



Weather of Fredericksburg and Spotsylvania National Military Park

Mid-Atlantic Network Summary Report for 2014

Natural Resource Report NPS/MIDN/NRR—2016/1112



ON THE COVER

Sunrise at Chancellorsville Battlefield, Fredericksburg and Spotsylvania National Military Park.
Photograph by: Theresa Rasmussen

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Natural Resource Report NPS/MIDN/NRR—2016/1112

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List of Key Acronyms

ASOS	Automated Surface Observation System
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
FAA	Federal Aviation Administration
FRSP	Fredericksburg and Spotsylvania National Military Park
IFLOWS	Integrated Flood Observing and Warning System
MIDN	Mid-Atlantic Network
NADP	National Atmospheric Deposition Program
NARR	North American Regional Reanalysis
NCDC	National Climatic Data Center
NMP	National Military Park
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PASC	Pennsylvania State Climatologist
PDSI	Palmer Drought Severity Index
POR	Period of Record
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RAWS	Remote Automated Weather Stations
USDM	United States Drought Monitor
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Introduction

Weather and climate are widely recognized as key drivers of terrestrial and aquatic ecosystems, affecting biotic as well as abiotic ecosystem characteristics and processes. Global and regional scale climatic patterns, trends, and variations are critical to the cycling of elements, nutrients, and minerals through ecosystems and can deliver pollutants from regional and even global sources (National Assessment Synthesis Team 2001). These variations and trends influence the fundamental properties of ecologic systems such as soil-water relationships and plant-soil processes and their disturbance rates and intensity. Information obtained from meteorological monitoring will be useful to interpreting and understanding changes in species composition, community structure, water and soil chemistry, and related landscape processes (Comiskey and Callahan 2008).

The purpose of this report is to provide a concise weather and climate summary for January 1 to December 31, 2014, and to place current patterns and trends in an appropriate historical, regional, and global context (Marshall et al. 2012). It is our intention that this report will satisfy an inherent interest in meteorological phenomena and meet the Mid-Atlantic Network (MIDN) Weather and Climate Monitoring objectives:

- Document current status and long-term trends in air temperature and precipitation at multiple temporal scales (e.g., daily, monthly, seasonal, annual, and decadal) and spatial scales (e.g., individual stations and aggregated stations such as climate divisions) utilizing existing weather and climate monitoring programs and datasets.

To accomplish this objective, a variety of atmospheric data streams were evaluated for their quality, longevity, and applicability to the MIDN parks. Since no single weather network contains all the pertinent measures of atmospheric phenomena to assess ecosystem health, an objective analysis of the data networks was developed and outlined in the Weather and Climate Monitoring Protocol for the Eastern Rivers and Mountains Network and Mid-Atlantic Network of the National Park Service (Marshall et al. 2012). Through this analysis, a select number of weather/climate observing stations were chosen as representative of each park; these are the primary data sources used in the profile of 2014's climate summary and trends.

In addition to a suite of summary tables, graphs, and narratives, we specifically identify a series of key weather indicators to report status and trends on an annual basis and periodically in separate and more thorough reports. These key indicators are further described in the protocol (Marshall et al. 2012) and summarized in this report.

Climate of the Eastern Piedmont of Virginia

Fredericksburg and Spotsylvania National Military Park (NMP) lies in VA Climate Division 2 (Eastern Piedmont). A climate division is a region that is reasonably homogenous with respect to climatic and hydrologic characteristics and is frequently used for compiling climate statistics (<http://www.esrl.noaa.gov/psd/data/usclimdivs/data/map.html>). Virginia is divided into six climate divisions. This section of Virginia is generally considered to have a humid continental type of climate, but the rolling hills and valleys have a marked effect on the weather and climate of the parks. The prevailing westerly winds carry most of the weather disturbances that affect the region from the interior of the continent, with the Atlantic Ocean having only an occasional influence on the climate of the area (Davey et al. 2006, Gawtry and Stenger 2007). Coastal storms do, at times, affect the day-to-day weather, especially in the winter. Also, storms of tropical origin can have significant effect within this part of Virginia, causing severe floods in some instances.

Temperatures are moderately continental with the tempering effects due to the nearby mountains that contribute to cloud production in the summer and onshore winds modifying the chill at times during the winter. The lowest readings in the winter occur with polar air masses of Canadian origin settling over the Northeast after a fresh snowfall. The highest readings of the summer happen when the sub-tropical fair weather system, the Bermuda high, pushes westward into the Carolinas; its clockwise circulation directs hot, humid air from the Gulf region into the area. The southwest winds gain additional warmth when descending the crest of the Appalachians. The last freeze and first frost typically occur in mid-April and October, respectively.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 38–48 in (965–1,219 mm), while the majority of places receive 40–45 in (1,016–1,150 mm). Greatest amounts usually occur in the late spring and summer months, while February is the driest month, having about 2 in (51 mm) less than the wettest months. Precipitation tends to be somewhat greater in the mountains, due primarily to coastal storms which occasionally frequent the area. During the warm season, these storms can bring heavy rain, although in winter, heavy snow or a mixture of rain and snow may be produced.

Surface winds blow from the west and northwest in the cold season and from the southwest during the warm half of the year. Thunderstorms follow a frequency that matches the solar cycle, occurring between the equinoxes and reaching a peak near the solstice. Hail is relatively infrequent, occurring about once every other year, but flash floods and damaging thunderstorm winds affect parts of the park each summer. On average, tornadoes pass through the area about once every three years. The direct effects of an Atlantic hurricane are uncommon, though remnant rains from tropical storms have contributed to the region's worst floods. Ice storms, which can cause significant disruption, occur at irregular intervals and are primarily confined to the months between December and March (Kocin and Uccellini 2004).

Observing Stations

A total of seven weather observing stations comprising three weather observing networks were selected as the most representative weather stations around Fredericksburg and Spotsylvania NMP in 2014 (Figure 1). Representative stations within a 100-km range of each park were chosen based on several criteria, which include proximity to the park, the representativeness of the station to the park elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al. 2012). Moreover, the percentage of time a station reports a particular parameter (e.g., temperature) can influence data inclusion. Therefore, a total of seven stations were ultimately used for this 2014 report: Culpepper Regional Airport, Shannon Airport, Piedmont Research Station, Corbin, Fredericksburg Sewage Plant, Louisa, and Fredericksburg Battlefield (Table 1, Figure 1).

