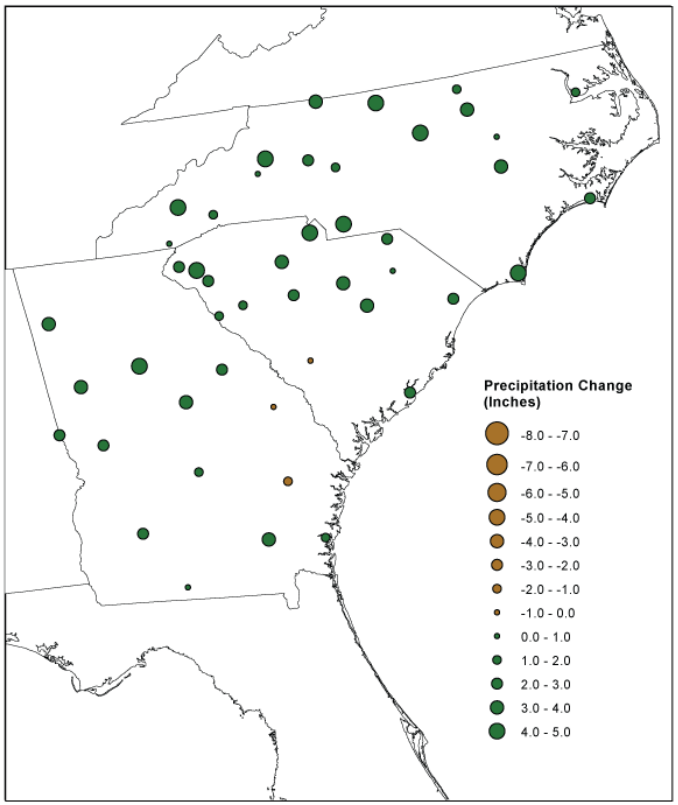


Fall Precipitation
1901-2015

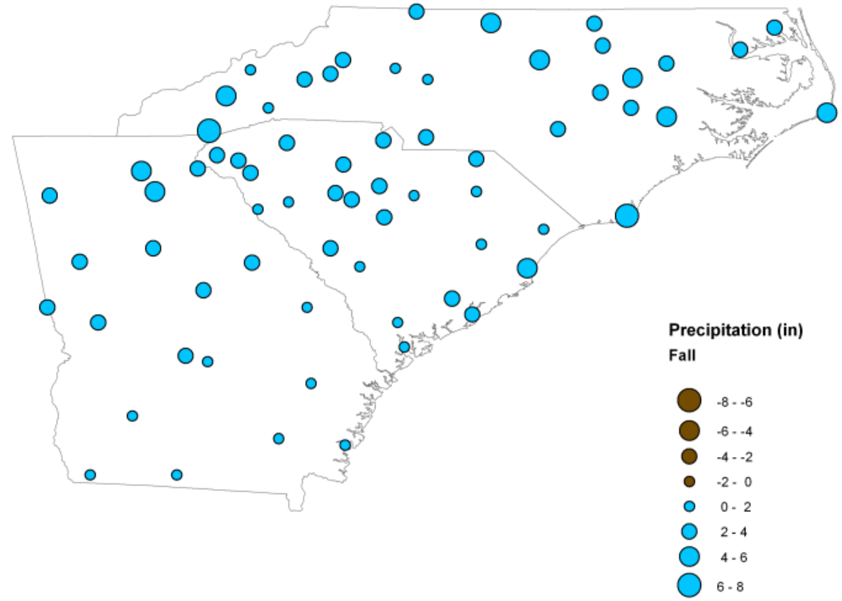


Fall Average Precipitation Comparison 1901 - 2015

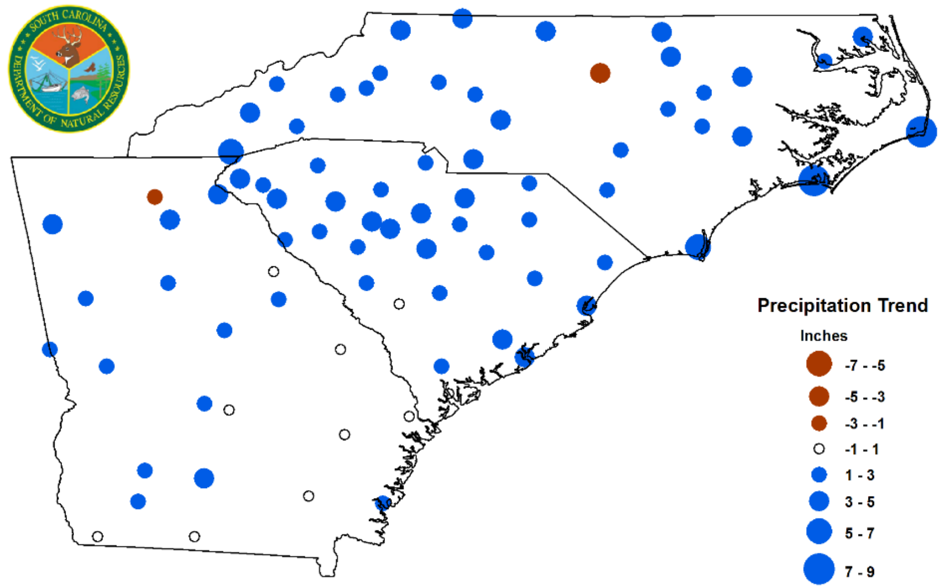
1901-2005



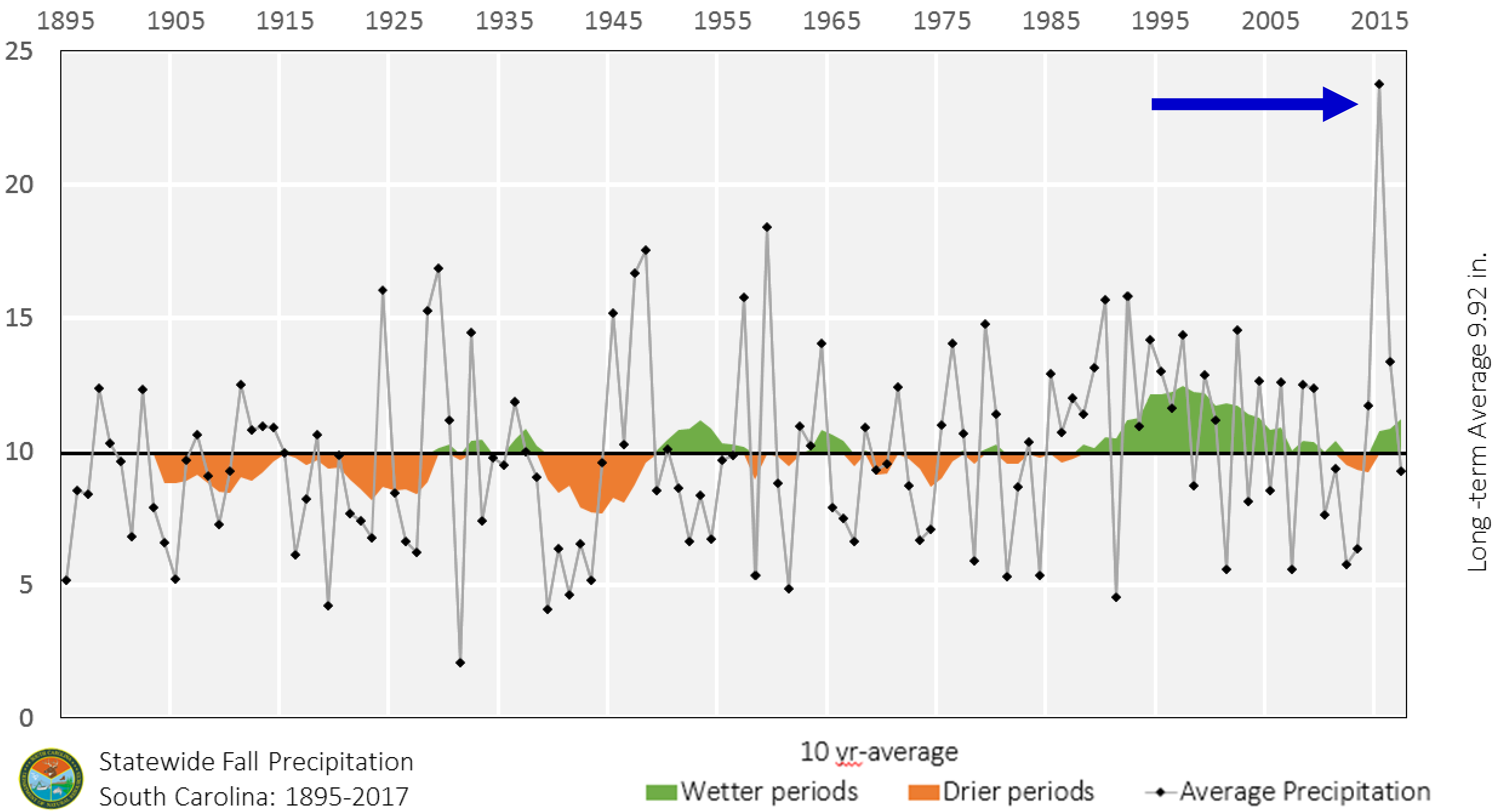
1901-2010

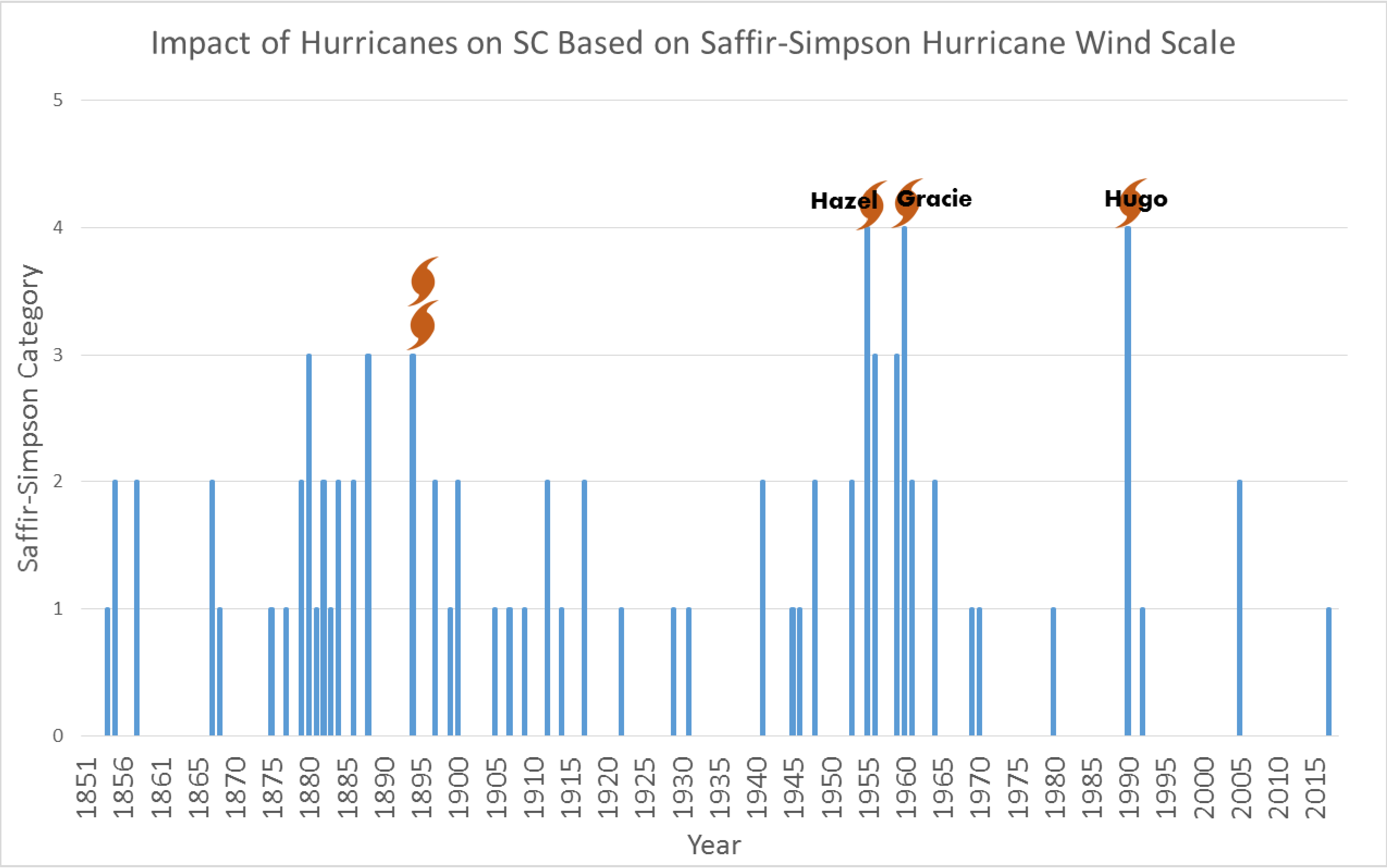


1901-2015

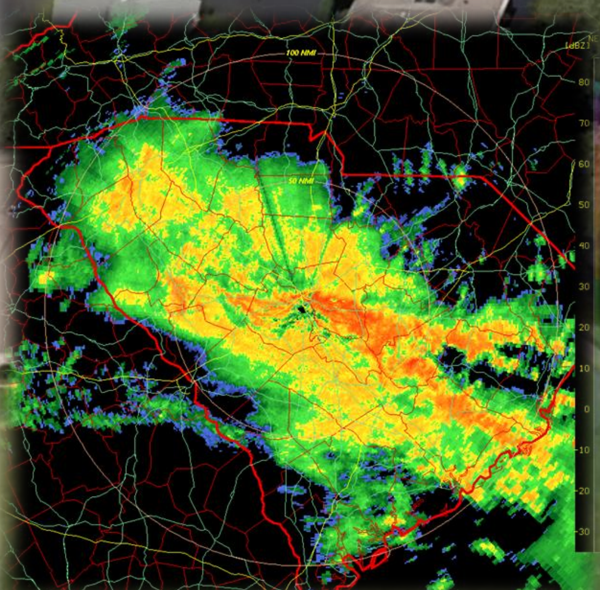


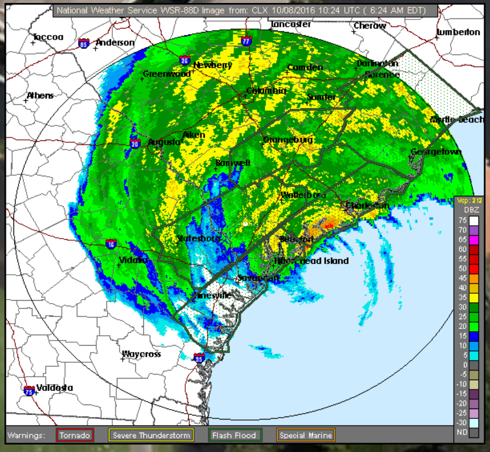
SC Statewide Average Fall Precipitation 1895-2017

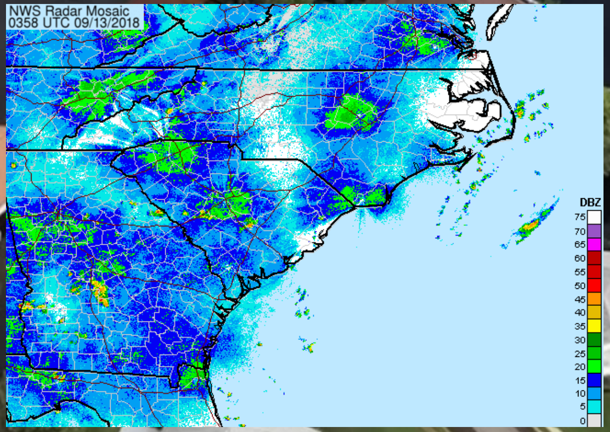



Impact of Hurricanes on SC Based on Saffir-Simpson Hurricane Wind Scale
Saffir-Simpson Category
0
1
2
3
4
5
Hazel
Gracie
Hugo
1851
1856
1861
1865
1870
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year