Two stations, Louisa, VA (1916-current) and Piedmont Research Station, VA (1947-current), were used for a long-term trend analysis using the period of record for both stations ending December 31, 2013. Graphs of these long-term trends are shown in the Appendix section of this document. For temperatures, long-term means and the standard deviation above and below the long-term mean are computed for each indicator. Because precipitation distributions do not fall on a normal curve like temperature distributions do, standard deviations are not computed for the precipitation indicators.

The following are the climate indicators selected for each of the parks:

- Average Annual Mean Temperature – A measure of the composite mean temperature (averaging the maximum and minimum on a daily basis) for an entire year
- Average Annual Maximum Temperature – A measure of the average of the daily maximum temperature for an entire year
- Highest Annual Maximum Temperature – A measure of the individual highest maximum temperature each year
- Annual Number of Hot Days (maximum temperature equal to or exceeding 90°F (32°C)) – A measure of warm season heat using a threshold of days with a 90°F (32°C) maxima
- Average Annual Minimum Temperature – A measure of the average of the daily minimum temperature for an entire year
- Lowest Annual Minimum Temperature – A measure of the individual lowest minimum temperature each year
- Annual Number of Cold Days (maximum temperature less than or equal to 32°F (0°C)) – A measure of cold season chill using a threshold of days with a 32°F (0°C) maxima
- Annual Number of Subfreezing Days (minimum temperature less than or equal to 32°F (0°C)) – A measure of cold season chill using a threshold of days with a 32°F (0°C) minima

- Annual Number of Subzero Days (minimum temperature less than or equal to 0°F (-17.8°C))
– A measure of cold season chill using a threshold of days with a 0°F (-17.8°C) minima
- Growing Season Length (number of days between last freeze in spring and first freeze in fall)
– A measure of the local growing season as tallied by the total number of days between the last 32°F (0°C) in the spring and the first 32°F (0°C) in the fall
- Annual Precipitation – A measure of total liquid (and its equivalent melted snow) for all days
- Autumn Precipitation (October 1 – December 31) - The three month total precipitation including rain and melted snow
- Annual Number of Heavy Precipitation Days (liquid equal to or greater than 1.0 in (25mm)) – A measure of the frequency of heavy precipitation events during each year
- Annual Number of Extreme Precipitation Days (liquid equal to or greater than 2.0 in (50mm)) – A measure of frequency of extreme precipitation events during each year
- Annual Number of Micro-droughts – A measure of micro-droughts for the year as the number of periods of 7+ days without rain
- Annual Snowfall – A measure of total solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Measureable Snow Days – A measure of the severity of winter precipitation as the number of days receiving more than or equal to 0.1 in (0.3 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Moderate Snow Days– A measure of the severity of winter precipitation as the number of days receiving more than or equal to 3 in (7.6 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Heavy Snow Days– A measure of the severity of winter precipitation as the number of days receiving more than or equal to 5 in (12.7 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)

The average value of a climate element over 30 years is defined as a climatological normal, which is calculated and established by NOAA's National Climatic Data Center (NCDC). Every ten years, NCDC computes new thirty-year climate normals for selected temperature and precipitation elements for a large number of U.S. climate and weather stations. The current (as of 2014) normals cover the period 1981–2010. In this report, the 30-year normals established by NCDC are used as the baseline for comparisons (e.g., departures from normal). In cases where data for the 30-year normal period are not available, we use alternative comparisons such as the new pseudo-normals from NCDC or a recent 10-year period. In some cases, sufficient data may simply not be available to calculate

normals. For metrics that NCDC may not routinely calculate a normal, such as the number of days with more than 2 in (55 mm) of rain or liquid equivalent, normals are calculated using the same time period (e.g., 1981–2010) as the current NCDC standard. Throughout the report, descriptions of a station’s values as compared to the normals are described as a difference from the “average”, “mean”, “typical”, “long-term value”, as well as “normal”, to improve the readability of the document. However, all of these terms are comparing a value from one year at that station to that station’s normal, whether it is the 30-year normal or the pseudo-normal calculated on a shorter time frame.

Two stations, Piedmont Research Station and Louisa, have a long-term record and are used to create a 30-year normal (mean values for 1981–2010) for temperature and precipitation. Temperature indicators for 2014 are compared to the normals for the two stations, while precipitation indicators are compared for only one station (Louisa). All seven stations are used to provide monthly summaries for temperature, and four are used to show departures from normal. Fredericksburg Sewage Plant has a shorter reporting period, but departures from normal are compared to the longer term record for that station (1995–2007). For precipitation, Corbin, Fredericksburg Sewage Plant, Louisa, Piedmont Research Station and Fredericksburg Battlefield are used to calculate monthly summaries. These stations, with the exception of Fredericksburg Battlefield due to a short Period of Record, are used to calculate monthly departures from normal.

In addition to the summary information available in this report, a near real-time data stream has been made available to the MIDN through a Web interface for the weather observing stations, along with monthly, seasonal, and annual summaries. The Web interface is accessible through the following link: <http://climate.met.psu.edu/NPS/interface.php>.

Table 1. List of weather observing stations around Fredericksburg and Spotsylvania National Military Park selected as most representative of the parks in 2014.

Station	Observing Network ¹	Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2014	Percentage of Time Reporting Precipitation for 2014	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
KCJR	ASOS	Culpepper Regional Airport	05/11/1998	Present	78.9	99.2	96.4	40.2
KEZF	ASOS	Shannon Airport	01/01/1996	Present	100.0	100.0	92.7	27.2
ORGV2	COOP	Piedmont Research Station	11/01/1946	Present	94.0	99.7	99.7	99.6
CORV2	COOP	Corbin	01/01/1959	Present	100.0	100.0	97.8	98.4
FEDV2	COOP	Fredericksburg Sewage Plant	01/01/1995	Present	92.9	99.7	95.7	95.5
LOUV2	COOP	Louisa	05/01/1916	Present	100.0	100.0	97.9	97.1
VAFSP ²	NPS	Fredericksburg Battlefield	01/01/2009	Present	100.0	100.0	99.5	99.8

¹ Observing networks are: ASOS — Automated Surface Observation System, COOP — National Weather Service Cooperative Observer Program, NPS — National Park Service.

² Station code was NAD83 in previous reports.

Temperature Summary

Below-average temperatures were the rule for the region around Fredericksburg and Spotsylvania NMP for seven out of the twelve months in 2014, ranking as the 46th coolest on record, with pronounced negative anomalies in January, March, August, and November (Figures 2 and 3)¹. Annual temperatures were rather cool with daytime maximums averaging as much as 2.1°F (1.2°C) below normal and nighttime readings were between 1.5°F to 5.5°F (0.9°C to 3.1°C) below normal (Table 2). With the one exception of growing season length at the Louisa station, every indicator documented a cooler than normal year (Table 2).