Extreme Rainfall







NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: SC

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

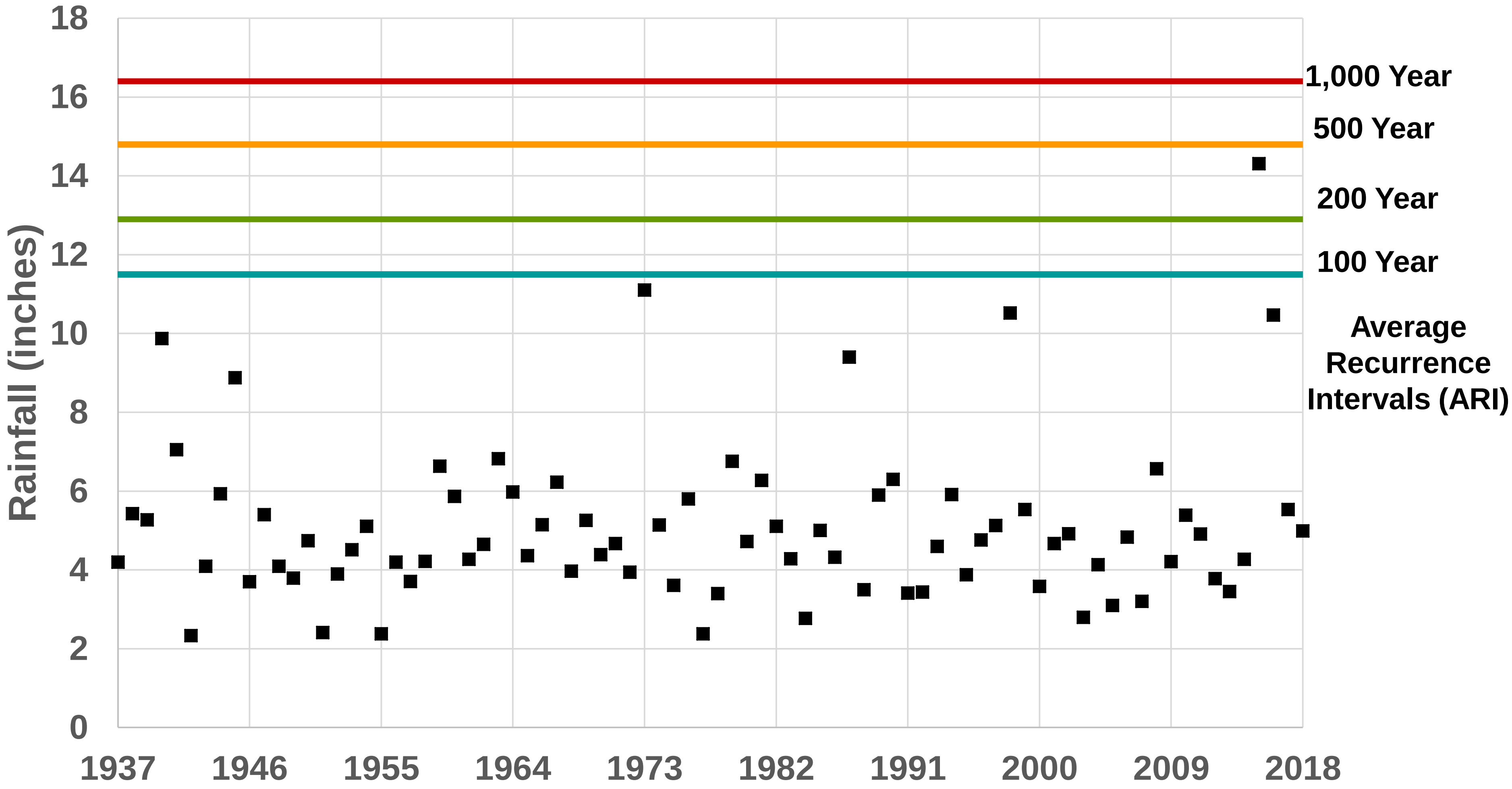
NOAA Atlas 14, Volume 2, Version 3

PF tabular | PF graphical | Supplementary information | Print page

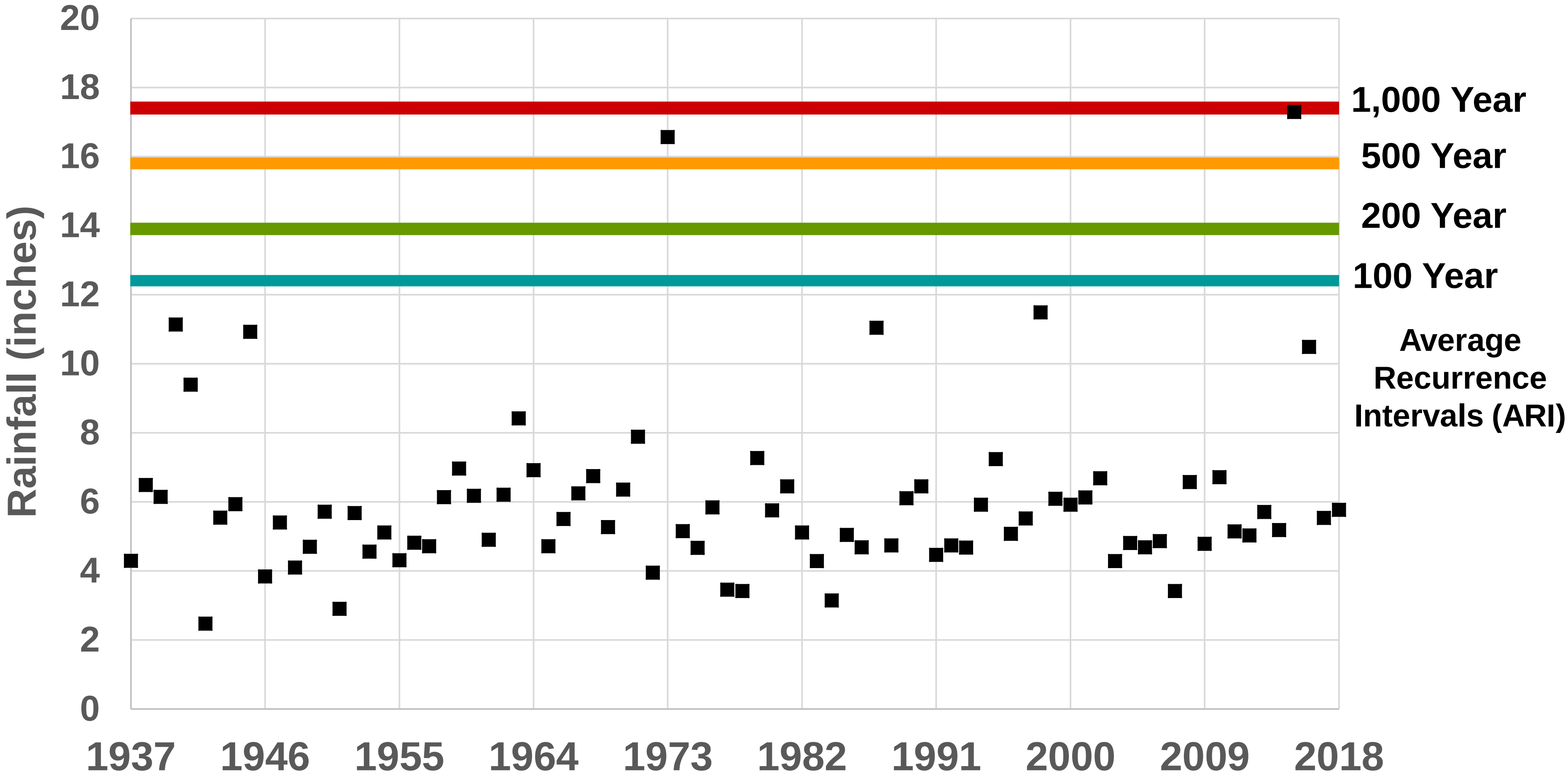
PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.500** (0.464-0.539)	**0.583** (0.542-0.631)	**0.671** (0.622-0.726)	**0.760** (0.701-0.819)	**0.857** (0.788-0.923)	**0.938** (0.860-1.01)	**1.02** (0.927-1.10)	**1.09** (0.990-1.18)	**1.19** (1.07-1.29)	**1.28** (1.13-1.38)
10-min	**0.798** (0.741-0.862)	**0.933** (0.867-1.01)	**1.08** (0.996-1.16)	**1.22** (1.12-1.31)	**1.37** (1.26-1.47)	**1.50** (1.37-1.61)	**1.62** (1.47-1.74)	**1.73** (1.57-1.87)	**1.88** (1.69-2.04)	**2.01** (1.79-2.18)
15-min	**0.997** (0.926-1.08)	**1.17** (1.09-1.27)	**1.36** (1.26-1.47)	**1.54** (1.42-1.66)	**1.73** (1.59-1.87)	**1.89** (1.73-2.04)	**2.04** (1.86-2.20)	**2.19** (1.98-2.36)	**2.37** (2.12-2.56)	**2.52** (2.24-2.74)
30-min	**1.37** (1.27-1.48)	**1.62** (1.51-1.75)	**1.93** (1.79-2.09)	**2.23** (2.06-2.40)	**2.56** (2.36-2.76)	**2.85** (2.61-3.07)	**3.13** (2.85-3.37)	**3.40** (3.08-3.67)	**3.77** (3.38-4.08)	**4.09** (3.63-4.43)
60-min	**1.71** (1.58-1.84)	**2.03** (1.89-2.20)	**2.48** (2.30-2.68)	**2.90** (2.68-3.13)	**3.41** (3.14-3.68)	**3.86** (3.54-4.16)	**4.31** (3.93-4.65)	**4.77** (4.32-5.15)	**5.41** (4.84-5.85)	**5.96** (5.30-6.47)
2-hr	**2.03** (1.88-2.18)	**2.44** (2.26-2.62)	**3.03** (2.81-3.26)	**3.60** (3.32-3.87)	**4.29** (3.94-4.61)	**4.89** (4.46-5.24)	**5.47** (4.97-5.88)	**6.07** (5.47-6.52)	**6.86** (6.12-7.38)	**7.53** (6.66-8.13)
3-hr	**2.17** (2.02-2.35)	**2.61** (2.42-2.83)	**3.26** (3.01-3.53)	**3.90** (3.59-4.22)	**4.70** (4.30-5.07)	**5.41** (4.92-5.84)	**6.12** (5.53-6.61)	**6.88** (6.16-7.42)	**7.90** (6.98-8.54)	**8.81** (7.69-9.54)
6-hr	**2.57** (2.37-2.79)	**3.08** (2.84-3.35)	**3.86** (3.55-4.20)	**4.61** (4.23-5.01)	**5.59** (5.10-6.07)	**6.46** (5.84-7.00)	**7.33** (6.58-7.95)	**8.27** (7.35-8.96)	**9.55** (8.38-10.4)	**10.7** (9.26-11.6)
12-hr	**2.99** (2.74-3.28)	**3.59** (3.29-3.94)	**4.51** (4.14-4.95)	**5.43** (4.95-5.94)	**6.62** (5.99-7.22)	**7.69** (6.90-8.37)	**8.79** (7.81-9.56)	**9.98** (8.77-10.8)	**11.6** (10.1-12.6)	**13.1** (11.2-14.3)
24-hr	**3.43** (3.13-3.75)	**4.17** (3.81-4.57)	**5.40** (4.92-5.90)	**6.39** (5.80-6.98)	**7.78** (7.04-8.51)	**8.92** (8.04-9.74)	**10.1** (9.08-11.1)	**11.4** (10.2-12.5)	**13.2** (11.7-14.4)	**14.6** (12.9-16.0)
2-day	**4.01** (3.67-4.41)	**4.87** (4.45-5.34)	**6.23** (5.69-6.83)	**7.34** (6.68-8.03)	**8.89** (8.06-9.73)	**10.2** (9.17-11.1)	**11.5** (10.3-12.6)	**12.9** (11.5-14.1)	**14.9** (13.2-16.3)	**16.5** (14.5-18.0)
3-day	**4.29** (3.93-4.69)	**5.19** (4.76-5.68)	**6.60** (6.04-7.22)	**7.74** (7.05-8.45)	**9.32** (8.47-10.2)	**10.6** (9.59-11.6)	**12.0** (10.8-13.1)	**13.4** (12.0-14.6)	**15.4** (13.7-16.8)	**16.9** (15.0-18.6)
4-day	**4.56** (4.18-4.98)	**5.51** (5.06-6.02)	**6.97** (6.38-7.60)	**8.14** (7.43-8.86)	**9.76** (8.88-10.6)	**11.1** (10.0-12.0)	**12.4** (11.2-13.5)	**13.9** (12.4-15.1)	**15.8** (14.1-17.3)	**17.4** (15.4-19.1)
7-day	**5.33** (4.91-5.79)	**6.42** (5.92-6.98)	**8.02** (7.39-8.71)	**9.29** (8.53-10.1)	**11.0** (10.1-12.0)	**12.4** (11.3-13.5)	**13.9** (12.6-15.1)	**15.4** (13.9-16.7)	**17.4** (15.7-19.0)	**19.0** (17.0-20.8)
10-day	**6.07** (5.61-6.58)	**7.29** (6.73-7.88)	**8.95** (8.26-9.67)	**10.2** (9.42-11.0)	**12.0** (11.0-12.9)	**13.3** (12.2-14.4)	**14.7** (13.4-15.9)	**16.1** (14.6-17.5)	**18.0** (16.3-19.6)	**19.5** (17.6-21.2)
20-day	**8.14** (7.56-8.76)	**9.71** (9.02-10.5)	**11.7** (10.9-12.6)	**13.3** (12.3-14.3)	**15.4** (14.3-16.6)	**17.1** (15.8-18.4)	**18.8** (17.3-20.2)	**20.5** (18.8-22.0)	**22.8** (20.8-24.6)	**24.6** (22.4-26.6)
30-day	**10.0** (9.42-10.7)	**11.9** (11.2-12.7)	**14.1** (13.3-15.1)	**15.8** (14.8-16.8)	**18.0** (16.9-19.2)	**19.7** (18.4-21.0)	**21.4** (20.0-22.8)	**23.1** (21.5-24.6)	**25.4** (23.5-27.1)	**27.1** (25.0-29.0)
45-day	**12.6** (11.9-13.4)	**14.9** (14.1-15.8)	**17.4** (16.4-18.5)	**19.3** (18.2-20.5)	**21.8** (20.5-23.1)	**23.7** (22.2-25.1)	**25.5** (23.9-27.1)	**27.3** (25.5-29.0)	**29.7** (27.6-31.7)	**31.5** (29.2-33.7)
60-day	**15.0** (14.1-15.9)	**17.7** (16.7-18.7)	**20.5** (19.3-21.7)	**22.6** (21.3-23.9)	**25.3** (23.8-26.8)	**27.3** (25.6-28.9)	**29.3** (27.4-31.0)	**31.2** (29.2-33.1)	**33.7** (31.4-35.9)	**35.6** (33.1-38.0)

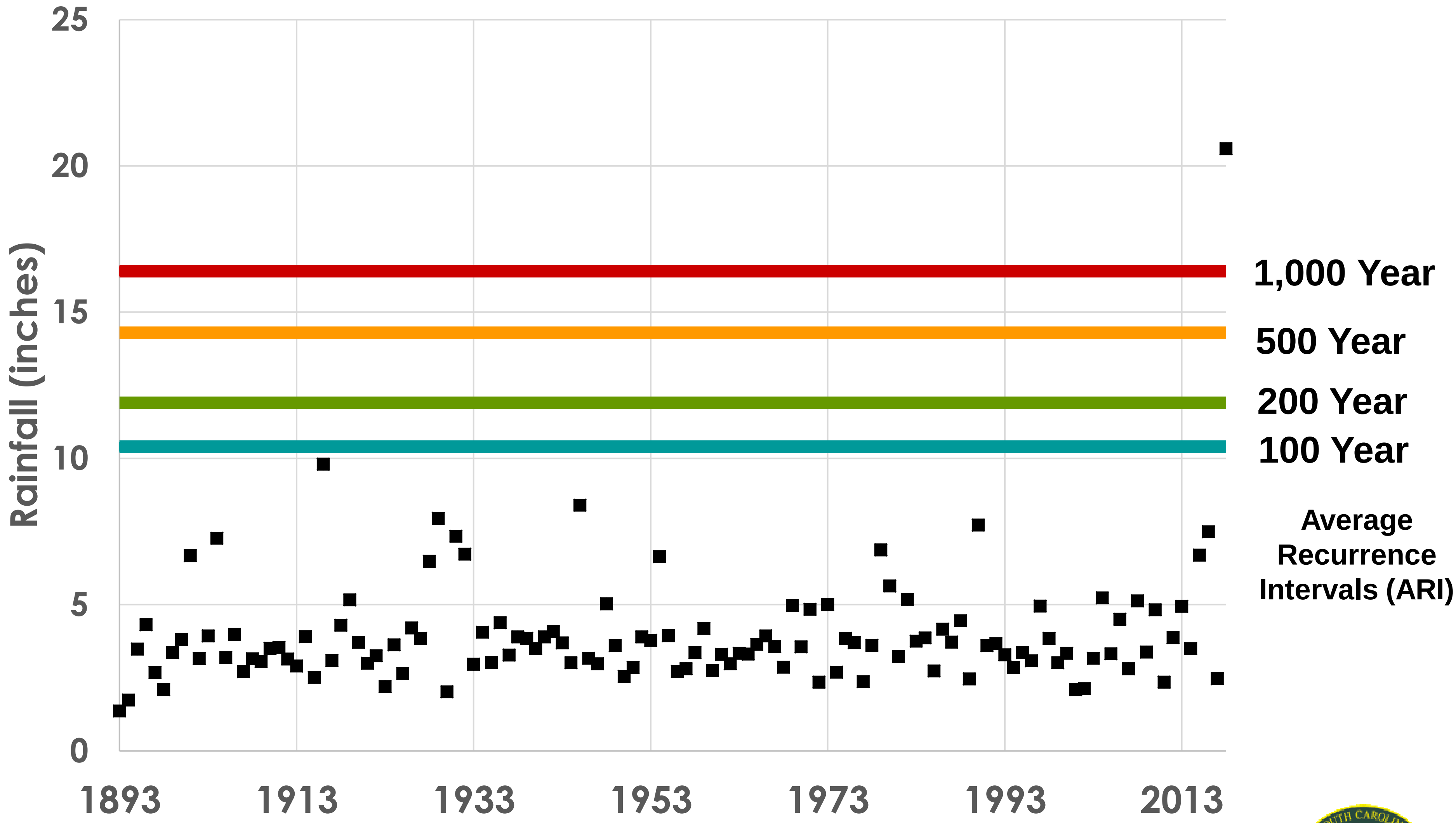
Charleston: 2-day Maximum Rainfall Totals



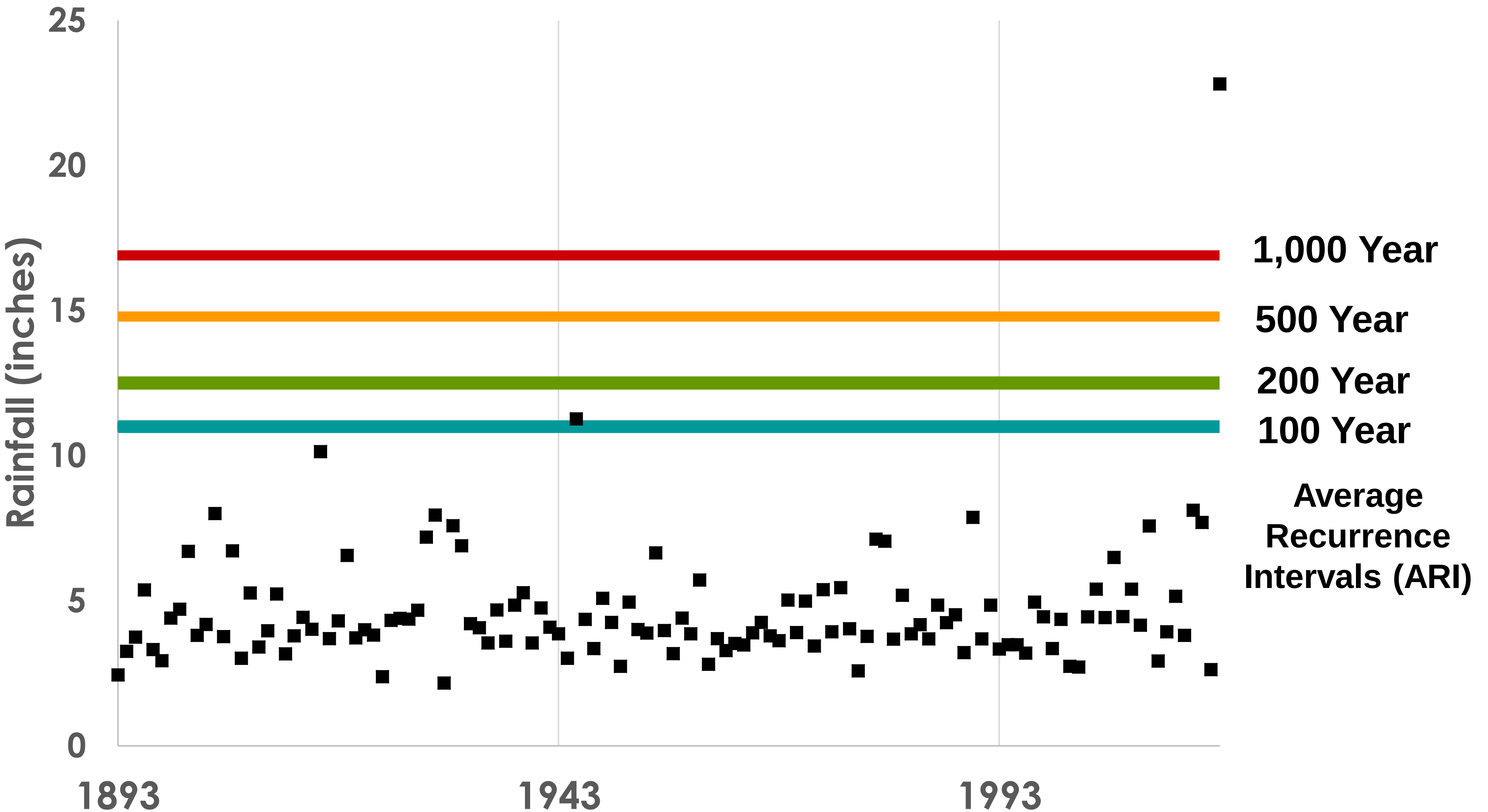
Charleston: 4-day Maximum Rainfall Totals



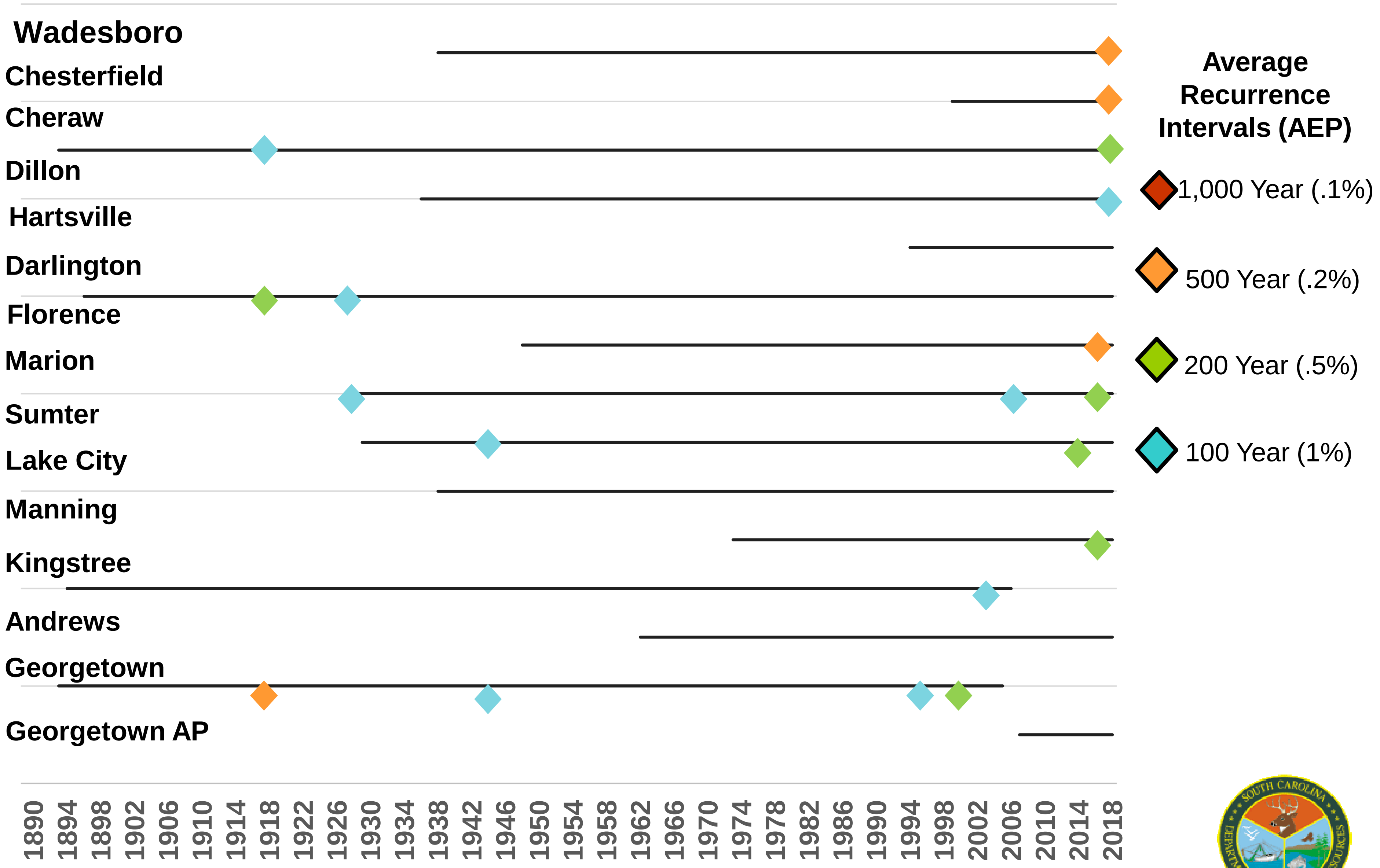
Cheraw: 2-day Maximum Rainfall Totals



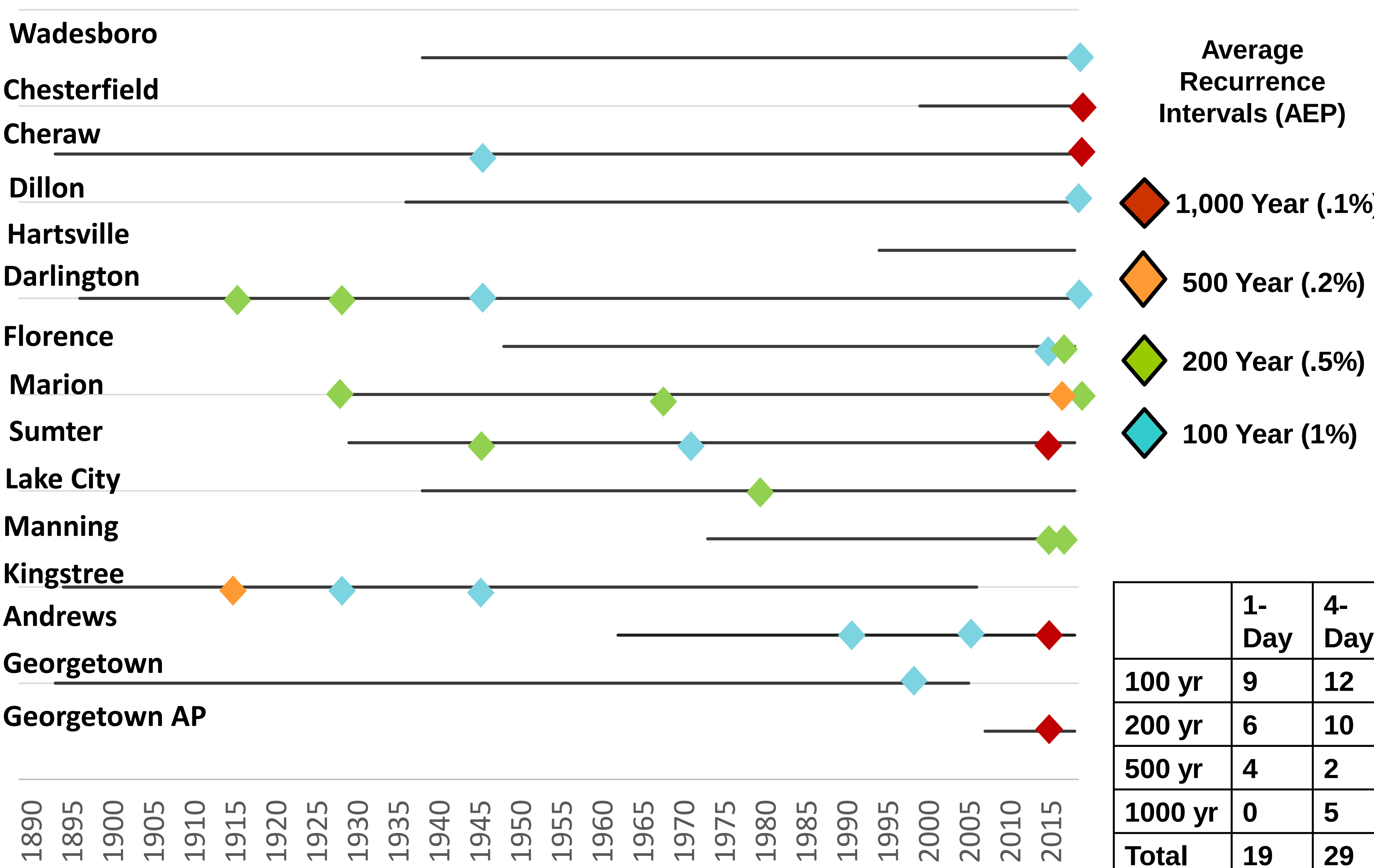
Cheraw: 4-day Maximum Rainfall Totals



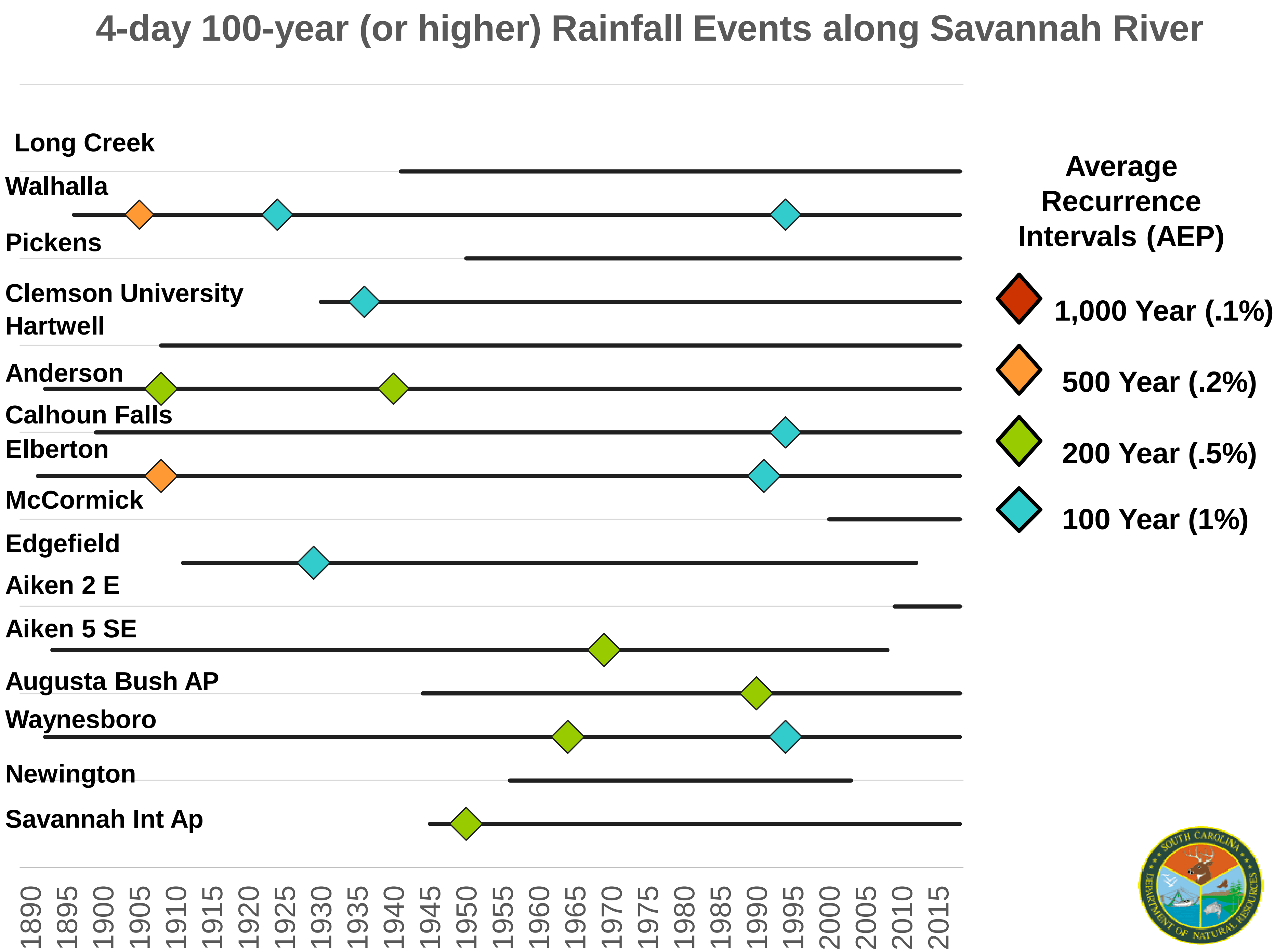
1-day 100-year (or higher) Rainfall Events Pee Dee

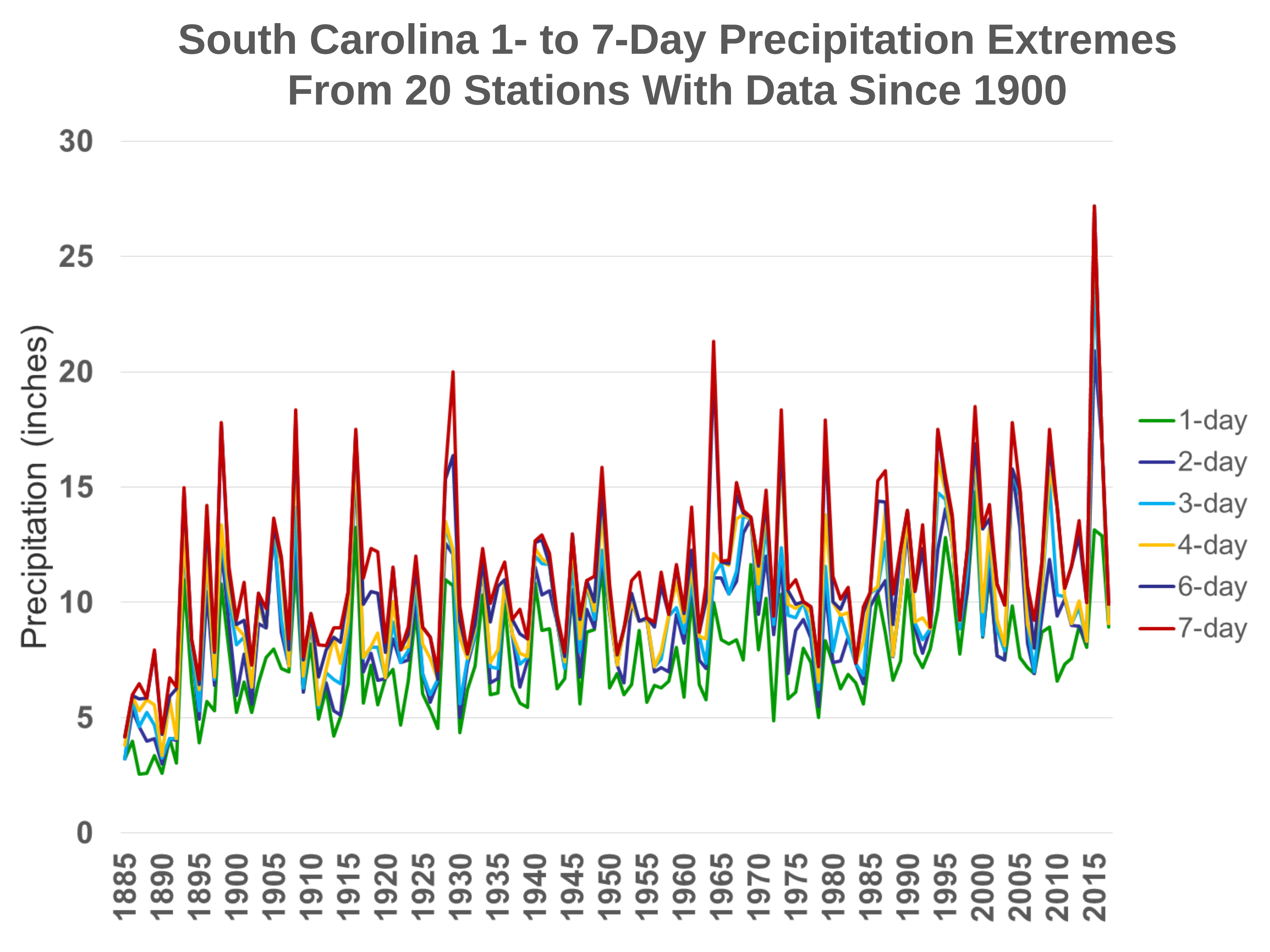


4-day 100-year (or higher) Rainfall Events in Pee Dee



	1-Day	4-Day
100 yr	9	12
200 yr	6	10
500 yr	4	2
1000 yr	0	5
Total	19	29


4-day 100-year (or higher) Rainfall Events along Savannah River
Long Creek
Walhalla
Pickens
Clemson University
Hartwell
Anderson
Calhoun Falls
Elberton
McCormick
Edgefield
Aiken 2 E
Aiken 5 SE
Augusta Bush AP
Waynesboro
Newington
Savannah Int Ap
Average Recurrence Intervals (AEP)
1,000 Year (.1%)
500 Year (.2%)
200 Year (.5%)
100 Year (1%)
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015



South Carolina 1- to 7-Day Precipitation Extremes
From 20 Stations With Data Since 1900
Precipitation (inches)
30
25
20
15
10
5
0
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
1-day
2-day
3-day
4-day
6-day
7-day

U.S. Global Change Research Program

Fourth National Climate Assessment, Vol II — Impacts, Risks, and Adaptation in the United States

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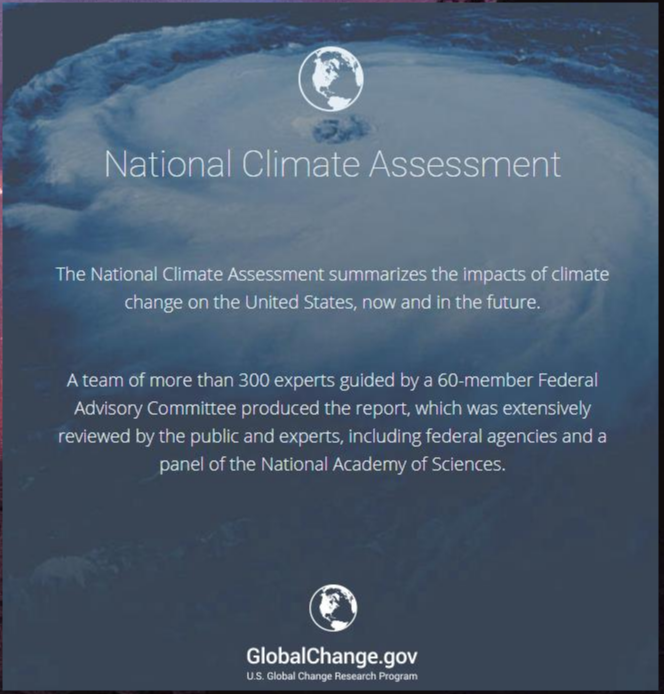

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https://nca2018.globalchange.gov/chapter/front-matter-about/

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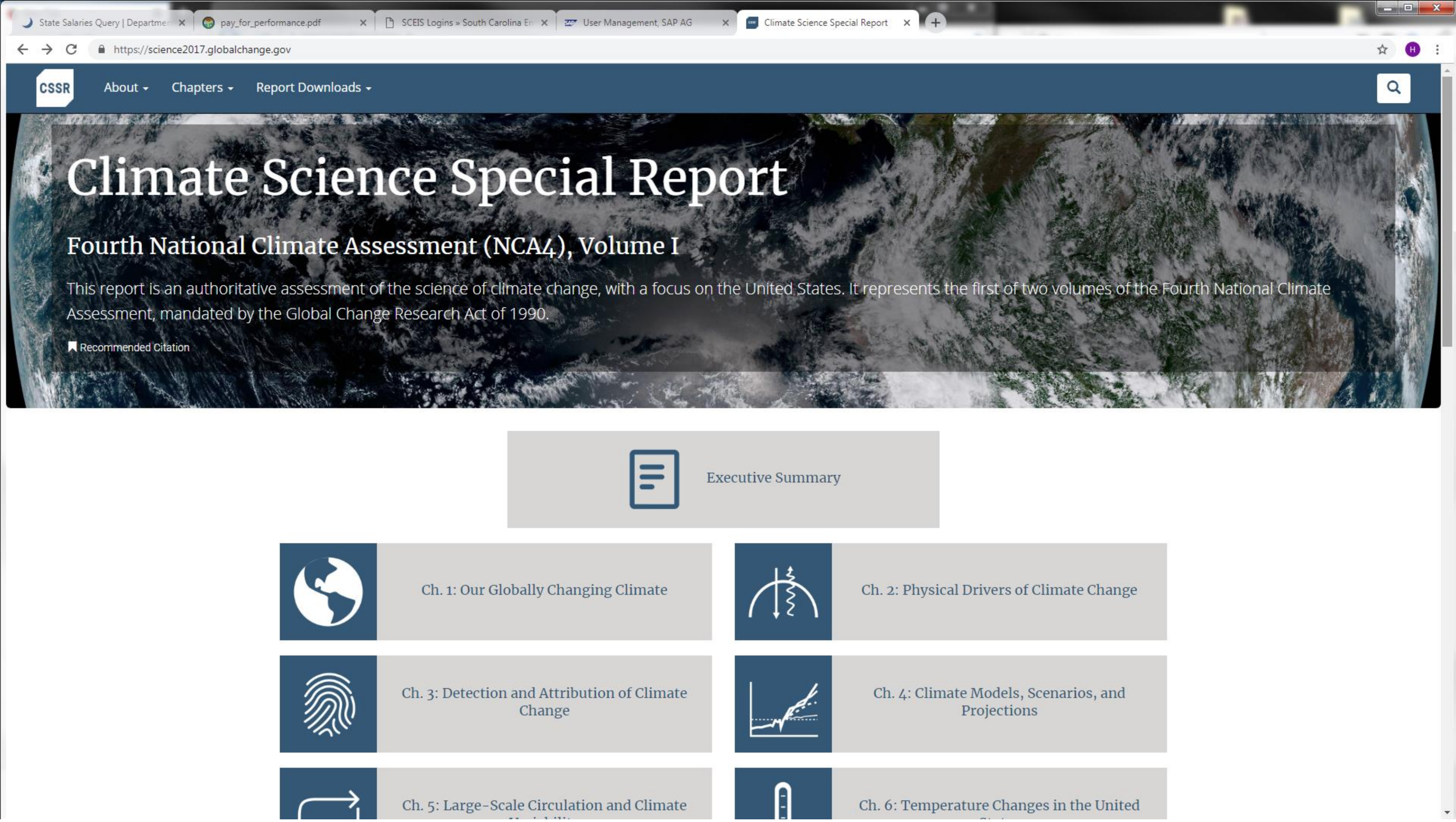
Fourth National Climate Assessm

https://nca2018.globalchange.gov

ABOUT CHAPTERS DOWNLOADS



http://science2017.globalchange.gov/

Scenario Products

Assessment is an analysis of the widely-used scenarios termed “Representative Concentration Pathways,” or RCPs, that form the foundation for the majority of recent coordinated global climate model experiments.

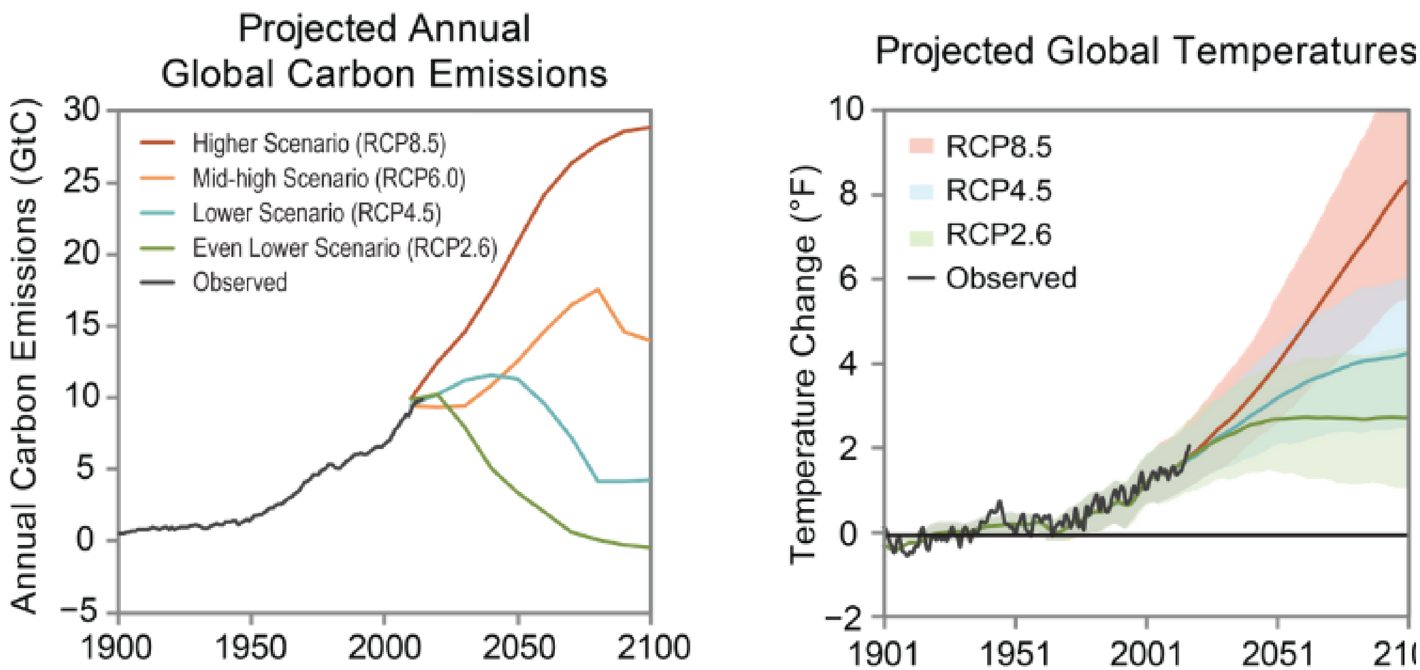
NCA4 focuses primarily on RCP8.5 and RCP4.5, while also considering other scenario information where appropriate (for example, RCP2.6). These RCPs capture a range of plausible atmospheric concentration futures that drive climate models. RCP8.5 is the high-end scenario (high emissions, high concentrations, large temperature increase). RCP4.5 is not the lowest scenario, but it is similar to the low-end scenario that was used in NCA3. RCP2.6 represents the low end of the range considered, but it also assumes significantly greater emissions reductions

2 Key Message #5

Increasing U.S. Temperatures

Annual average temperature over the contiguous United States has increased by 1.2°F (0.7°C) over the last few decades and by 1.8°F (1°C) relative to the beginning of the last century. Additional increases in annual average temperature of about 2.5°F (1.4°C) are expected over the next few decades regardless of future emissions, and increases ranging from 3°F to 12°F (1.6°–6.6°C) are expected by the end of century, depending on whether the world follows a higher or lower future scenario, with proportionally greater changes in high temperature extremes.