January brought a very cool start to the year (Tables 3 and 4). The lowest reading of 2014 at Piedmont Research Station was 2.0°F (-16.7°C) on January 24 (Table 2). Below-average temperatures continued into February with departures ranging from -0.1°F to -1.9°F (-0.1°C to -1.1°C) from normal (Table 4). March turned much colder again with some of the largest departures of the year. Readings in March averaged as much as 7.3°F (4.0°C) below the long-term mean. Winter, as a whole, ranked as the 16th coolest in 120 years in the Eastern Piedmont (Table 5).

Temperatures during April continued the cold stretch, reaching 3.8°F (2.1°C) below normal at Piedmont Research Station, VA (Table 4). Warmer conditions ensued in May with Corbin, VA seeing temperatures 3.1°F (1.7°C) above normal (Figure 3 and Table 4). Temperatures receded to seasonal levels in June as they averaged from -0.5°F to 0.9°F (-0.3°C to 0.5°C) from normal (Table 4). Overall, spring 2014 tied as the 18th warmest for the Eastern Piedmont (Table 5).

The first two months of the summer were relatively cool. July had anomalies from 1.0°F to 2.9°F (0.7°C to 1.6°C) below normal (Figures 2 and 3). August was even cooler, with temperature anomalies reaching 3.7°F (2.1°C) below normal at Louisa, VA. Maximum temperatures for the year were several degrees below normal levels, and the number of hot days was well below normal with as few as 13 days compared to an average of 22 days at Piedmont Research Station (Table 2). The summer months tied as the 43rd coolest in 120 years of records in the Eastern Piedmont (Table 5).

Autumn was ranked the 43rd warmest in 120 years, primarily due to a warm October and December (Table 5, Figures 2 and 3). In between these mild months, November brought the second largest negative departures for the year ranging from -2.9°F to -4.9°F (-1.6°C to -2.7°C) (Table 4). The first freeze of the fall occurred in late October/early November. The calendar year ended rather mild, as December brought anomalies ranging from 2.2°F to 2.7°F (1.2°C to 1.5°C) above normal (Table 4). Overall, 2014 had an above average number of sub-freezing days (116-118 vs. a normal of 92-100) and cold days (8-15 vs. a normal of 5-9) (Table 2).

¹ The maps in Figures 2 and 3 were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). PRISM uses an interpolation scheme for temperature between actual observations and corrects these estimates for changes in topography across the region (Daly et al. 2002). More information can be found at <http://www.prism.oregonstate.edu/>.

Fredericksburg and Spotsylvania National Military Park
Departure from Average Monthly Maximum Temperature
2014 vs. 1981–2010

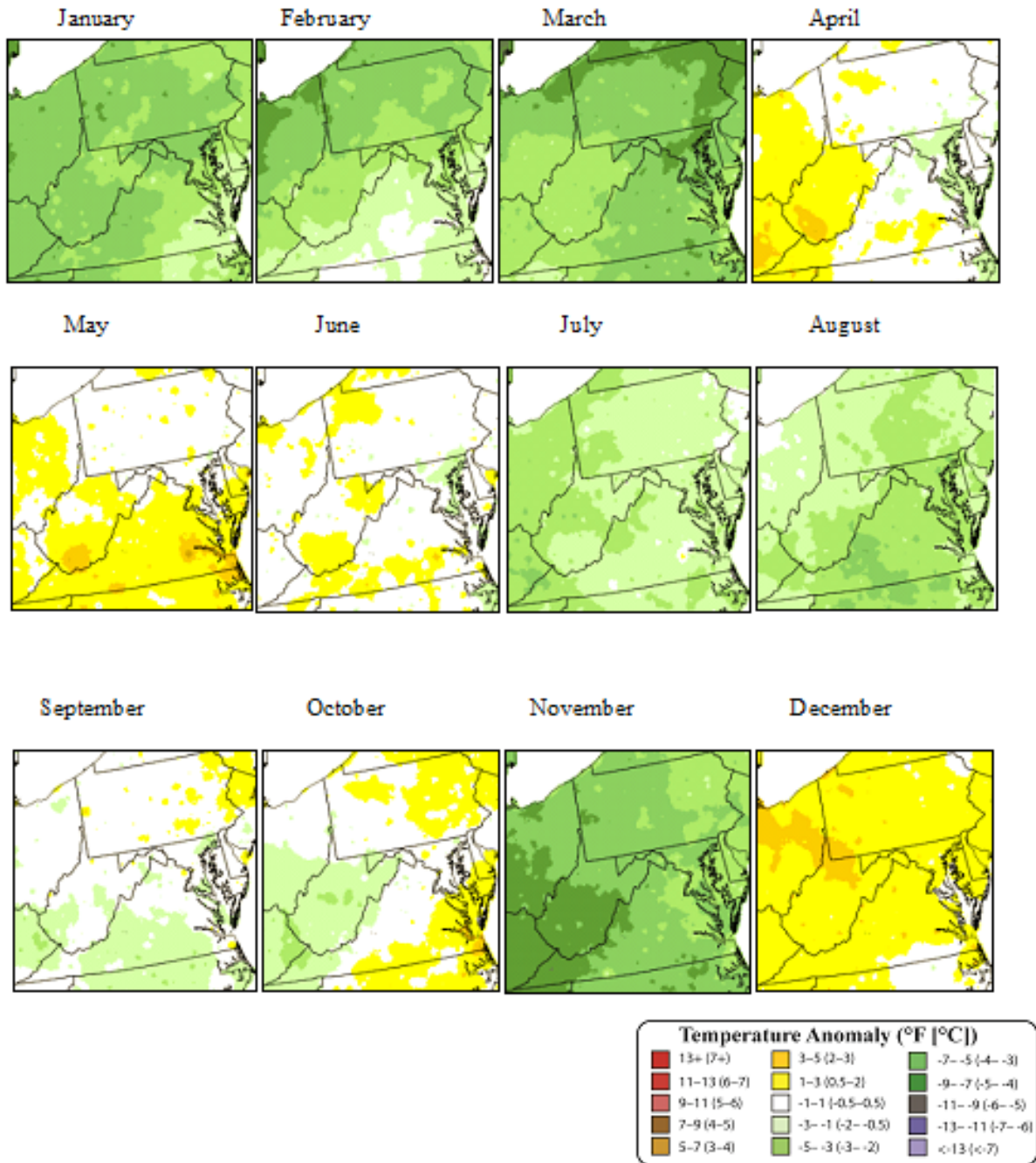


Figure 2. Maps showing departure from average monthly maximum temperature in 2014 compared to the 30-year normal (1981–2010).