Figure 3



The two panels above show annual historical and a range of plausible future carbon emissions in units of gigatons of carbon (GtC) per year (left) and the historical observed and future temperature change that would result for a range of future scenarios relative to the 1901–1960 average, based on the central estimate (lines) and a range (shaded areas, two standard deviations) as simulated by the full suite of CMIP5 global climate models (right). By 2081–2100, the projected range in global mean temperature change is 1.1°–4.3°F under the even lower scenario (RCP2.6; 0.6°–2.4°C, green), 2.4°–5.9°F under the lower scenario (RCP4.5; 1.3°–3.3°C, blue), 3.0°–6.8°F under the mid-high scenario (RCP6.0; 1.6°–3.8°C, not shown) and 5.0°–10.2°F under the higher scenario (RCP8.5; 2.8°–5.7°C, orange). See the main report for more details on these scenarios and implications. *Based on Figure 4.1 in Chapter 4.*

Fig. 2.4: Observed and Projected Changes in Annual Average Temperature

Annual average temperatures across North America are projected to increase, with proportionally greater changes at higher as compared to lower latitudes, and under a higher scenario (RCP8.5, right) as compared to a lower one (RCP4.5, left). This figure compares (top) observed change for 1986–2016 (relative to 1901–1960 for the contiguous United States and 1925–1960 for Alaska, Hawai‘i, Puerto Rico, and the U.S. Virgin Islands) with projected differences in annual average temperature for mid-century (2036–2065, middle) and end-of-century (2070–2099, bottom) relative to the near-present (1986–2015). *Source: adapted from Vose et al. 2017.*[85]

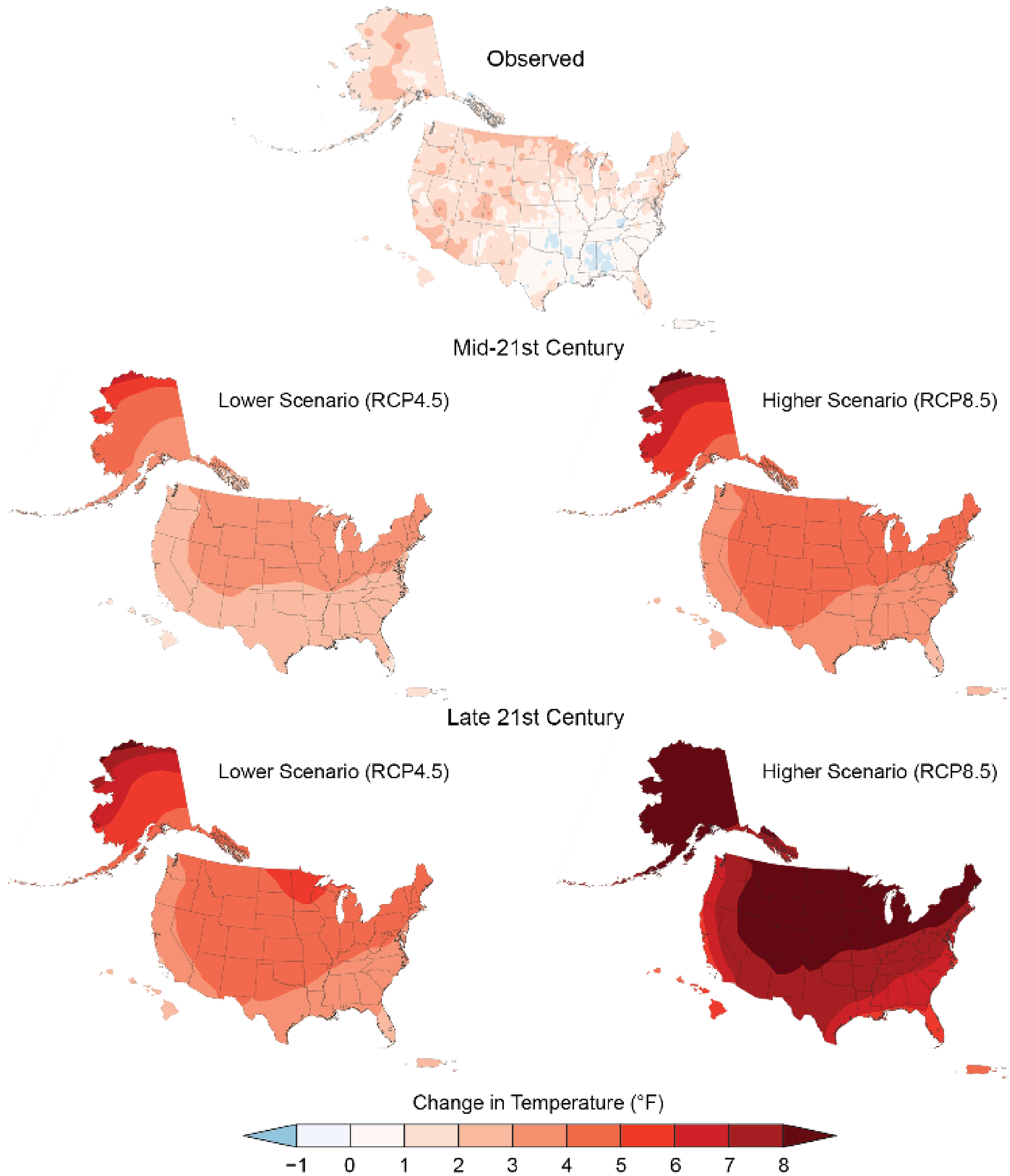


Fig. 19.5: Projected Number of Warm Nights

The maps show the projected number of warm nights (days with minimum temperatures above 75°F) per year in the Southeast for the mid-21st century (left; 2036–2065) and the late 21st century (right; 2070–2099) under a higher scenario (RCP8.5; top row) and a lower scenario (RCP4.5; bottom row). These warm nights currently occur only a few times per year across most of the region (Figure 19.4) but are expected to become common events across much of the Southeast under a higher scenario. Increases in the number of warm nights adversely affect agriculture and reduce the ability of some people to recover from high daytime temperatures. With more heat waves expected, there will likely be a higher risk for more heat-related illness and deaths. *Sources: NOAA NCEI and CICS-NC.*

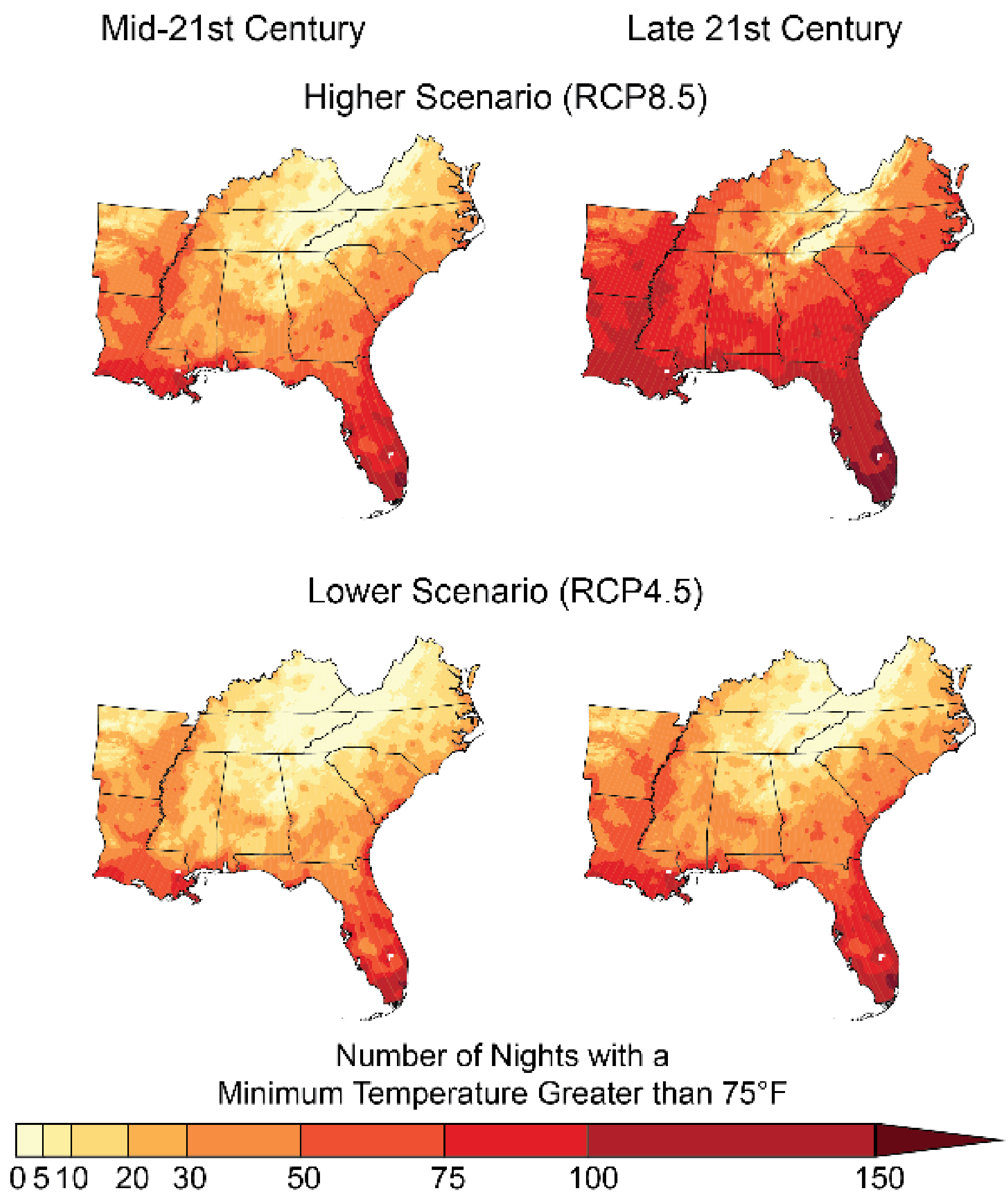
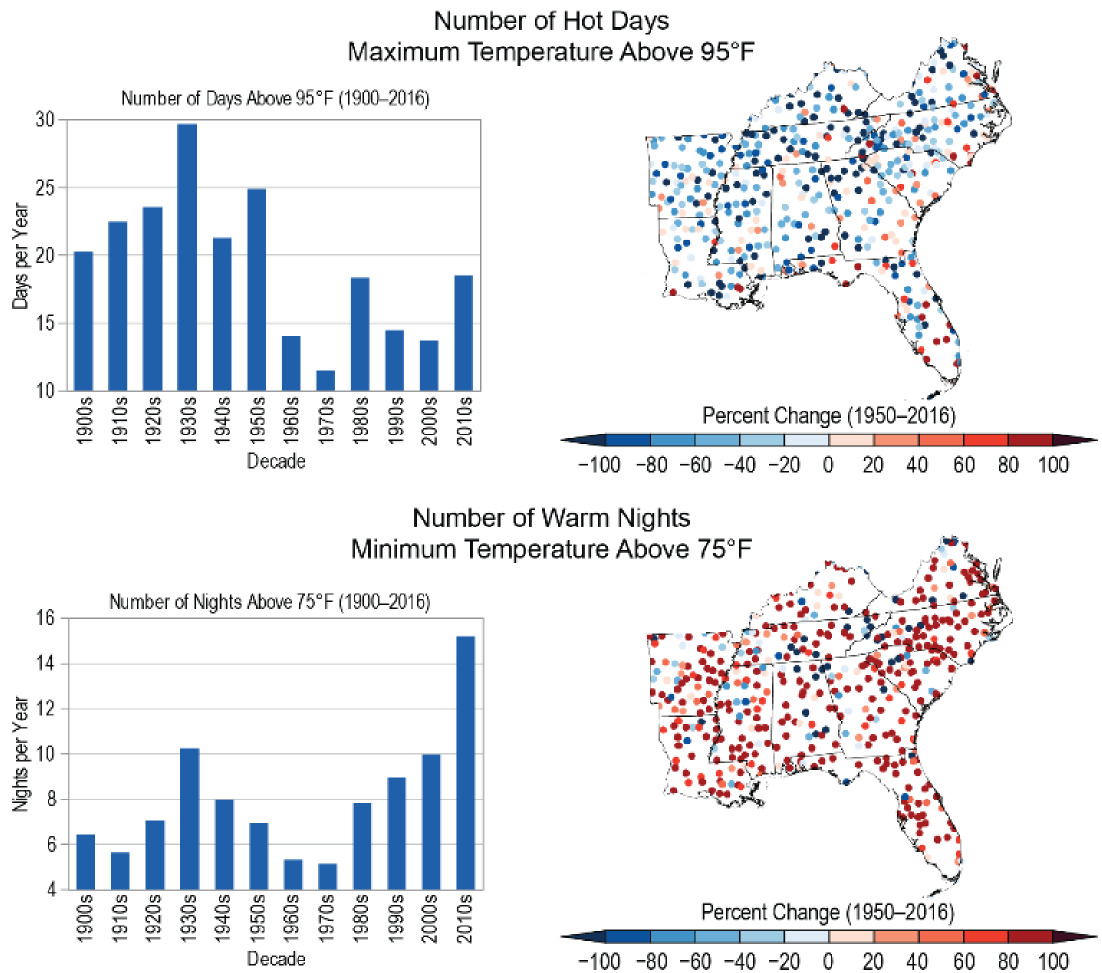
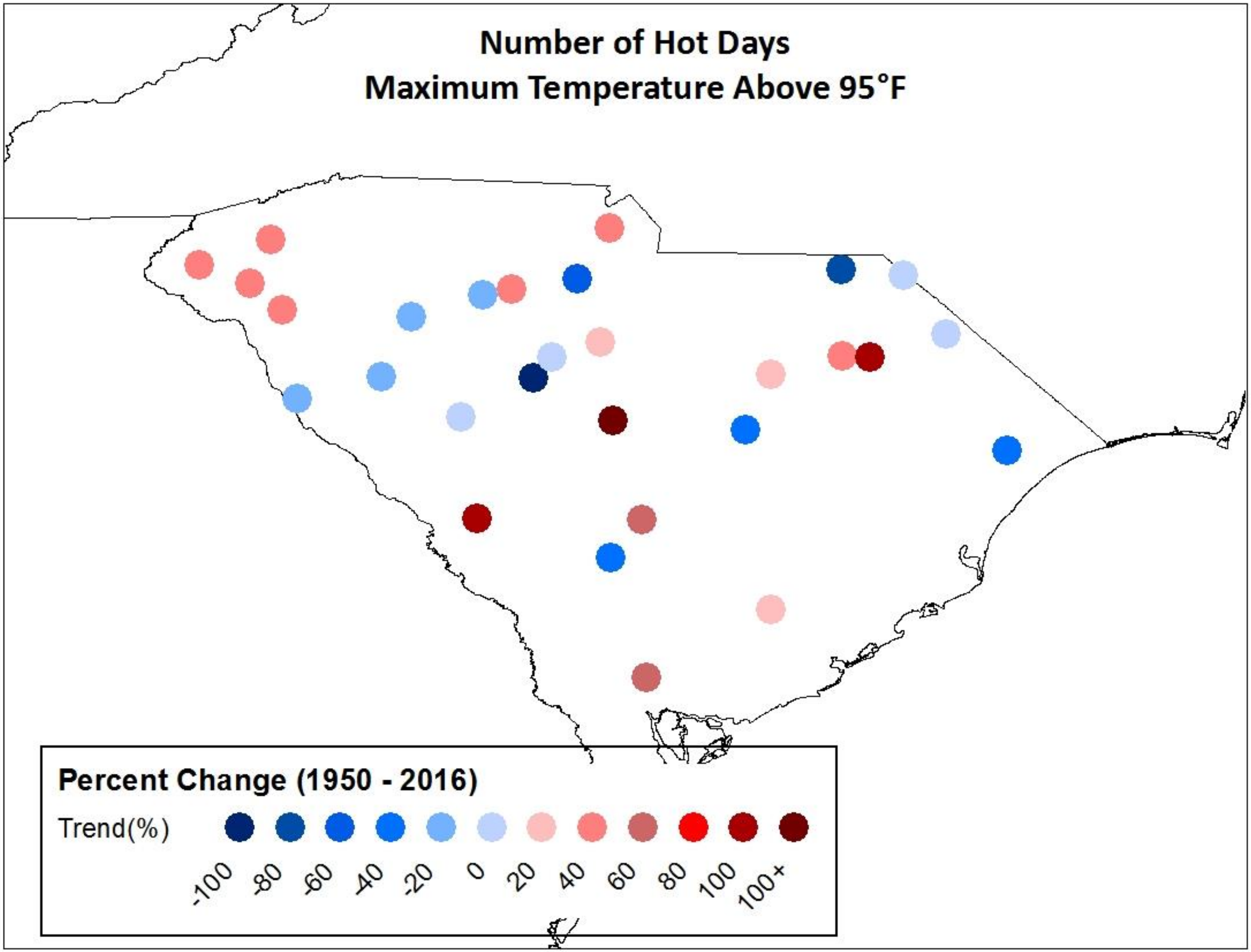
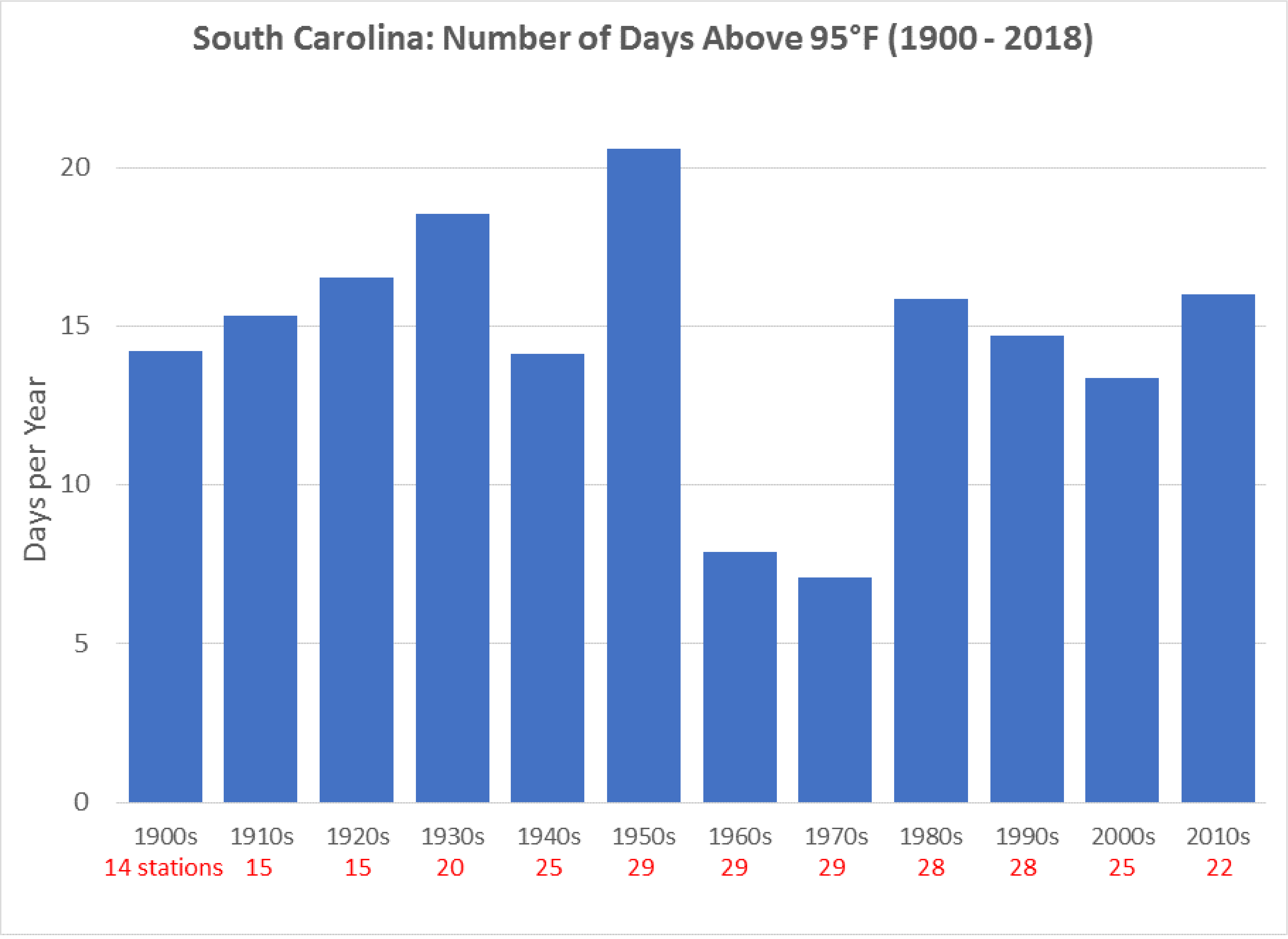


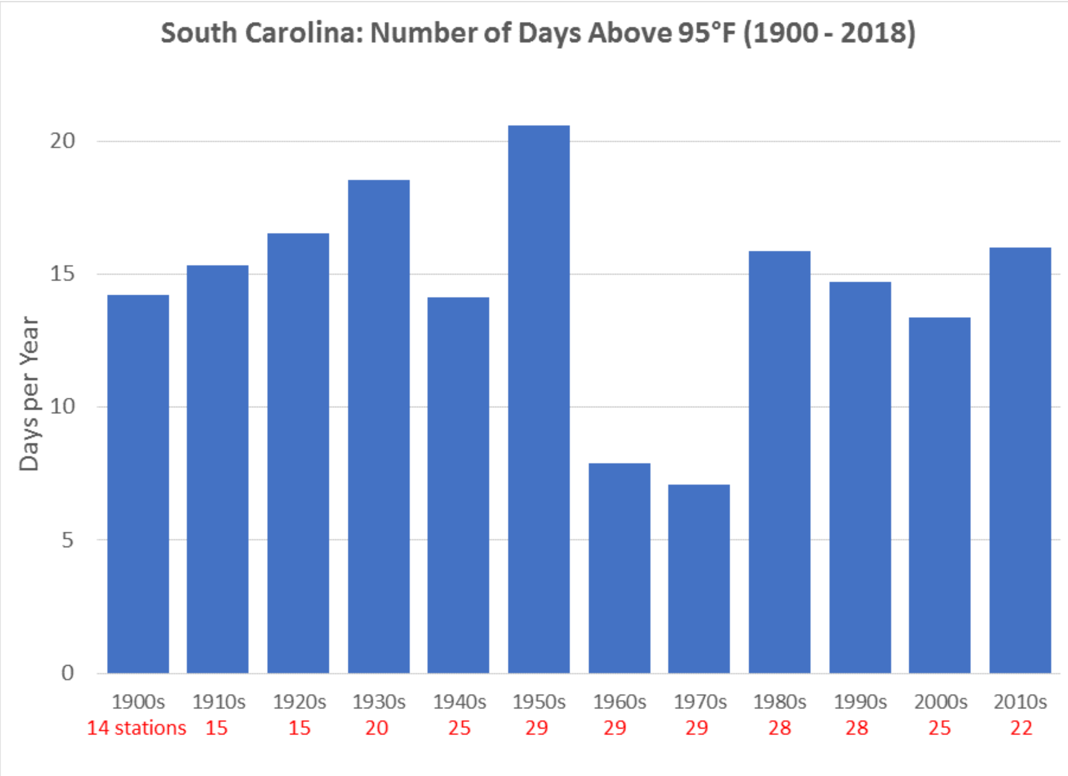
Fig. 19.1: Historical Changes in Hot Days and Warm Nights