Fredericksburg and Spotsylvania National Military Park
Departure from Average Monthly Minimum Temperature
2014 vs. 1981–2010

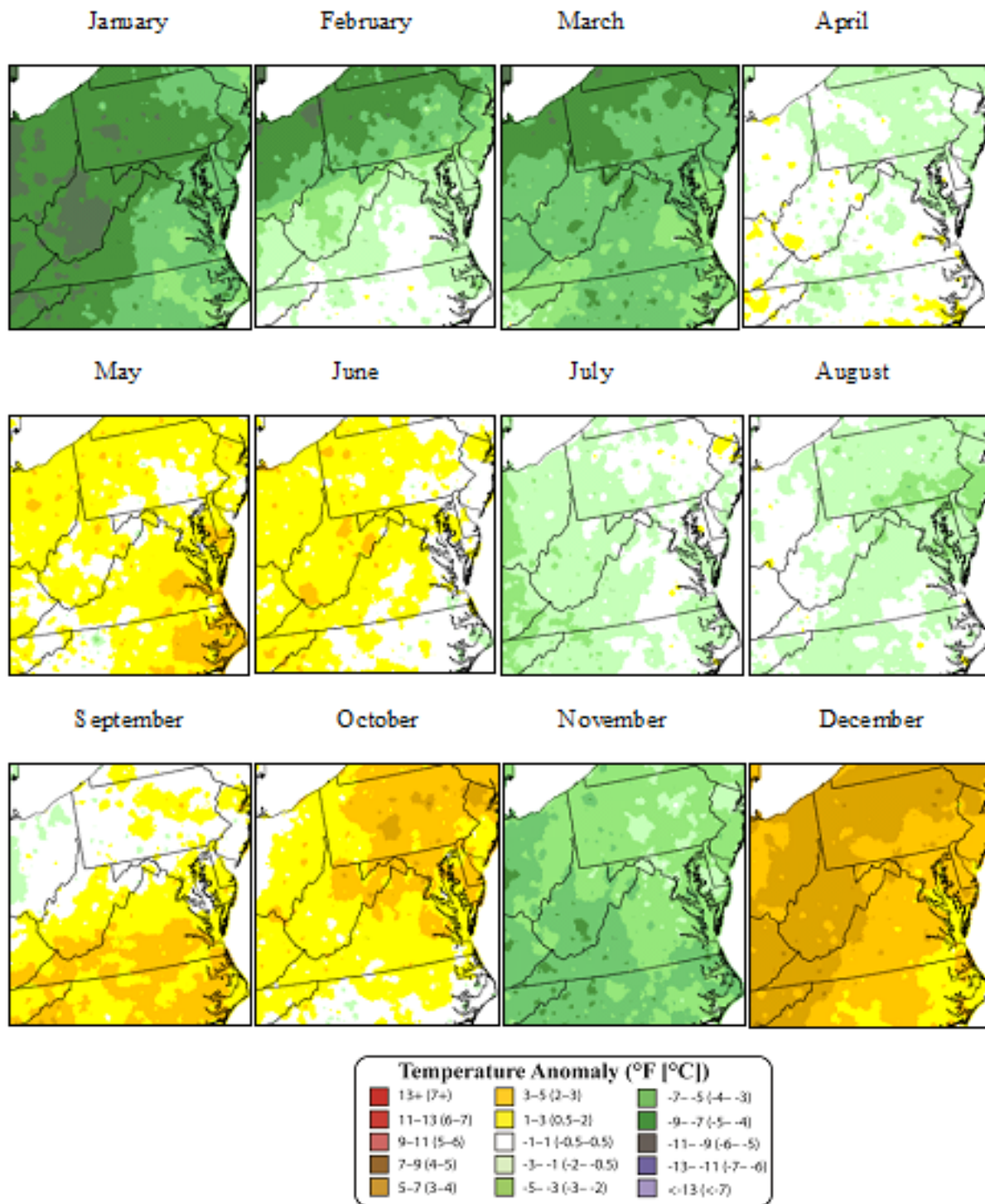


Figure 3. Maps showing departure from average monthly minimum temperature in 2014 compared to the 30-year normal (1981–2010).

Table 1. Status of 2014 temperature indicators compared to the 30-year normal (1981–2010) and the station period of record at the Louisa (LOUV2) and Piedmont Research Station (ORGV2) weather observing stations.

Temperature Indicator	Louisa, VA 2014	Louisa, VA 1981–2010	Louisa, VA 1916-2013 Mean (± 1 SD)	Piedmont Research Station, VA 2014	Piedmont Research Station, VA 1981-2010	Piedmont Research Station, VA 1947-2013 Mean (± 1 SD)
Average Annual Temperature	55.4°F 13.0°C	56.8°F 13.8°C	56.0 (54.8 – 57.3)°F 13.3 (12.7 – 14.1)°C	53.4°F 11.9°C	55.8°F 13.2°C	55.7 (54.4 – 57.0)°F 13.2 (12.4 – 13.9)°C
Average Annual Maximum Temperature	67.3°F 19.6°C	68.7°F 20.4°C	NA	64.1°F 17.8°C	66.2°F 19.0°C	NA
Maximum Temperature	95.0°F 35.0°C	96.5°F 35.8°C	97.9 (94.9 – 101.1)°F 36.6 (34.9 – 38.4)°C	94.0°F 34.4°C	97.0°F 36.1°C	97.3 (94.1 – 100.4)°F 36.3 (34.5 – 38.0)°C
Hot Days (days with Tmax $\geq$ 90°F/32°C)	21	31	34 (19 – 49)	13	22	29 (15 – 42)
Average Annual Minimum Temperature	43.4°F 6.3°C	44.9°F 7.2°C	NA	42.6°F 5.9°C	45.5°F 7.5°C	NA
Minimum Temperature	-5.0°F -20.6°C	0.5°F -17.5°C	0.7 (-6.3 to 7.8) °F -17.4 (-13.4 to -21.3) °C	2.0°F -16.7°C	3.5°F -15.8°C	3.6 (-2.0 to 9.3) °F -15.8 (-12.6 to -18.9) °C
Cold Days (days with Tmax $\leq$ 32°F/0°C)	8	5	NA	15	9	NA
Sub-freezing Days (days with Tmin $\leq$ 32°F/0°C)	118	100	106 (93 – 119)	116	92	100 (88 – 112)
Sub-zero Days (days with Tmin $\leq$ 0°F/-17.8°C)	2	1	NA	0	0	NA
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	178	169	170 (154 – 186)	189	210	194 (176 – 211)