Sixty-one percent of major Southeast cities are exhibiting some aspects of worsening heat waves, which is a higher percentage than any other region of the country.[12] Hot days and warm nights together impact human comfort and health and result in the need for increased cooling efforts. Agriculture is also impacted by a lack of nighttime cooling. Variability and change in the annual number of hot days and warm nights are shown. The bar charts show averages over the region by decade for 1900–2016, while the maps show the trends for 1950–2016 for individual weather stations. Average summer temperatures during the most recent 10 years have been the warmest on record, with very large increases in nighttime temperatures and more modest increases in daytime temperatures, as indicated by contrasting changes in hot days and warm nights. The annual number of hot days (maximum temperature above 95°F) has been lower since 1960 than the average during the first half of the 20th century; trends in hot days since 1950 are generally downward except along the south Atlantic coast and in Florida. Conversely, the number of warm nights (minimum temperature above 75°F) has doubled on average compared to the first half of the 20th century and locally has increased at most stations. *Sources: NOAA NCEI and CICS-NC.*

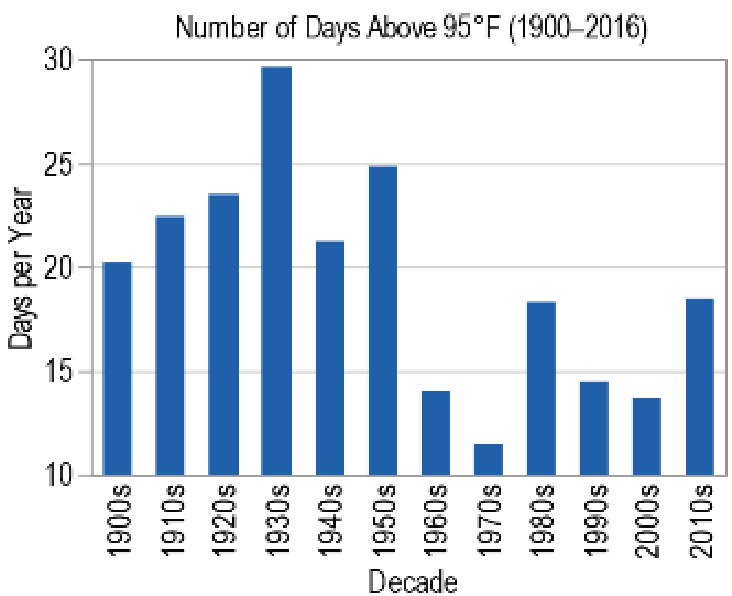


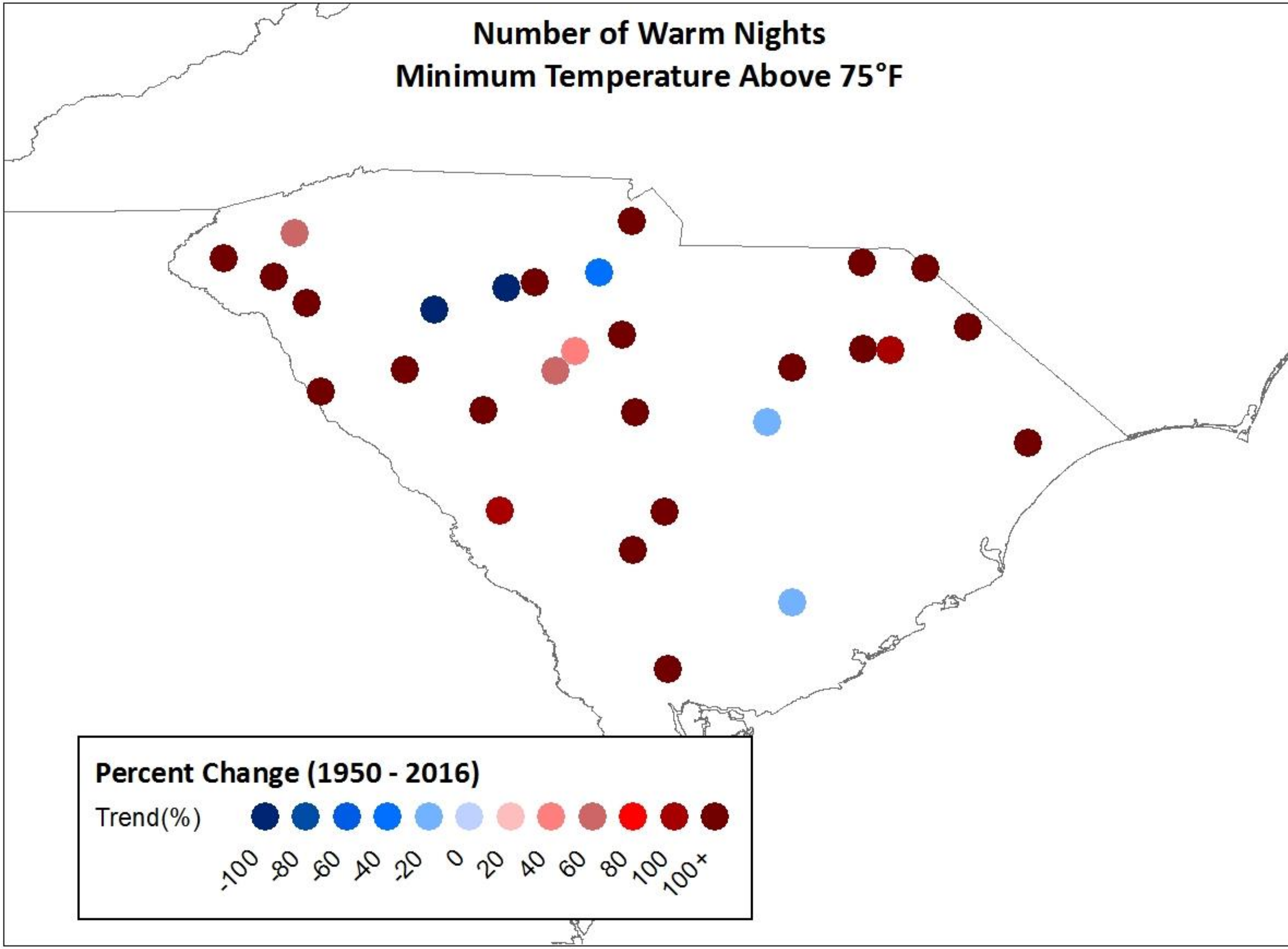

Number of Hot Days
Maximum Temperature Above 95°F
Percent Change (1950 - 2016)
Trend(%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
100+


South Carolina: Number of Days Above 95°F (1900 - 2018)
Days per Year
0
5
10
15
20
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
14 stations
15
15
20
25
29
29
29
28
28
25
22

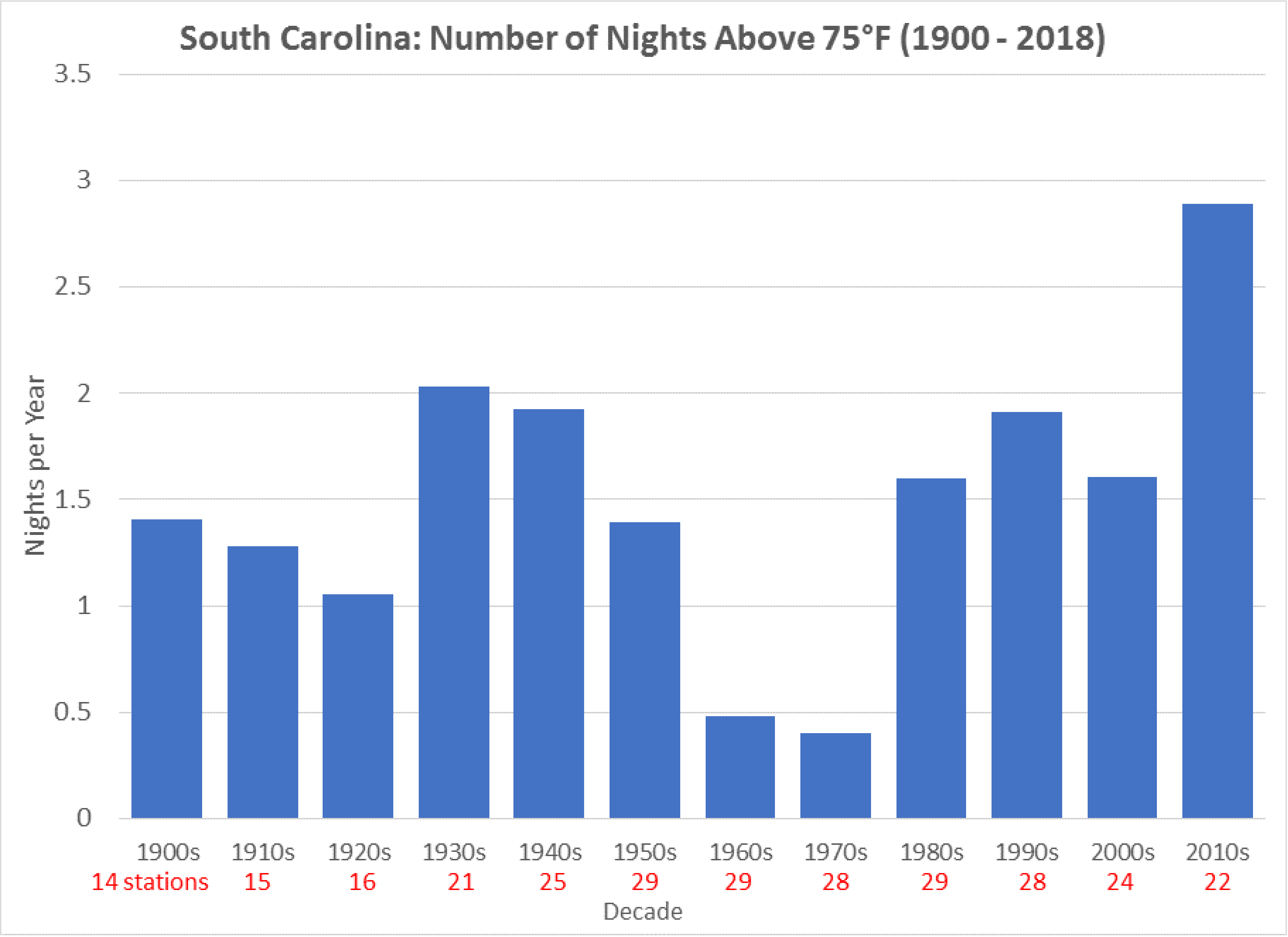

South Carolina: Number of Days Above 95°F (1900 - 2018)
Days per Year
0
5
10
15
20
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
14 stations
15
15
20
25
29
29
29
28
28
25
22

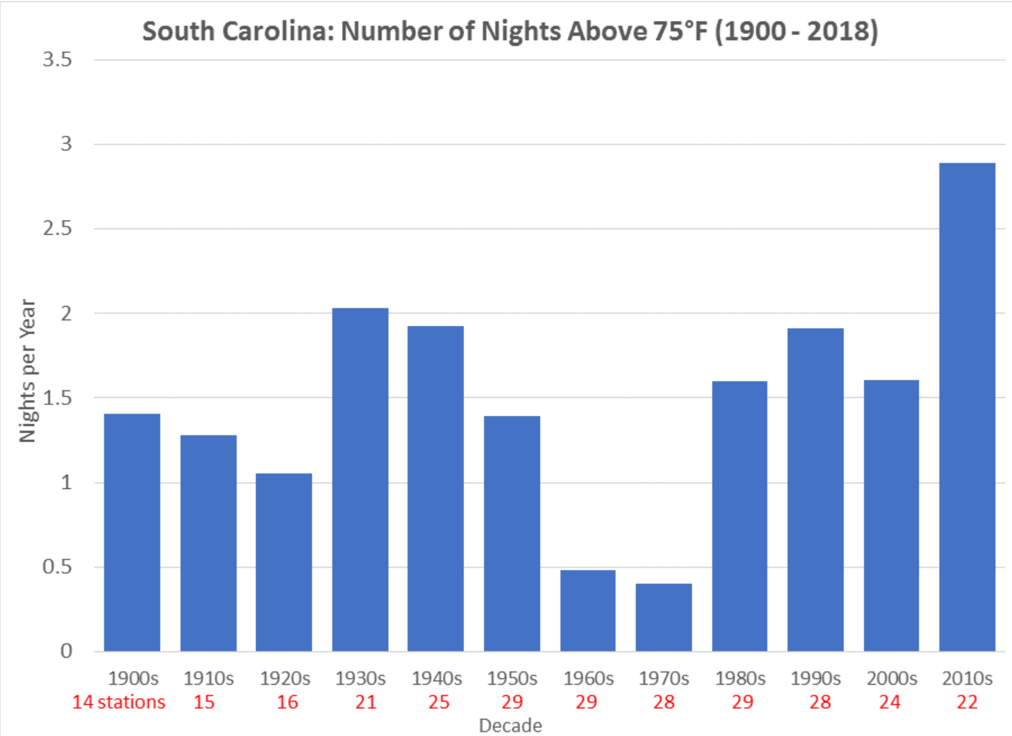
Southeast:


Number of Days Above 95°F (1900–2016)
Days per Year
10
15
20
25
30
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
Decade



Number of Warm Nights
Minimum Temperature Above 75°F
Percent Change (1950 - 2016)
Trend(%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
100+


South Carolina: Number of Nights Above 75°F (1900 - 2018)
Nights per Year
3.5
3
2.5
2
1.5
1
0.5
0
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
14 stations
15
16
21
25
29
29
28
29
28
24
22
Decade


South Carolina: Number of Nights Above 75°F (1900 - 2018)
Nights per Year
3.5
3
2.5
2
1.5
1
0.5
0
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
14 stations
15
16
21
25
29
29
28
29
28
24
22
Decade

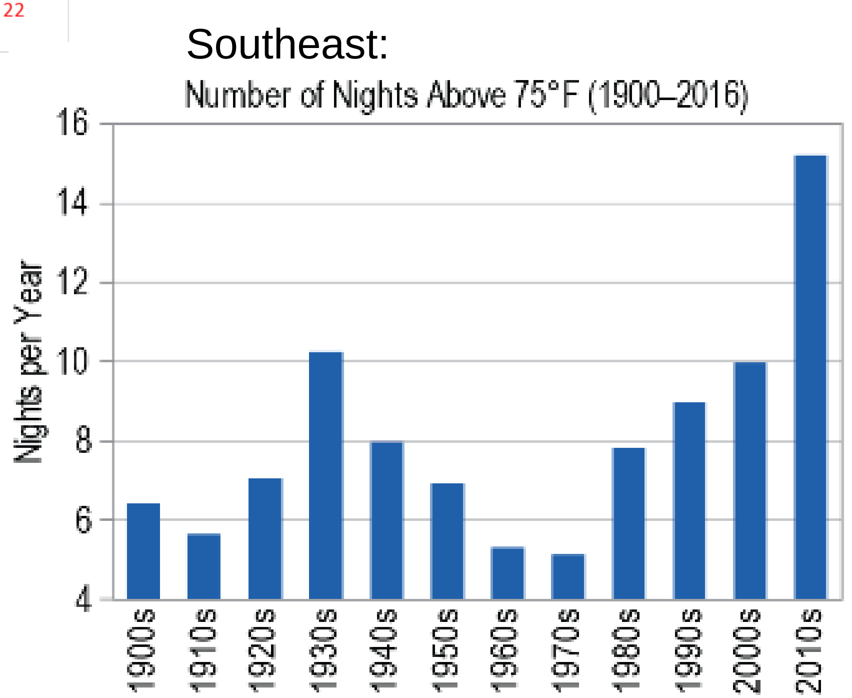
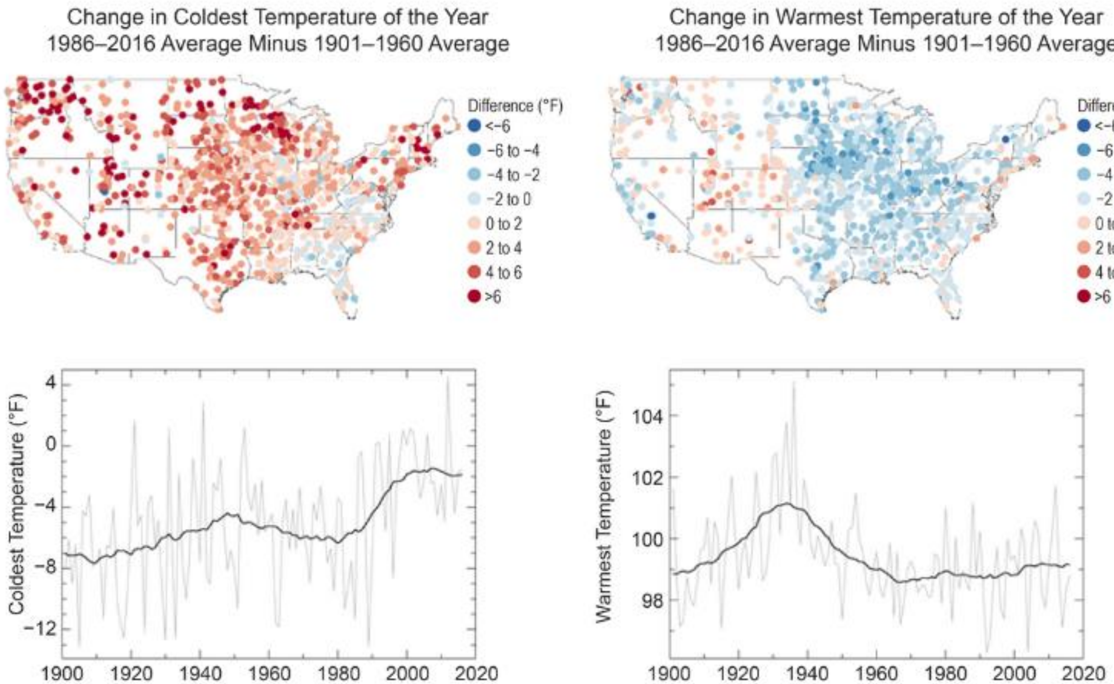

Southeast:
Number of Nights Above 75°F (1900–2016)
Nights per Year
16
14
12
10
8
6
4
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s

Figure 6.3



Observed changes in the coldest and warmest daily temperatures (°F) of the year in the contiguous United States. Maps (top) depict changes at stations; changes are the difference between the average for present-day (1986–2016) and the average for the first half of the last century (1901–1960). Time series (bottom) depict the area-weighted average for the contiguous United States. Estimates are derived from long-term stations with minimal missing data in the Global Historical Climatology Network–Daily dataset.[27] (Figure source: NOAA/NCEI).