Table 3. Summary of 2014 monthly average temperatures for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Culpepper Airport	KCJR	30.6°F	36.3°F	41.4°F	56.5°F	67.8°F	M	M	M	M	56.3°F	43.6°F	38.9°F	M
		-0.8°C	2.4°C	5.2°C	13.6°C	19.9°C	M	M	M	M	13.5°C	6.4°C	3.8°C	M
Shannon Airport	KEZF	31.7°F	37.7°F	42.9°F	56.8°F	67.9°F	75.2°F	77.2°F	74.4°F	70.4°F	60.5°F	45.9°F	41.6°F	57.0°F
		-0.2°C	3.2°C	6.1°C	13.8°C	19.9°C	24.0°C	25.1°C	23.6°C	21.3°C	15.8°C	7.7°C	5.3°C	13.9°C
Piedmont Research Station	ORGV2	28.5°F	35.9°F	37.7°F	51.5°F	64.4°F	72.1°F	73.5°F	M	M	58.0°F	42.6°F	39.8°F	M
		-1.9°C	2.1°C	3.2°C	10.8°C	18.0°C	22.3°C	23.1°C	M	M	14.4°C	5.9°C	4.3°C	M
Corbin	CORV2	31.3°F	37.8°F	43.0°F	55.2°F	66.9°F	73.6°F	75.7°F	72.8°F	69.2°F	59.6°F	45.0°F	41.0°F	55.9°F
		-0.4°C	3.2°C	6.1°C	12.9°C	19.4°C	23.1°C	24.3°C	22.6°C	20.7°C	15.3°C	7.2°C	5.0°C	13.3°C
Fredericksburg Sewage Plant	FEDV2	29.7°F	35.5°F	39.6°F	M	66.4°F	74.0°F	76.4°F	72.8°F	M	59.5°F	42.9°F	M	M
		-1.3°C	1.9°C	4.2°C	M	19.1°C	23.3°C	24.5°C	22.7°C	M	15.3°C	6.1°C	M	M
Louisa	LOUV2	31.2°F	37.5°F	42.8°F	54.7°F	66.4°F	73.0°F	75.2°F	71.8°F	68.7°F	58.5°F	43.8°F	40.6°F	55.4°F
		-0.4°C	3.1°C	6.0°C	12.6°C	19.1°C	22.8°C	24.0°C	22.1°C	20.4°C	14.7°C	6.6°C	4.8°C	13.0°C
Fredericksburg Battlefield	VAFSP	30.5°F	36.8°F	42.1°F	56.1°F	67.0°F	74.2°F	75.6°F	72.8°F	68.9°F	59.0°F	44.7°F	40.7°F	55.8°F
		-0.8°C	2.7°C	5.6°C	13.4°C	19.4°C	23.4°C	24.2°C	22.7°C	20.5°C	15.0°C	7.1°C	4.8°C	13.2°C

M = missing data (Monthly statistics are reported as 'M' if more than 4 days of data are missing).

Table 4. Summary of 2014 departure from normal temperature based on the 30-year normal (1981–2010) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Piedmont Research Station	ORGV2	-5.8°F	-1.4°F	-7.3°F	-3.8°F	0.7°F	-0.5°F	-2.9°F	M	M	1.3°F	-4.9°F	2.3°F	-5.4°F
		-3.2°C	-0.8°C	-4.0°C	-2.1°C	0.4°C	-0.3°C	-1.6°C	M	M	0.7°C	-2.7°C	1.2°C	-3.0 °C
Corbin	CORV2	-3.4°F	-0.1°F	-2.5°F	-0.3°F	3.1°F	0.9°F	-1.1°F	-2.5°F	0.9°F	2.4°F	-2.9°F	2.7°F	-0.3°F
		-1.9°C	-0.1°C	-1.4°C	-0.2°C	1.7°C	0.5°C	-0.6°C	-1.5°C	0.5°C	1.3°C	-1.6°C	1.5°C	-0.1°C
Fredericksburg Sewage Plant ¹	FEDV2	-5.1°F	-1.9°F	-5.4°F	M	2.2°F	0.5°F	-1.0°F	-3.3°F	M	2.1°F	-4.6°F	M	-1.1°F
		-2.9°C	-1.1°C	-3.0°C	M	1.2°C	0.3°C	-0.7°C	-1.8°C	M	1.2°C	-2.5°C	M	-0.6°C
Louisa	LOUV2	-4.8°F	-1.6°F	-3.9°F	-1.9°F	1.6°F	-0.2°F	-1.9°F	-3.7°F	0.3°F	1.1°F	-3.9°F	2.2°F	-1.3°F
		-2.6°C	-0.8°C	-2.2°C	-1.1°C	0.9°C	-0.1°C	-1.1°C	-2.1°C	0.2°C	0.6°C	-2.1°C	1.2°C	-0.7°C

¹Indicates a station's Period of Record does not cover the period of 1981-2010 but is five or more years. In these cases, the departures from normal values were calculated with normals derived from data spanning the length of the station's Period of Record.

M = missing data (Monthly statistics are reported as ' M' if more than 4 days of data are missing).

Table 5. Seasonal and annual temperature and precipitation rankings for 2014 over 120 years for the Eastern Piedmont (NOAA 2015).

	Climate Division 2 Rankings — Eastern Piedmont				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2014	105	18-T	78-T	43	75-T
Precipitation-2014	59	18	79	48-T	50

1 = warmest/wettest year and 120 = coldest/driest year. T = tie between multiple years.

Precipitation Summary

Annual precipitation was below normal for the calendar year 2014 at Fredericksburg and Spotsylvania NMP (Table 6). The year was marked by generally above average precipitation during the first half of the year, with the exception of a dry March, and a relatively dry second half. Overall, 2014 had a normal to above average number of days with heavy rain (greater than 1.0 in [25 mm]) as well as a normal to above average number of days with extreme rain (greater than 2.0 in (51 mm)) for the Louisa and Fredericksburg weather stations, respectively (Table 6).

Although it was a slightly drier year than normal, the number of days with measurable snow was above normal (8 compared to a normal of 6 at Louisa and 12 compared to normal of 2 at Piedmont), and the annual snowfall was 6.6 in to a substantial 33.2 in (16.7 cm to 84.3 cm) above normal at Louisa and Piedmont, respectively. (Table 6).