NCA Region	Change in Coldest Day of the Year	Change in Warmest Day of the Year
Northeast	2.83°F	−0.92°F
Southeast	1.13°F	−1.49°F
Midwest	2.93°F	−2.22°F
Great Plains North	4.40°F	−1.08°F
Great Plains South	3.25°F	−1.07°F
Southwest	3.99°F	0.50°F
Northwest	4.78°F	−0.17°F

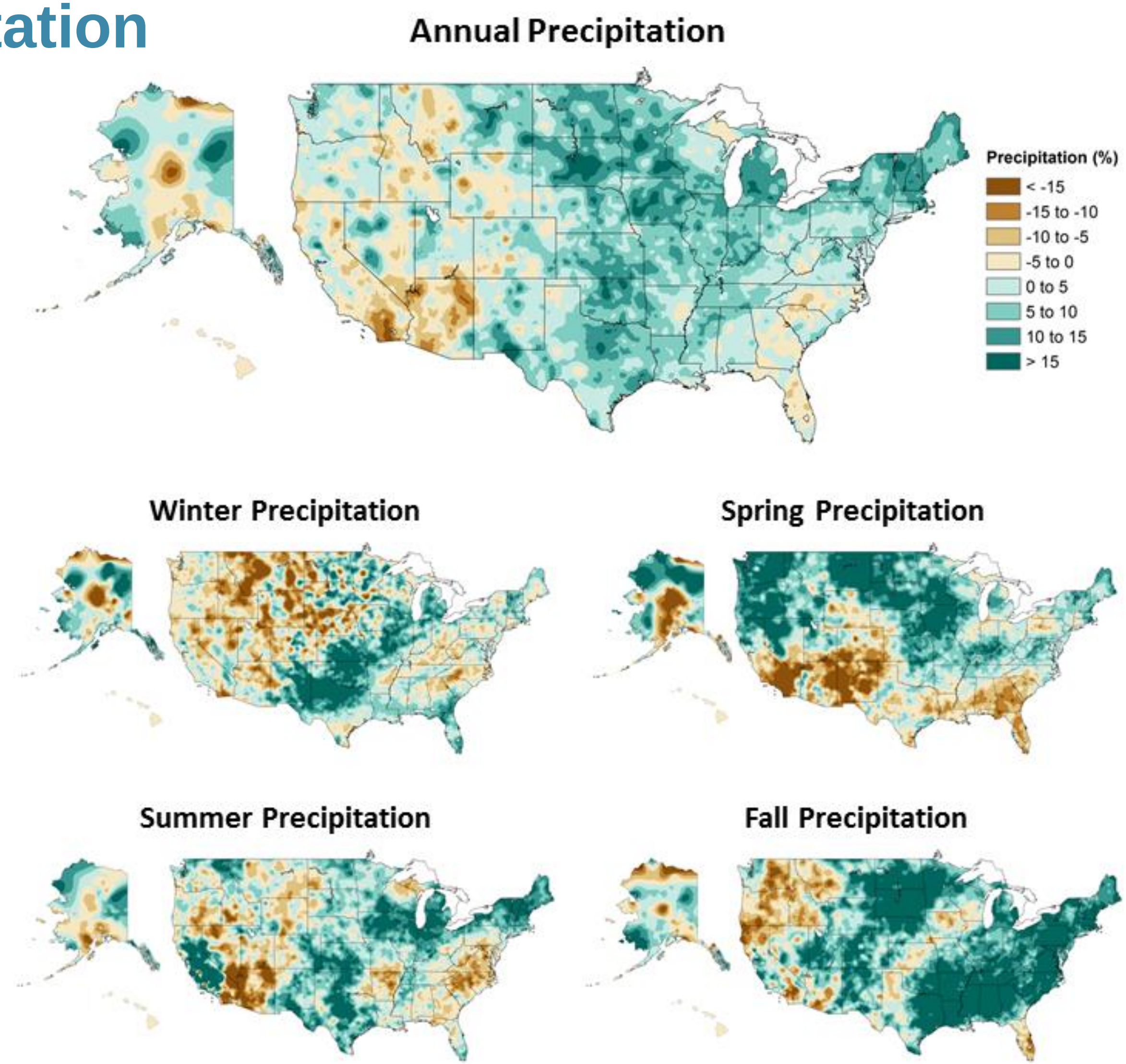
2 Key Message #6

Changing U.S. Precipitation

Annual precipitation since the beginning of the last century has increased across most of the northern and eastern United States and decreased across much of the southern and western United States. Over the coming century, significant increases are projected in winter and spring over the Northern Great Plains, the Upper Midwest, and the Northeast. Observed increases in the frequency and intensity of heavy precipitation events in most parts of the United States are projected to continue. Surface soil moisture over most of the United States is likely to decrease, accompanied by large declines in snowpack in the western United States and shifts to more winter precipitation falling as rain rather than snow.

Changing U.S. Precipitation

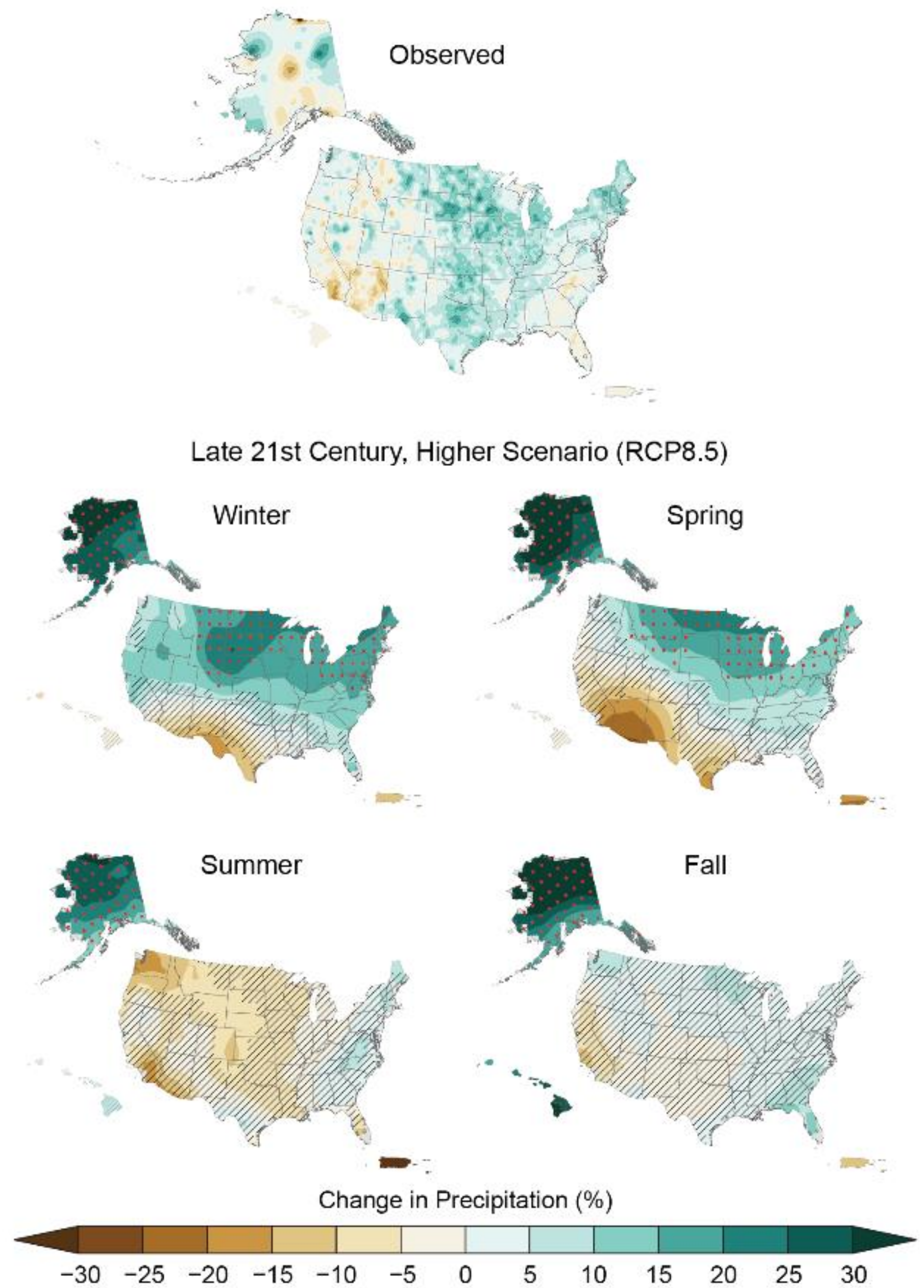
Annual and seasonal changes in precipitation over the United States. Changes are the average for present-day (1986–2015) minus the average for the first half of the last century (1901–1960 for the contiguous United States, 1925–1960 for Alaska and Hawai‘i) divided by the average for the first half of the century.

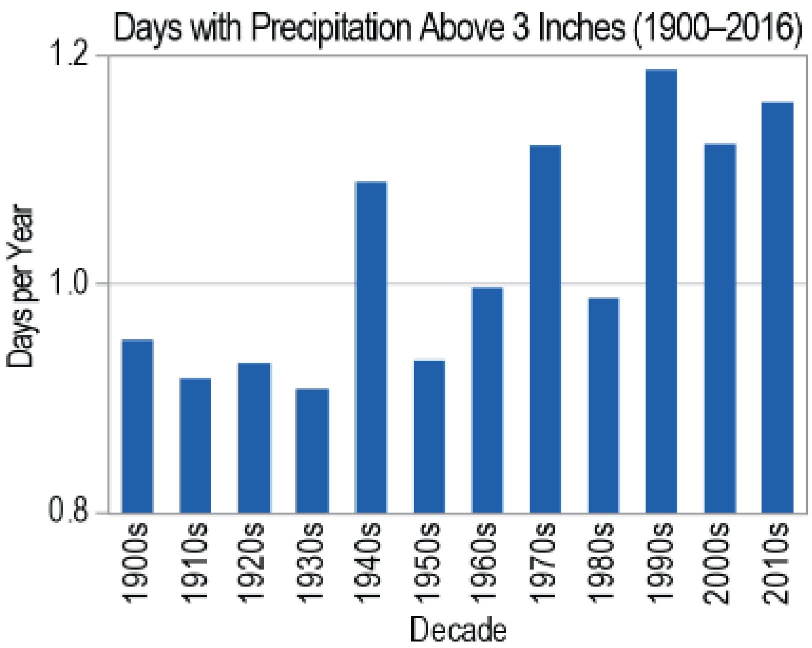


Changes in precipitation differ markedly across the seasons, as do regional patterns of increases and decreases. For the contiguous United States, fall exhibits the largest (10%) and most widespread increase, exceeding 15% in much of the Northern Great Plains, Southeast, and Northeast. Winter average for the United States has the smallest increase (2%), with drying over most of the western United States as well as parts of the Southeast.

Fig. 2.5: Observed and Projected Change in Seasonal Precipitation

Observed and projected precipitation changes vary by region and season. Historically, the Great Plains and the northeastern United States have experienced increased precipitation while the Southwest has experienced a decrease for the period 1986–2015 relative to 1901–1960. In the future, under the higher scenario (RCP8.5), the northern United States, including Alaska, is projected to receive more precipitation, especially in the winter and spring by the period 2070–2099 (relative to 1901–1960 for the contiguous United States and 1925–1960 for Alaska, Hawaiʻi, Puerto Rico, and the U.S. Virgin Islands). Parts of the southwestern United States are projected to receive less precipitation in the winter and spring. Areas with red dots show where projected changes are large compared to natural variations; areas that are hatched show where changes are small and relatively insignificant. *Source: adapted from Easterling et al. 2017.*[94]





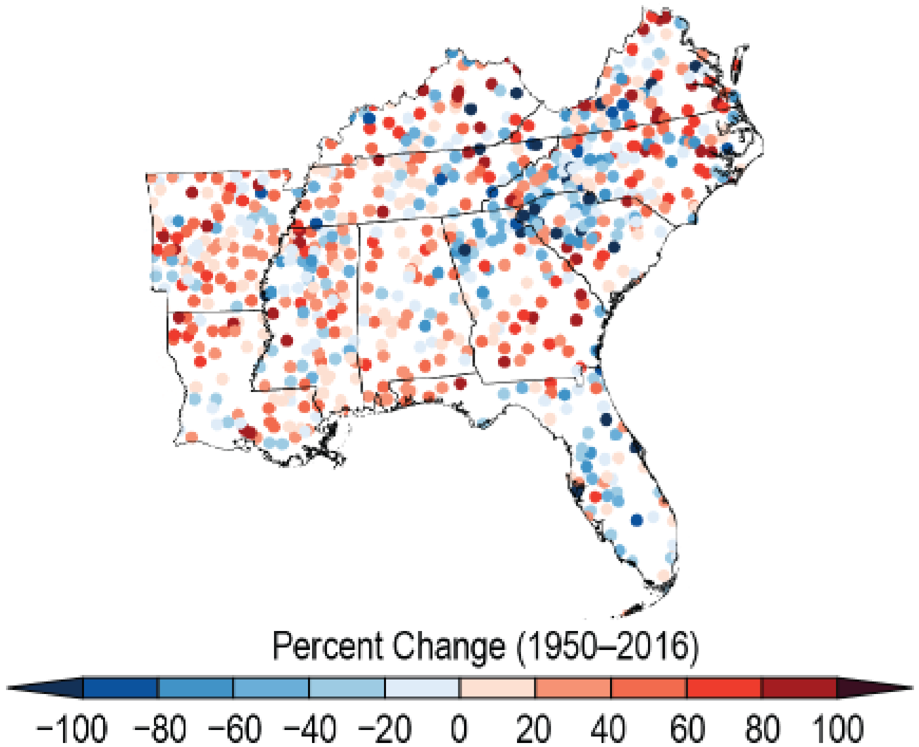
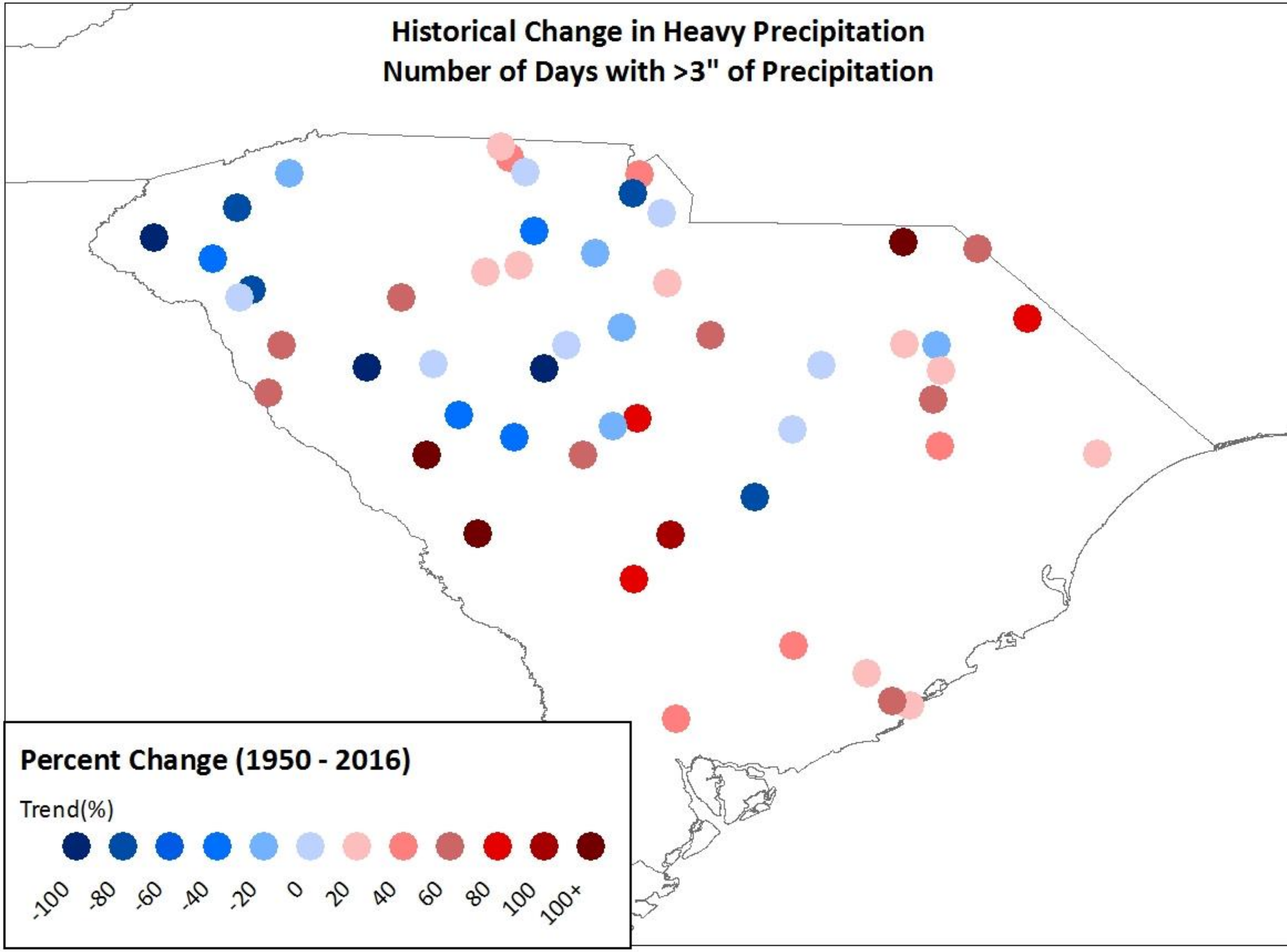
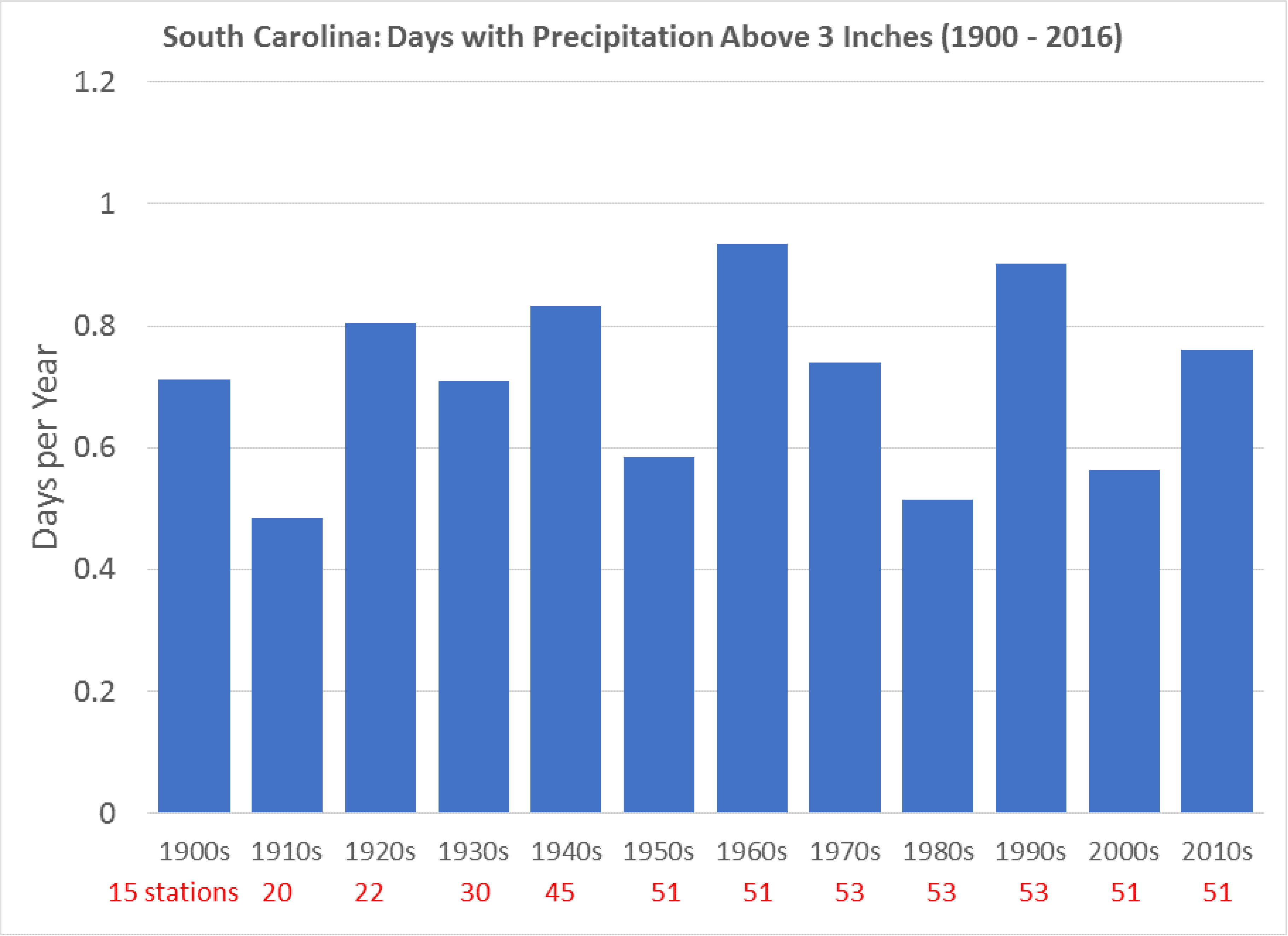
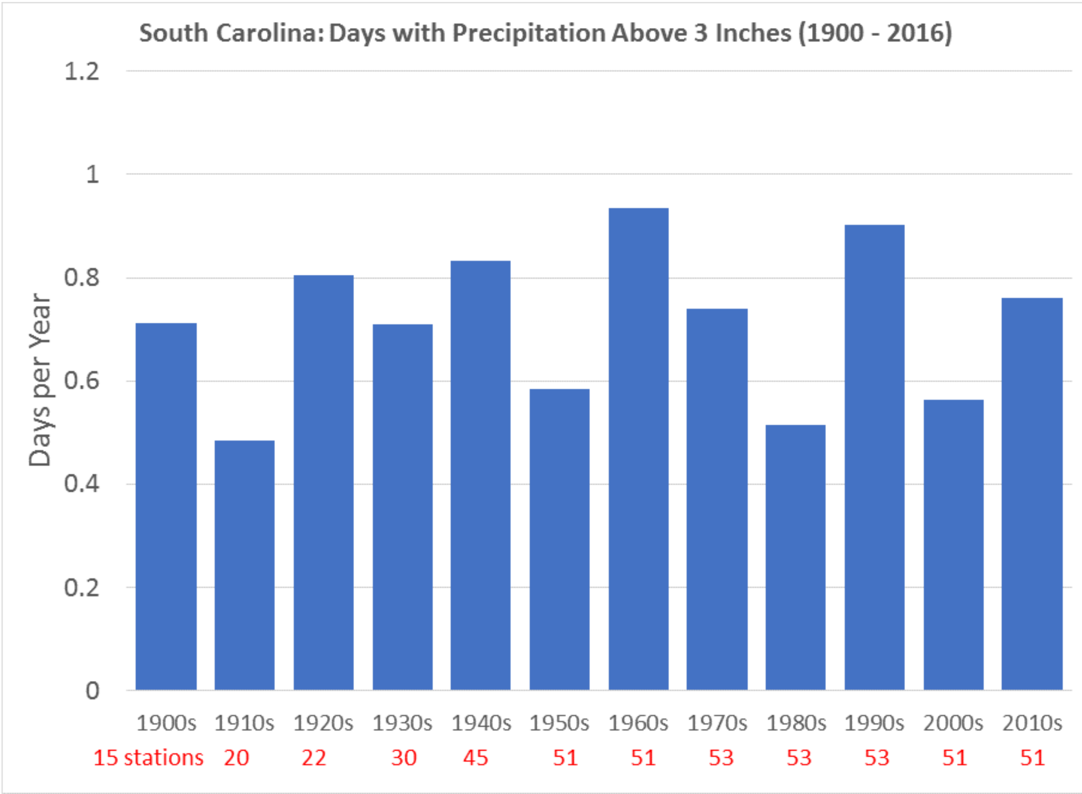


Fig. 19.3: Historical Change in Heavy Precipitation

The figure shows variability and change in (left) the annual number of days with precipitation greater than 3 inches (1900–2016) averaged over the Southeast by decade and (right) individual station trends (1950–2016). The numbers of days with heavy precipitation has increased at most stations, particularly since the 1980s. *Sources: NOAA NCEI and CICS-NC.*


Historical Change in Heavy Precipitation
Number of Days with >3" of Precipitation
Percent Change (1950 - 2016)
Trend(%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
100+


South Carolina: Days with Precipitation Above 3 Inches (1900 - 2016)
Days per Year
1.2
1
0.8
0.6
0.4
0.2
0
1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
15 stations
20
22
30
45
51
51
53
53
53
51
51


South Carolina: Days with Precipitation Above 3 Inches (1900 - 2016)
Days per Year
1.2
1
0.8
0.6
0.4
0.2
0
1900s 1910s 1920s 1930s 1940s 1950s 1960s 1970s 1980s 1990s 2000s 2010s
15 stations 20 22 30 45 51 51 53 53 53 51 51

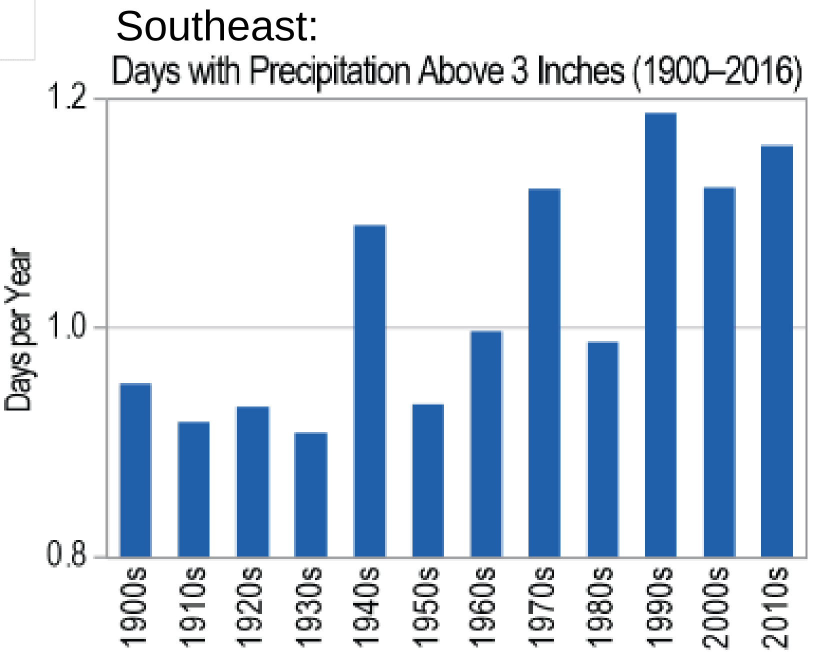
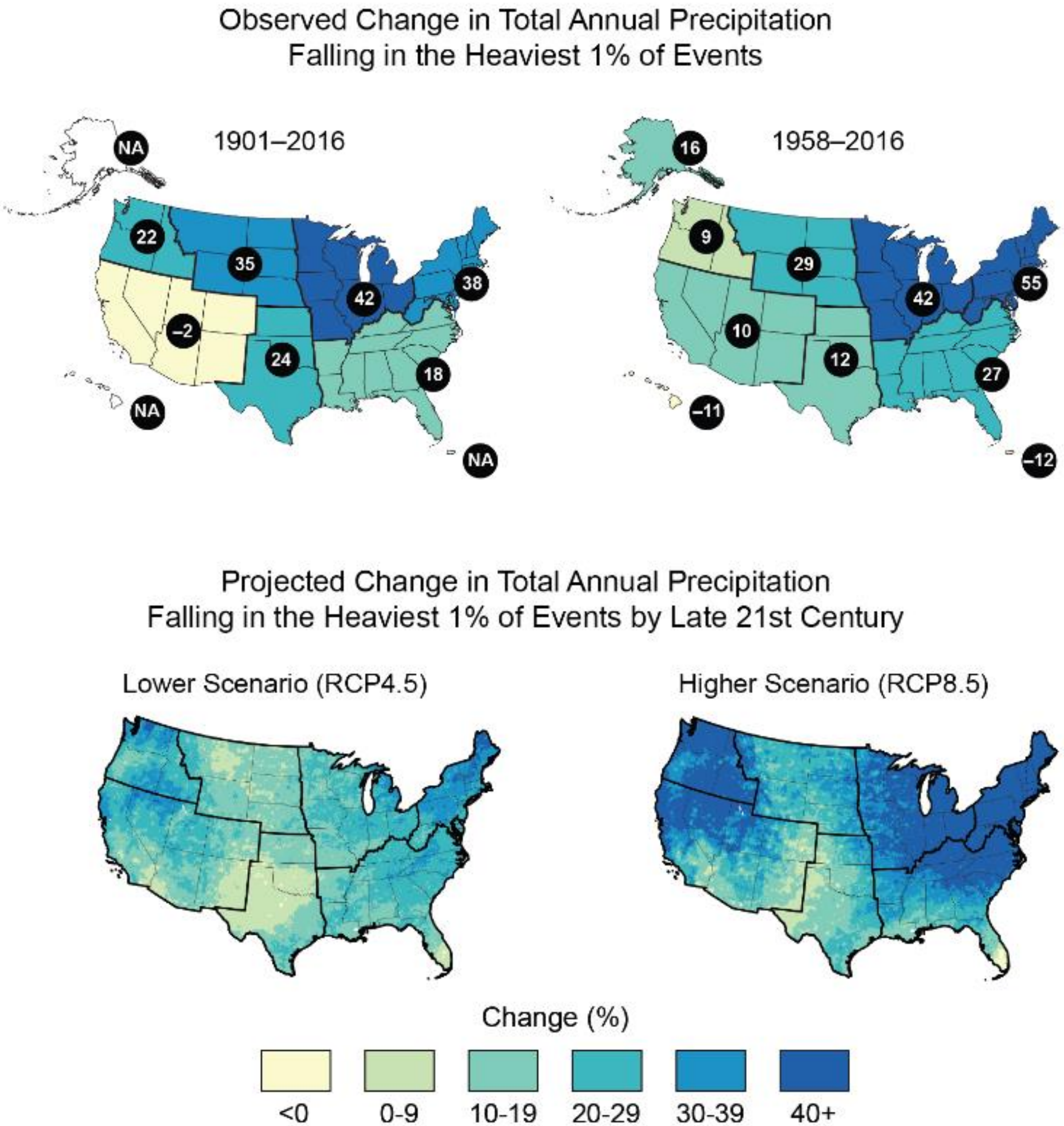
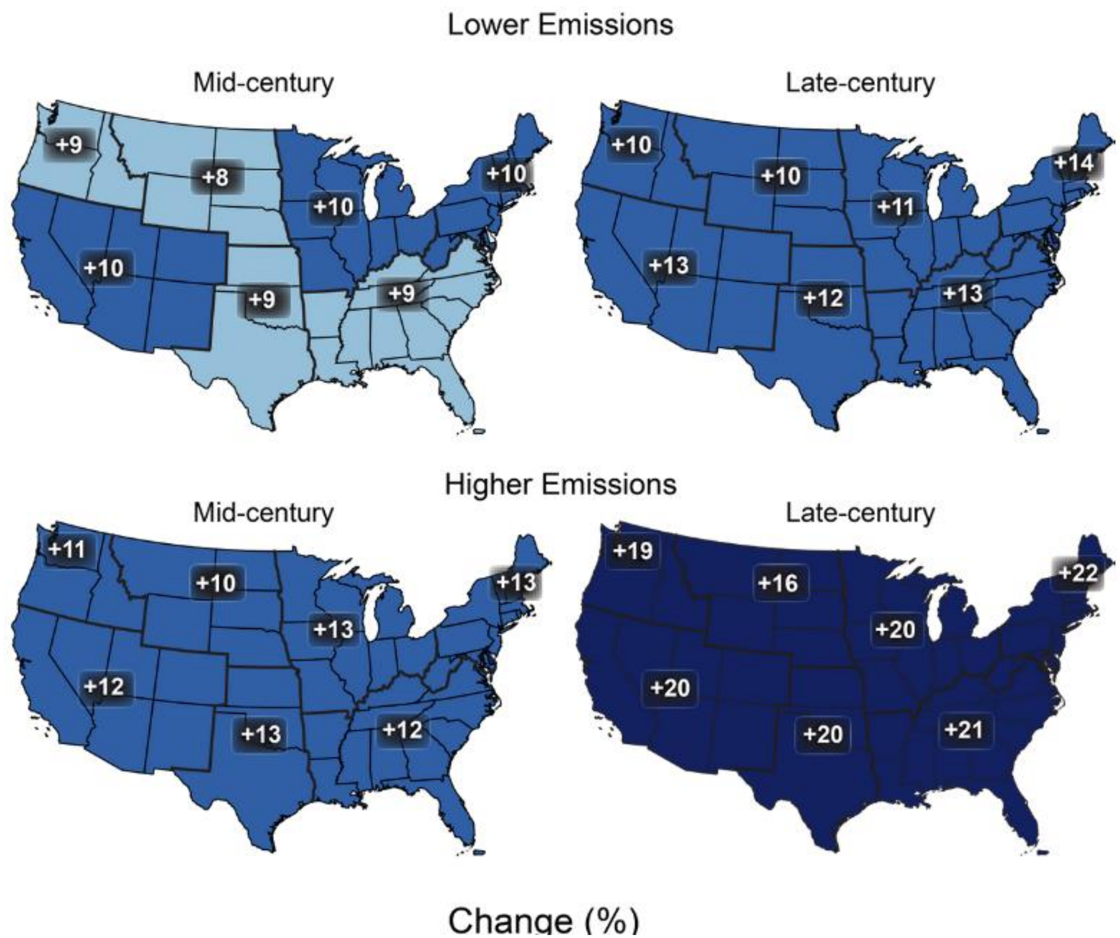

Southeast:
Days with Precipitation Above 3 Inches (1900–2016)
Days per Year
1.2
1.0
0.8
1900s 1910s 1920s 1930s 1940s 1950s 1960s 1970s 1980s 1990s 2000s 2010s

Fig. 2.6: Observed and Projected Change in Heavy Precipitation

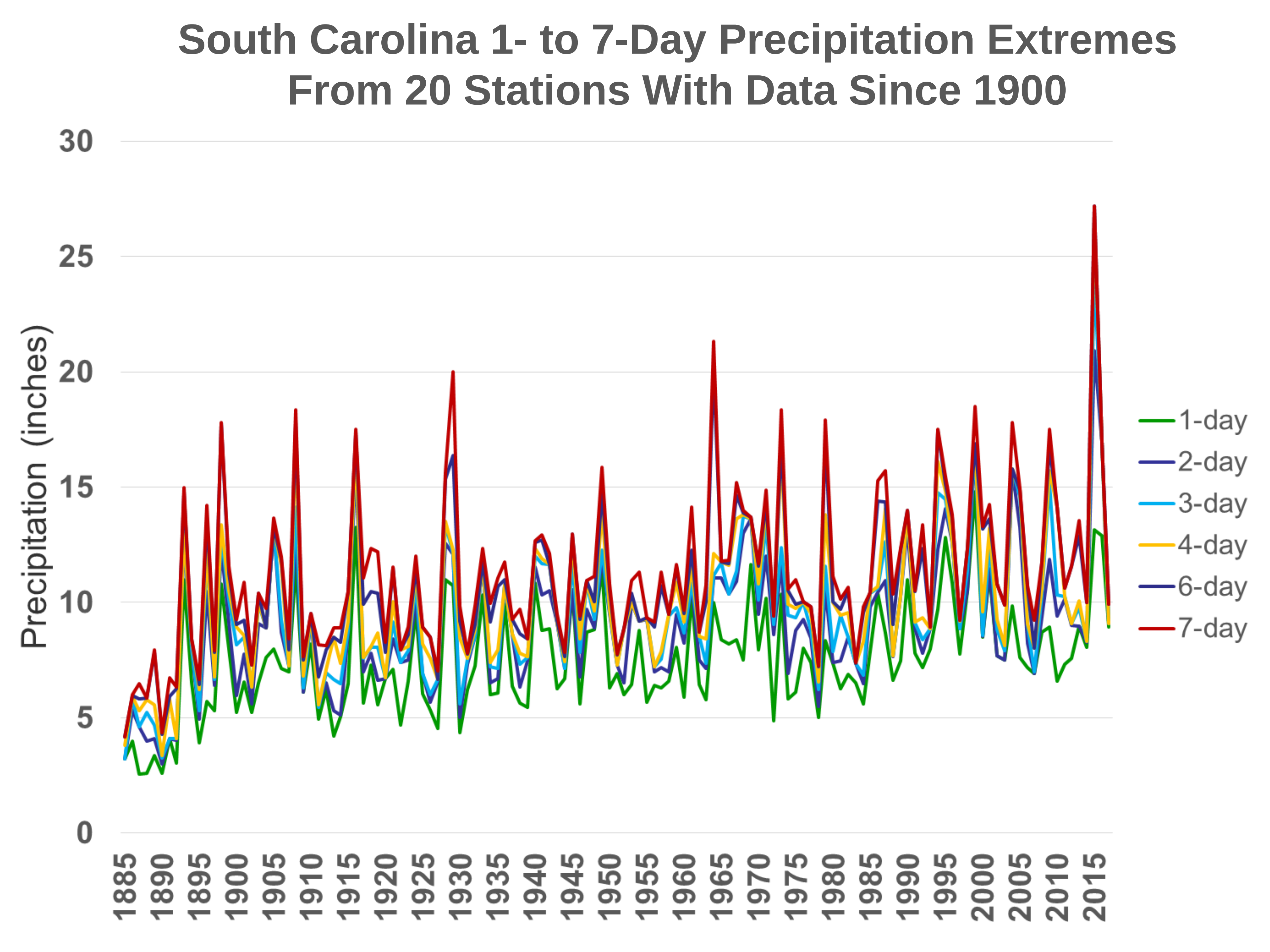
Heavy precipitation is becoming more intense and more frequent across most of the United States, particularly in the Northeast and Midwest, and these trends are projected to continue in the future. This map shows the observed (numbers in black circles give the percentage change) and projected change in the amount of precipitation falling in the heaviest 1% of events (99th percentile of the distribution). Observed historical trends are quantified in two ways. The observed trend for 1901–2016 is calculated as the difference between 1901–1960 and 1986–2016. The values for 1958–2016, a period with a denser station network, are linear trend changes over the period. The trends are averaged over each region. Projected future trends are for a lower (RCP4.5, left) and a higher (RCP8.5, right) scenario for the period 2070–2099 relative to 1986–2015. *Source: adapted from Easterling et al. 2017.*[94]

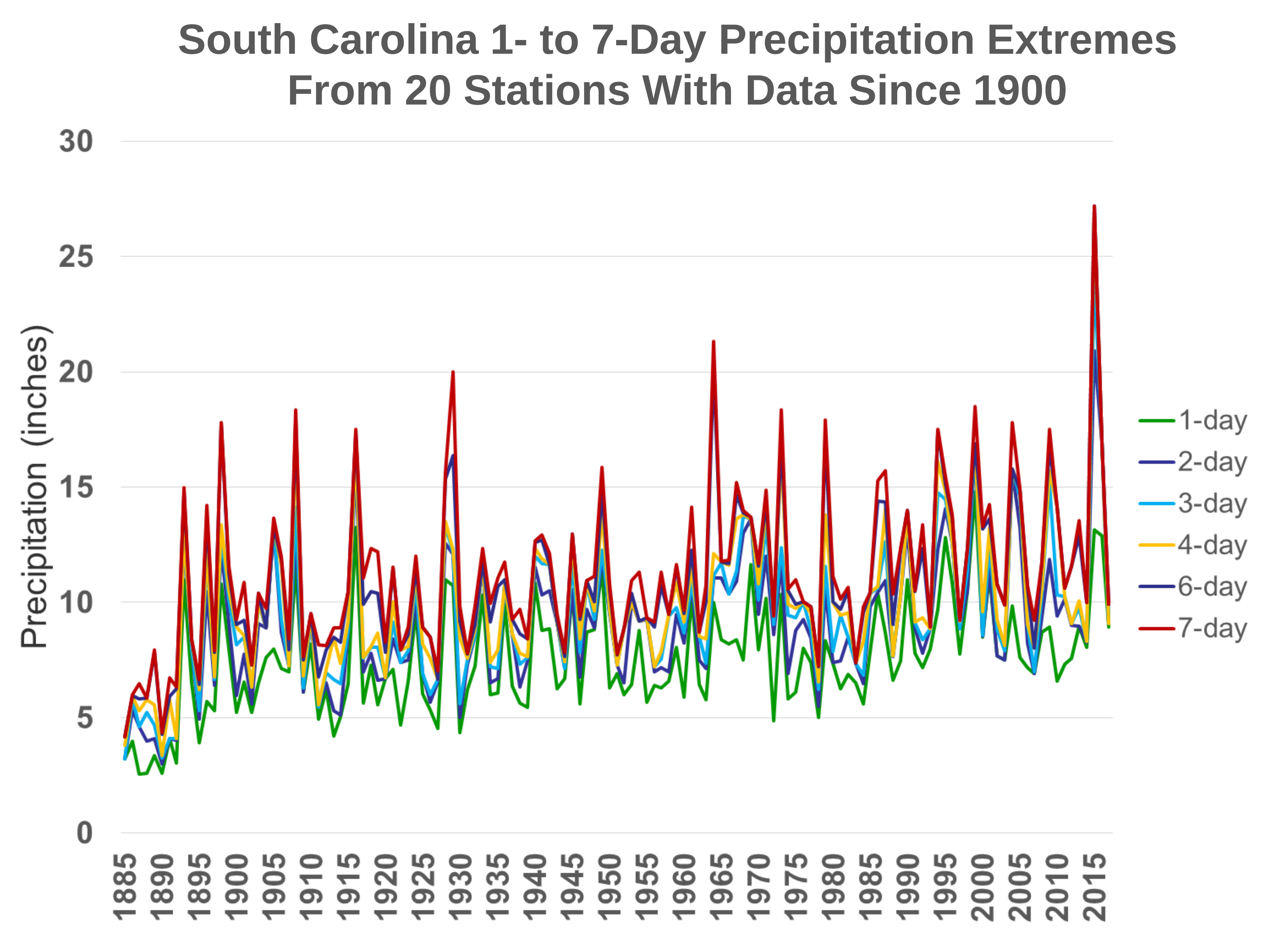


Projected Change in Daily, 20-year Extreme Precipitation

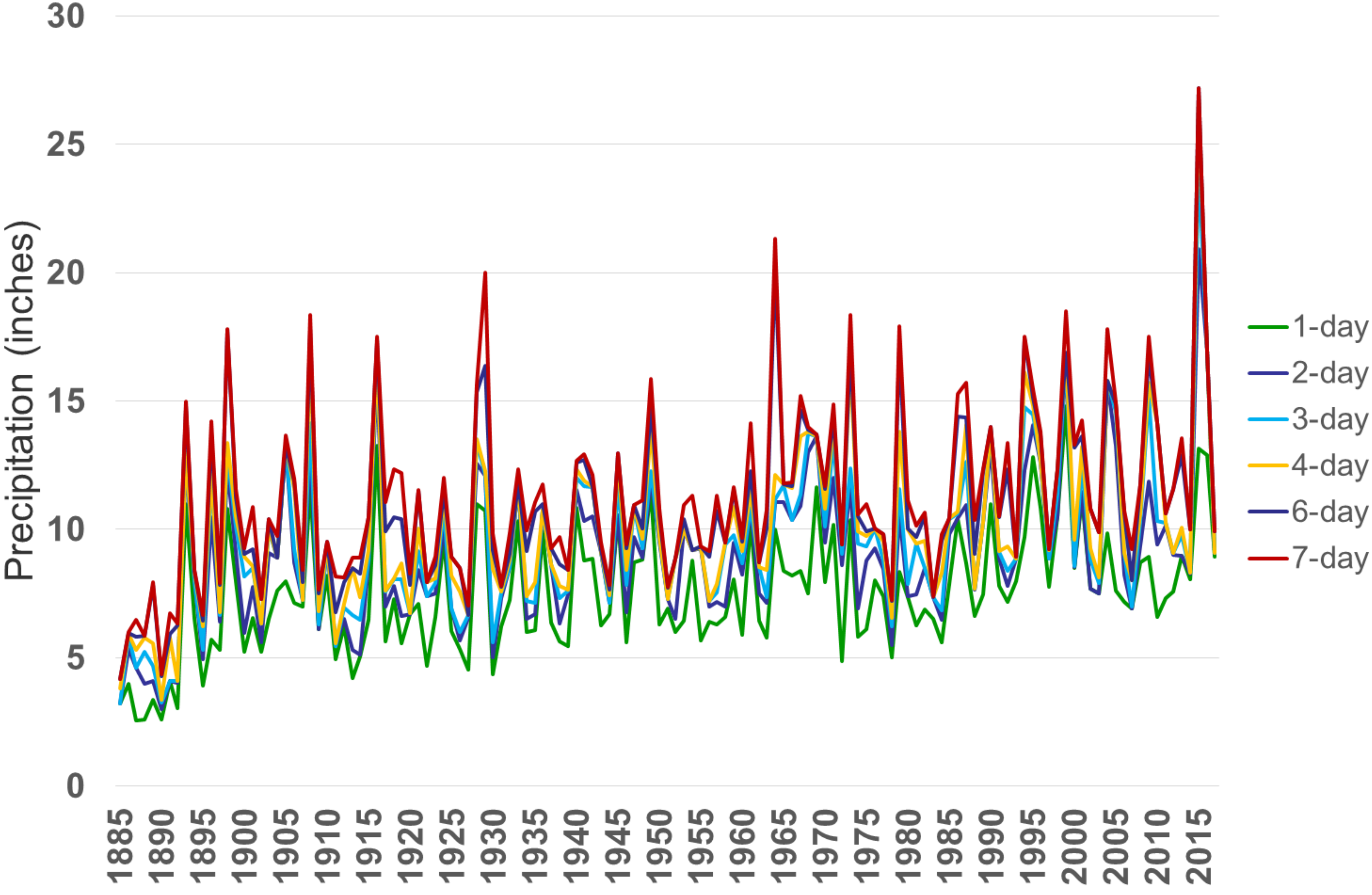


Projected change in the 20-year return period amount for daily precipitation for mid- (left maps) and late-21st century (right maps). Results are shown for a lower scenario (top maps; RCP4.5) and for a higher scenario (bottom maps, RCP8.5). These results are calculated from the LOCA downscaled data. (Figure source: CICS-NC and NOAA NCEI).