The first month was slightly drier than average, with stations tallying precipitation between 82-101 percent of normal (Table 9). February was moister with precipitation ranging from 73 to 120 percent of normal (Table 9). A notable dry spell occurred during this month from Feb 7-19, a 13 day period without measurable precipitation (Table 7). March was the driest month of the winter, with liquid equivalent amounts ranging from 2.18 to 3.40 in (55 to 86 mm). The first three months of the year were the 59th wettest for the Eastern Piedmont, essentially at the long-term mean (Table 5; 60 is the mid-point).

The spring months were noticeably wetter for Fredericksburg and Spotsylvania NMP, especially April and May (Figure 4, Tables 8 and 9). April was very wet with precipitation ranging from 161 to 186 percent of normal (Table 9). In fact, the wettest day of the year occurred on April 30th with 2.30 in (58 mm) (Table 7). May precipitation amounts were highly variable, ranging from 3.66 to as much as 7.57 in. (93 to 192 mm, Table 8). Overall, the spring months (April, May, and June) ranked 18th wettest in 120 years of records for the Eastern Piedmont (Table 5).

The summer had moderately dry weather during July, near normal precipitation in August, and very dry conditions in September such that the summer as a whole ranked as the 42nd driest since records began in 1895 (Table 5). The second longest dry spell of the year occurred during this season from September 15-24 (Table 7). In addition, another one of the wettest days of 2014 was recorded during the summer months with 2.04 in. (52 mm) falling on August 21st (Table 7). Louisa tallied 3.91 in (99 mm) during August, 109 percent above average (Tables 8 and 9).

The final three months of the year saw precipitation amounts closer to normal, though still below the long-term average with 0.2 (5mm) to 1.9 in (46mm) less than normal precipitation (Table 6). October's precipitation total ranged from 2.50 in to 4.33 in (64 mm to 110 mm, Table 8). November was another very dry month, with precipitation ranging from 52 to 71 percent of normal, and December was relatively average (Table 9).

Table 6. Status of 2014 precipitation indicators compared to the 30-year normal (1981–2010) and the station period of record at the Louisa (LOUV2) and Piedmont Research Station (ORGV2) weather observing stations.

Precipitation Indicator	Louisa, VA 2014	Louisa, VA 1981–2010	Louisa, VA 1916-2013 Mean (min – max)	Piedmont Research Station, VA 2014	Piedmont Research Station, VA 1981-2010	Piedmont Research Station, VA 1947-2013 Mean (min – max)
Annual Precipitation	40.4 in 1,026 mm	44.2 in 1,123 mm	42.4 (21.6 – 71.6) in 1,077 (549 – 1,819) mm	43.7 in 1,110 mm	42.6 in 1,082 mm	41.8 (30.4 – 63.5) in 1,062 (772 – 1,613) mm
Autumn (Oct, Nov, Dec) Precipitation	9.1 in 231 mm	10.9 in 277 mm	9.9 (2.1 – 21.7) in 251 (53 – 551) mm	10.0 in 254 mm	10.2 in 259 mm	10.0 (3.4 – 20.5) in 254 (86 – 521) mm
Heavy Precipitation Days (days with ≥1.0 in [25 mm] rain)	13	12	NA	8	3	NA
Extreme Precipitation Days (days with ≥2.0 in [51 mm] rain)	2	2	2 (0 – 7)	3	0	2 (0 – 6)
Micro-drought (periods of 7+ days without rain)	9	8	NA	11	11	NA
Annual Snowfall	24.3 in 61.7 cm	17.7 in 45.0 cm	17.8 (0 – 59.0) in 45.2 (0 – 149.9) cm	37.4 in 95.0 cm	4.2 in 10.7 cm	19.9 (3.0 – 63.3) in 50.5 (7.6 – 160.8) cm
Measurable Snow Days (days with ≥0.1 in [0.3 cm] snow)	8	6	NA	12	2	NA
Moderate Snow Days (days with ≥3.0 in [7.6 cm] snow)	3	2	NA	3	1	NA
Heavy Snow Days (days with ≥5.0 in [12.7 cm] snow)	1	1	NA	2	0	NA

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2014 from weather observing stations at Fredericksburg Sewage Plant (FEDV2) and Louisa (LOUV2).

Wettest Days in 2014	Dry Spells in 2014
Apr. 30: 2.30 in (58 mm)	Feb. 7 – 19
May 16: 2.20 in (56 mm)	Sep. 15 – 24
Aug. 21: 2.04 in (52 mm)	Jul. 11 – 20
May. 1: 1.90 in (48 mm)	Oct. 24 – Nov. 1
Aug. 12: 1.90 in (48 mm)	Apr. 17 – 25

Table 8. Summary of 2014 monthly total rainfall for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Corbin	CORV2	2.7 in	3.7 in	2.5 in	6.1 in	4.8 in	3.6 in	3.9 in	2.9 in	2.3 in	3.3 in	2.4 in	3.2 in	41.1 in
		69 mm	93 mm	62 mm	154 mm	121 mm	91 mm	98 mm	73 mm	59 mm	84 mm	60 mm	81 mm	1044 mm
Fredericksburg Sewage Plant	FEDV2	2.2 in	1.8 in	2.2 in	5.4 in	7.0 in	2. in	1.2 in	3.5 in	0.9 in	2.5 in	2.0 in	3.1 in	34.5 in
		56 mm	46 mm	55 mm	137 mm	178 mm	70 mm	30 mm	89 mm	23 mm	64 mm	50 mm	77 mm	876 mm
Louisa	LOUV2	2.5 in	3.2 in	2.6 in	6.0 in	3.7 in	4.6 in	3.5 in	3.9 in	1.3 in	3.4 in	2.5 in	3.2 in	40.4 in
		64 mm	80 mm	67 mm	153 mm	93 mm	117 mm	89 mm	99 mm	34 mm	86 mm	63 mm	81 mm	1026 mm
Fredericksburg Battlefield	NAD83	2.0 in	2.2 in	3.4 in	6.3 in	4.2 in	2.5 in	3.0 in	2.6 in	0.9 in	2.5 in	1.9 in	2.7 in	34.3 in
		51 mm	57 mm	86 mm	161 mm	107 mm	64 mm	77 mm	67 mm	22 mm	64 mm	48mm	68 mm	871 mm
Piedmont Research Station	ORGV2	2.8 in	3.2 in	3.1 in	6.2 in	7.6 in	4.1 in	3.2 in	2.4 in	1.2 in	4.3 in	2.7 in	2.9 in	43.7 in
		71 mm	82 mm	78 mm	158 mm	192 mm	104 mm	81 mm	60 mm	31 mm	110 mm	69 mm	74 mm	1110 mm

M = missing data (Monthly statistics are reported as ' M' if more than 4 days of data are missing). An exception was made for FEDV2 (September) and CORV2 (November). Five days of data are missing, but they were determined to have no substantial impact on the monthly totals.

Table 9. Summary of 2014 percent of normal rainfall based on the 30-year normal (1981–2010) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Corbin	CORV2	86	120	61	186	120	96	97	85	56	89	65	96	95
Fredericksburg Sewage Plant ¹	FEDV2	76	73	55	161	172	70	26	104	21	75	52	96	80
Louisa	LOUV2	82	108	69	186	88	128	75	109	32	93	60	101	91
Piedmont Research Station	ORGV2	101	117	88	183	183	98	68	73	31	127	71	95	102

¹Indicates a station's Period of Record does not cover the period of 1981-2010 but is more than five years. In these cases, the departure from normal values was calculated with normals derived from data spanning the length of the station's Period of Record.

M = missing data (Monthly statistics are reported as ' M' if more than 4 days of data are missing).

Fredericksburg and Spotsylvania National Military Park
Departure from Average Monthly Minimum Temperature
2014 vs. 1981–2010

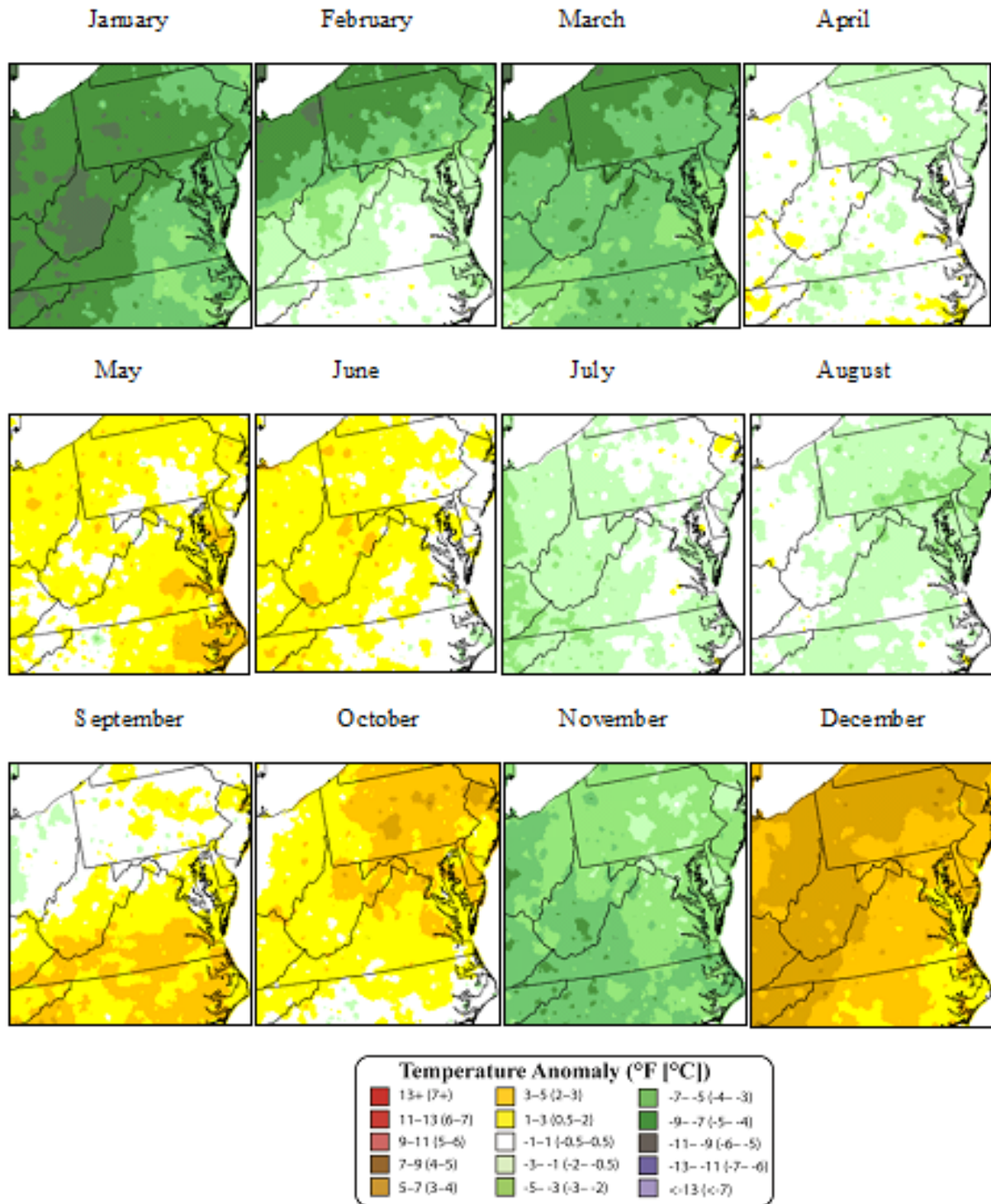


Figure 4. Maps showing percent of average monthly precipitation in 2014 compared to the 30-year normal (1981–2010).

Drought Status

There are a number of drought indices used to estimate the severity of drought in an area using algorithms that incorporate recent temperatures, rainfall, soil moisture, and other information (<http://www.drought.gov>). The main indices we report are the Palmer Drought Severity Index (PDSI) and the United States Drought Monitor (DM) – Drought Intensity Index. While both indices provide excellent summary information on broad-scale conditions, local conditions (such as at the park scale) may vary.

The PDSI is a soil moisture algorithm calibrated for relatively homogeneous regions and is calculated on a monthly basis using precipitation and temperature data, as well as the water content of the soil. The values vary between extremely moist (>4.0) and extreme drought (<-4.0) with “normal” values ranging between -1.9 and 1.9 . The long-term average is “zero”. Monthly PDSI values for Eastern Piedmont in 2014 are shown in Figure 5.

According to the PDSI, 2014 started off moderately wetter than normal with PDSI values at or above a 2.0. A dry June allowed the PDSI to come back down to near zero. For the remainder of the year, normal to slightly below normal precipitation was seen as the PDSI was slightly below zero. Comparing 2014 with the previous year, showed similar trends but seasonally reversed meaning the previous year started off near to slightly above normal and the latter half of the year was moderately wetter than normal which ultimately continued into 2014.