South Carolina 1- to 7-Day Precipitation Extremes
From 20 Stations With Data Since 1900
Precipitation (inches)
0
5
10
15
20
25
30
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
1-day
2-day
3-day
4-day
6-day
7-day


South Carolina 1- to 7-Day Precipitation Extremes
From 20 Stations With Data Since 1900
Precipitation (inches)
0
5
10
15
20
25
30
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
1-day
2-day
3-day
4-day
6-day
7-day

South Carolina 1- to 7-Day Precipitation Extremes From 20 Stations With Data Since 1900



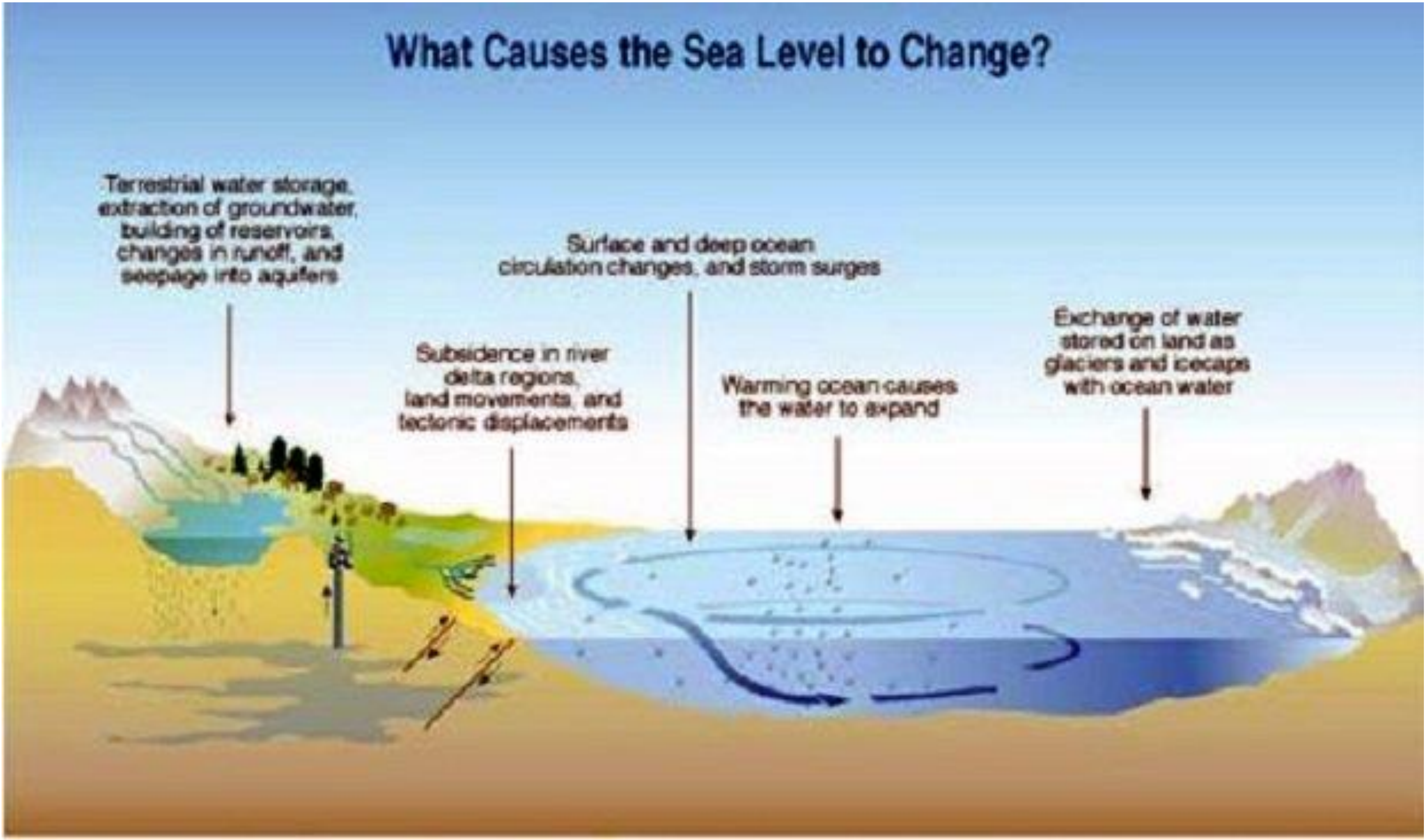
19 Comments from the Chapter

Infrastructure related to drinking water treatment and wastewater treatment may be compromised by climate-related events *(Ch. 3: Water, KM 2)*. Water utilities across the Southeast are preparing for these impacts. Tampa Bay Water, the largest wholesale water utility in the Southeast, is coordinating with groups including the Florida Water and Climate Alliance to study the impact of climate change on its ability to provide clean water in the future. Spartanburg Water, in South Carolina, is reinforcing the ability of the utility to "cope with, and recover from disruption, trends and variability in order to maintain services." Similarly, the Seminole Tribe of Florida, which provides drinking and wastewater services, assessed flooding and sea level rise threats to their water infrastructure and developed potential adaptation measures. The development of "green" water infrastructure (using natural hydrologic features to manage water and provide environmental and community benefits), such as the strategies promoted in the City of Atlanta Climate Action Plan, is one way to adapt to future water management needs. Implementation of these strategies has already resulted in a reduction in water consumption in the city of Atlanta, relieving strain on the water utility and increasing resilience.

2 Key Message #4

Rising Global Sea Levels

Global average sea level has risen by about 7–8 inches (about 16–21 cm) since 1900, with almost half this rise occurring since 1993 as oceans have warmed and land-based ice has melted. Relative to the year 2000, sea level is very likely to rise 1 to 4 feet (0.3 to 1.3 m) by the end of the century. Emerging science regarding Antarctic ice sheet stability suggests that, for higher scenarios, a rise exceeding 8 feet (2.4 m) by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed.


What Causes the Sea Level to Change?
Terrestrial water storage, extraction of groundwater, building of reservoirs, changes in runoff, and seepage into aquifers
Surface and deep ocean circulation changes, and storm surges
Subsidence in river delta regions, land movements, and tectonic displacements
Warming ocean causes the water to expand
Exchange of water stored on land as glaciers and icecaps with ocean water

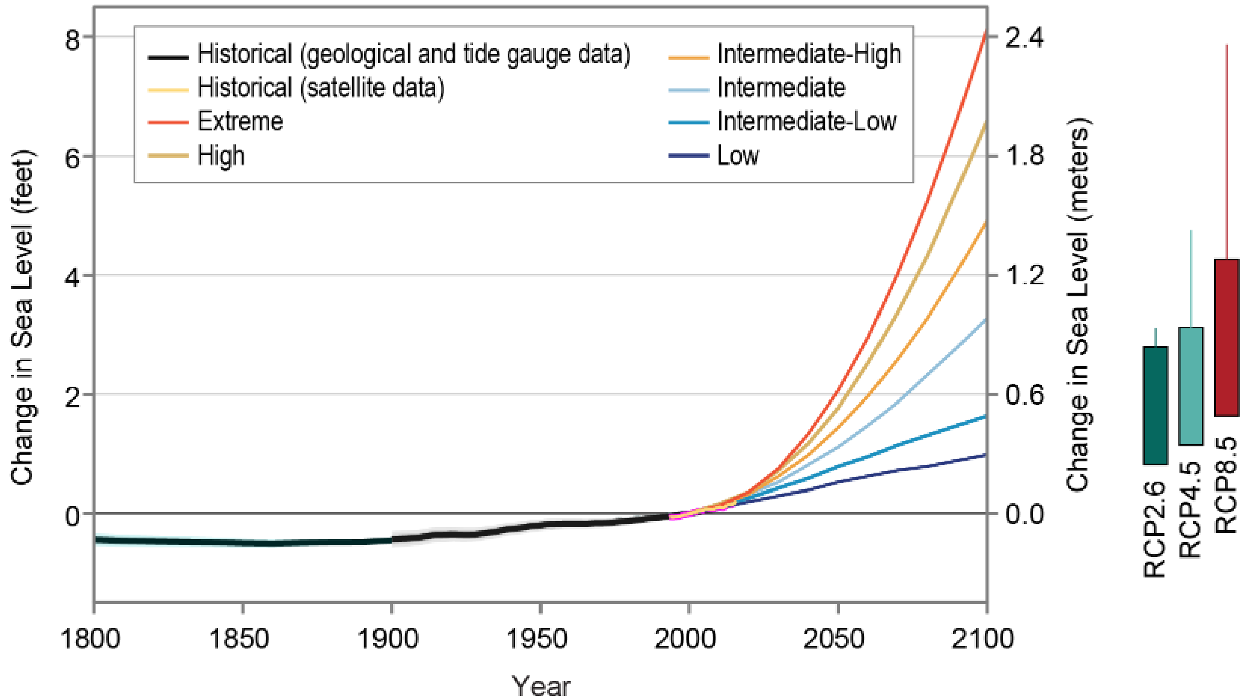


Fig. 2.3: Historical and Projected Global Average Sea Level Rise

How much global average sea level will rise over the rest of this century depends on the response of the climate system to warming, as well as on future scenarios of human-caused emissions of heat-trapping gases. The colored lines show the six different global average sea level rise scenarios, relative to the year 2000, that were developed by the U.S. Federal Interagency Sea Level Rise Taskforce[76] to describe the range of future possible rise this century. The boxes on the right-hand side show the *very likely* ranges in sea level rise by 2100, relative to 2000, corresponding to the different RCP scenarios described in Figure 2.2. The lines above the boxes show possible increases based on the newest research of the potential Antarctic contribution to sea level rise (for example, DeConto and Pollard 2016[80] versus Kopp et al. 2014[77]). Regardless of the scenario followed, it is *extremely likely* that global average sea level rise will continue beyond 2100. *Source: adapted from Sweet et al. 2017.*[57]

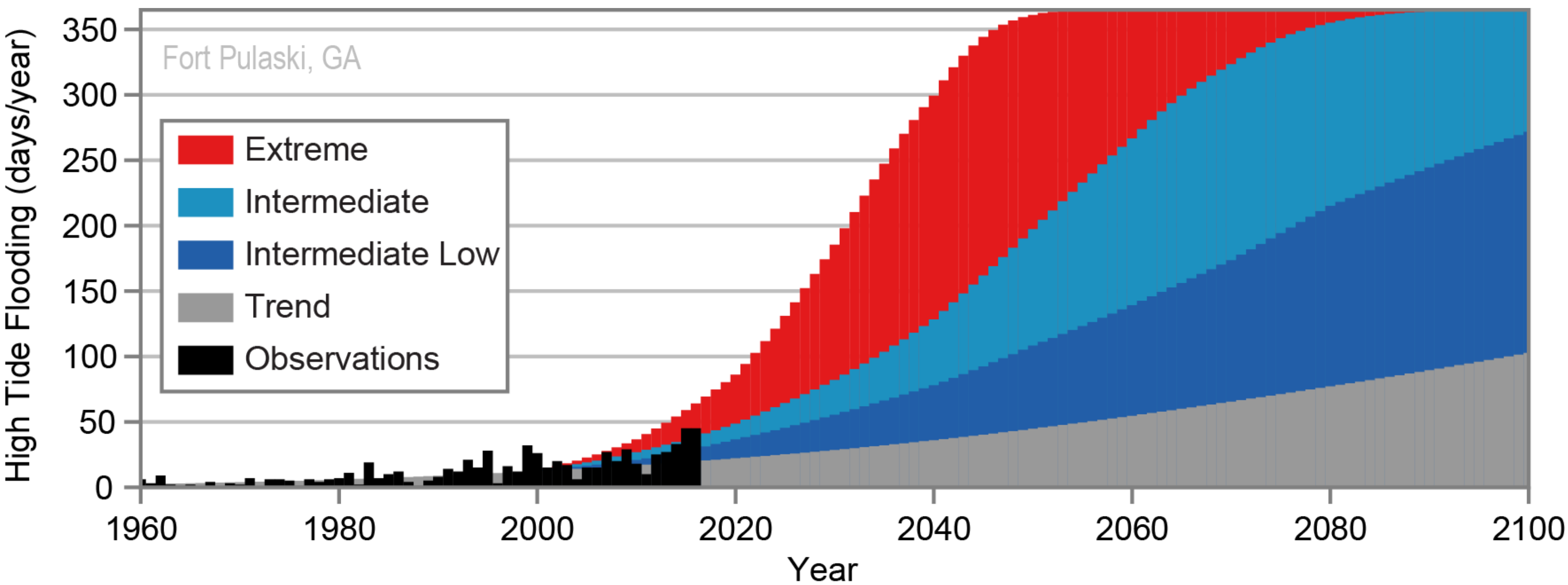


Fig. 19.7: Annual Number of High Tide Flooding Days

The figure shows the annual number of days experiencing high tide floods based on observations for 1960–2016 for Fort Pulaski, near Savannah, Georgia (black), and projected increases in the number of annual flood events based on four future scenarios: a continuation of the current relative sea level trend (gray) and the Intermediate-Low (dark blue), Intermediate (light blue), and Extreme (red) sea level rise scenarios. See Sweet et al. (2017)[51] and Appendix 3: Data & Scenarios for additional information on projection and trend data. *Source: adapted from Sweet and Park 2014.*[63]

Fig. 19.9: Storm Water in Charleston, South Carolina

(left) U.S. Highway 17 (Septima Clark Parkway—crosstown) in Charleston, South Carolina, during a flood event. Floodwaters can get deep enough to stall vehicles. (right) Market Street drainage tunnel being constructed in Charleston, South Carolina, as part of a drainage improvement project to prevent current and future flooding. This tunnel crosses a portion of downtown Charleston 140 feet underground and is designed to rapidly convey storm water to the nearby Ashley River. *Photo credit: City of Charleston 2015.*[45]

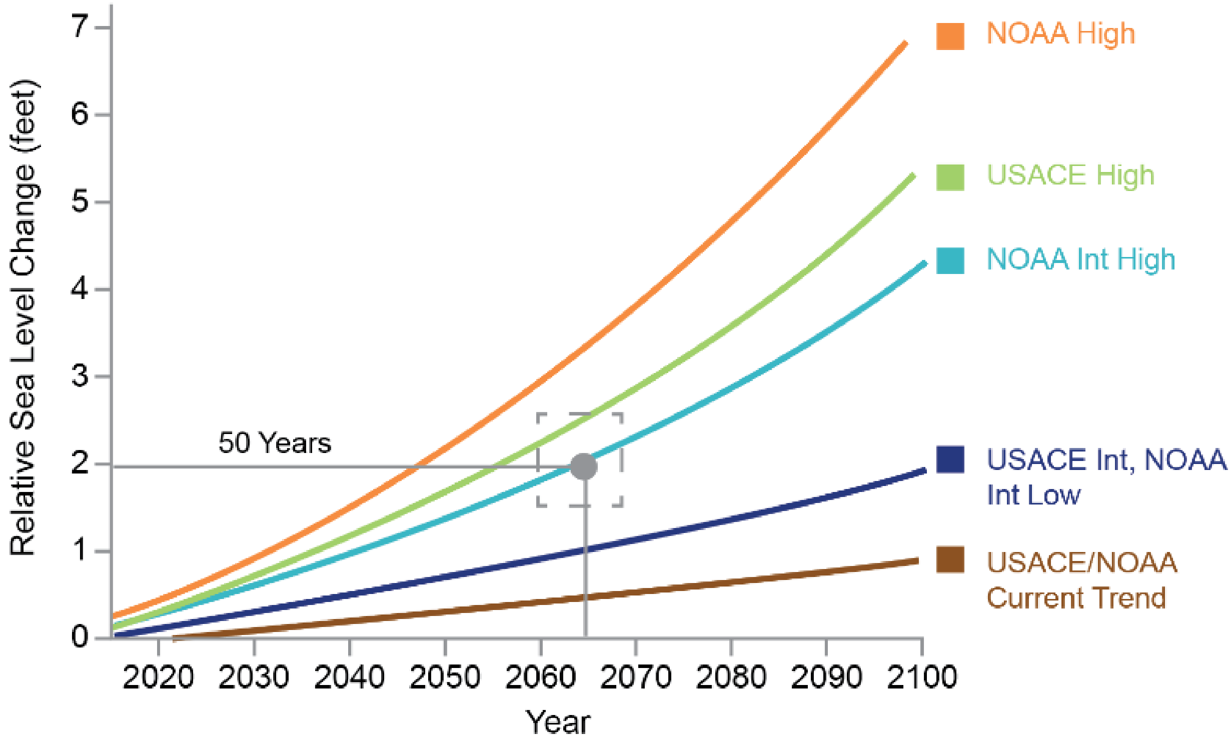


Fig. 19.10: Projected Sea Level Rise for Charleston, South Carolina

The City of Charleston Sea Level Rise Strategy calls for a 50-year outlook, based on existing federal sea level change projections in 2015 (colored curves), and calls for using a range of 1.5–2.5 feet of sea level rise (dashed box). A 1.5-foot increase will be used for short-term, less vulnerable investments, such as a parking lot. A 2.5-foot increase will be used for critical, longer-term investments, such as emergency routes and public buildings. This 1-foot range was chosen to approximate the average of these projections in 2065. *Source: City of Charleston 2015.*[45]

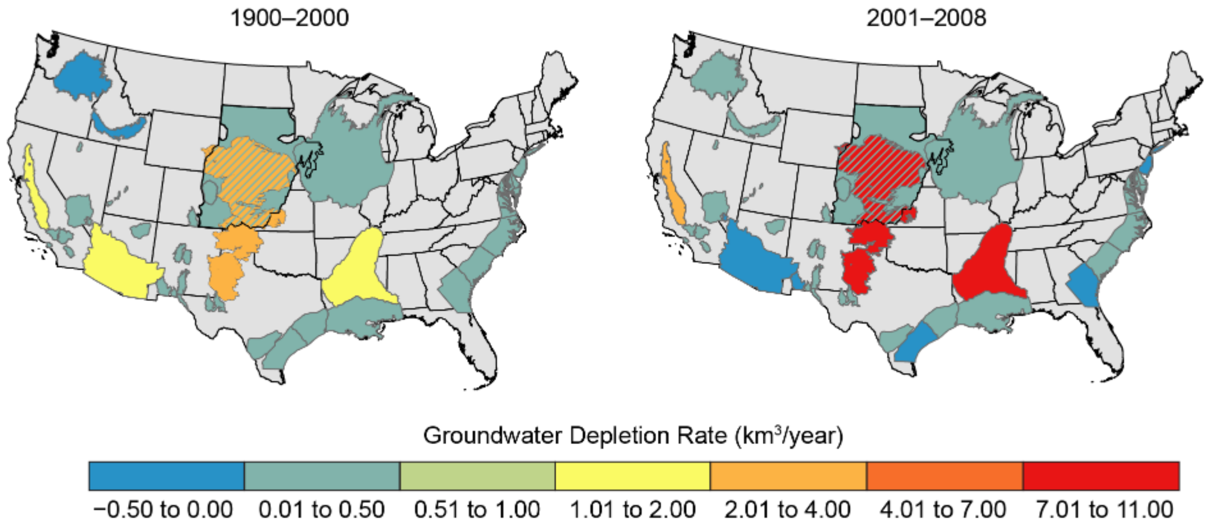


Fig. 3.2: Depletion of Groundwater in Major U.S. Regional Aquifers

(left) Groundwater supplies have been decreasing in the major regional aquifers of the United States over the last century (1900–2000). (right) This decline has accelerated recently (2001–2008) due to persistent droughts in many regions and the lack of adequate surface water storage to meet demands. This decline in groundwater compromises the ability to meet water needs during future droughts and impacts the functioning of groundwater dependent ecosystems (e.g., Kløve et al. 2014[3]). The values shown are net volumetric rates of groundwater depletion (km^3 per year) averaged over each aquifer. Subareas of an aquifer may deplete at faster rates or may be actually recovering. Hatching in the figure represents where the High Plains Aquifer overlies the deep, confined Dakota Aquifer. *Source: adapted from Konikow 2015.*[4] *Reprinted from Groundwater with permission of the National Groundwater Association. ©2015.*

3 Key Message #2

Deteriorating Water Infrastructure at Risk

Deteriorating water infrastructure compounds the climate risk faced by society. Extreme precipitation events are projected to increase in a warming climate and may lead to more severe floods and greater risk of infrastructure failure in some regions. Infrastructure design, operation, financing principles, and regulatory standards typically do not account for a changing climate. Current risk management does not typically consider the impact of compound extremes (co-occurrence of multiple events) and the risk of cascading infrastructure failure.

Thank you

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