The DM – Drought Intensity Index is a synthesis of multiple indices (including the PDSI) and impacts, which represents a consensus of federal and academic scientists (NIDIS 2014). The DM produces a summary map of drought intensity for the nation and all states each week. It is on a scale ranging from abnormally dry (D0) to exceptional drought (D4). Mid-month (i.e., the second or third week) values for Virginia (Figure 6) and the Southeast (Figure 7) are shown for 2014.

Based on the DM, although parts of Virginia were abnormally dry during certain seasons, no droughts occurred in the state and droughts were relatively rare across the Southeast during 2014 (Figure 6 and Figure 7).

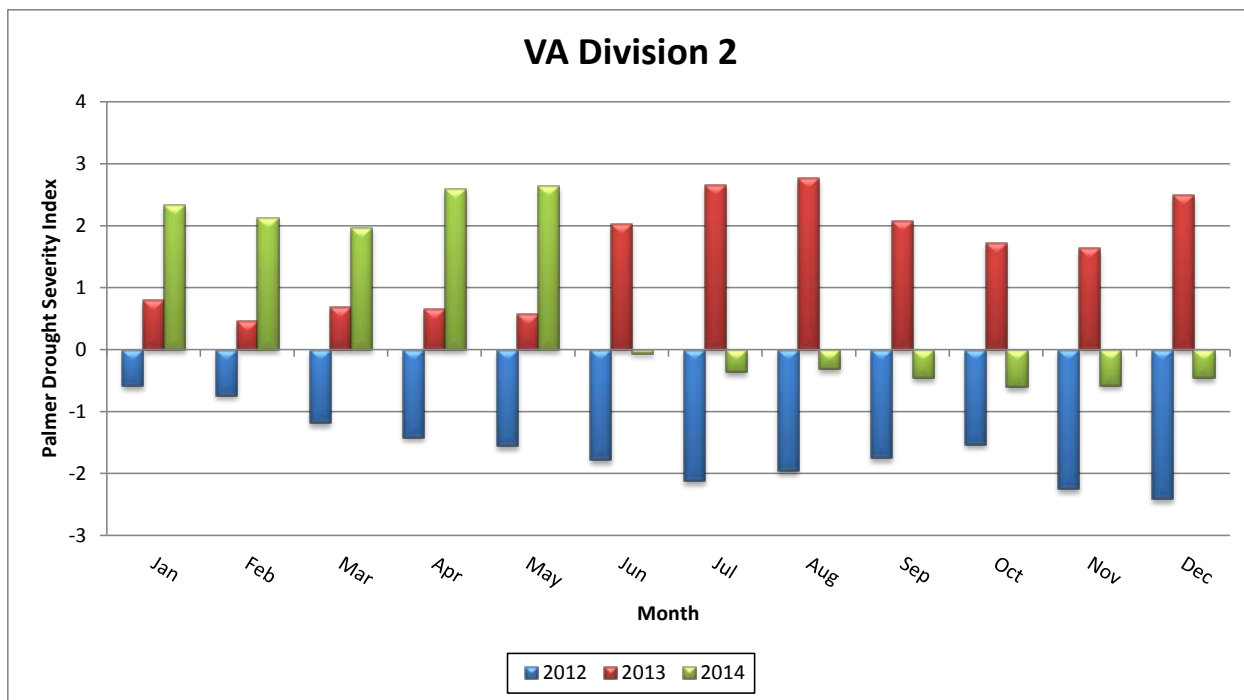


Figure 5. Palmer Drought Severity Index (PDSI) for the Eastern Piedmont, 2012–2014.

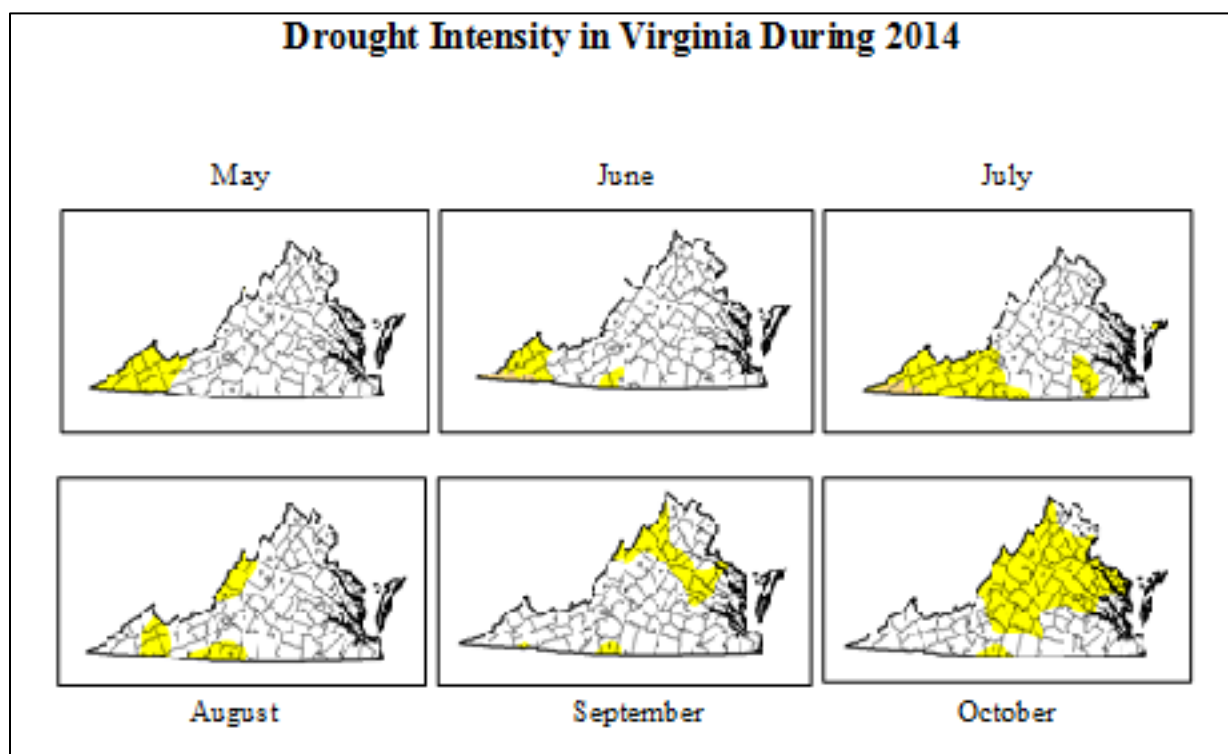


Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Virginia in 2014.

Drought Intensity for the Southeast during 2014

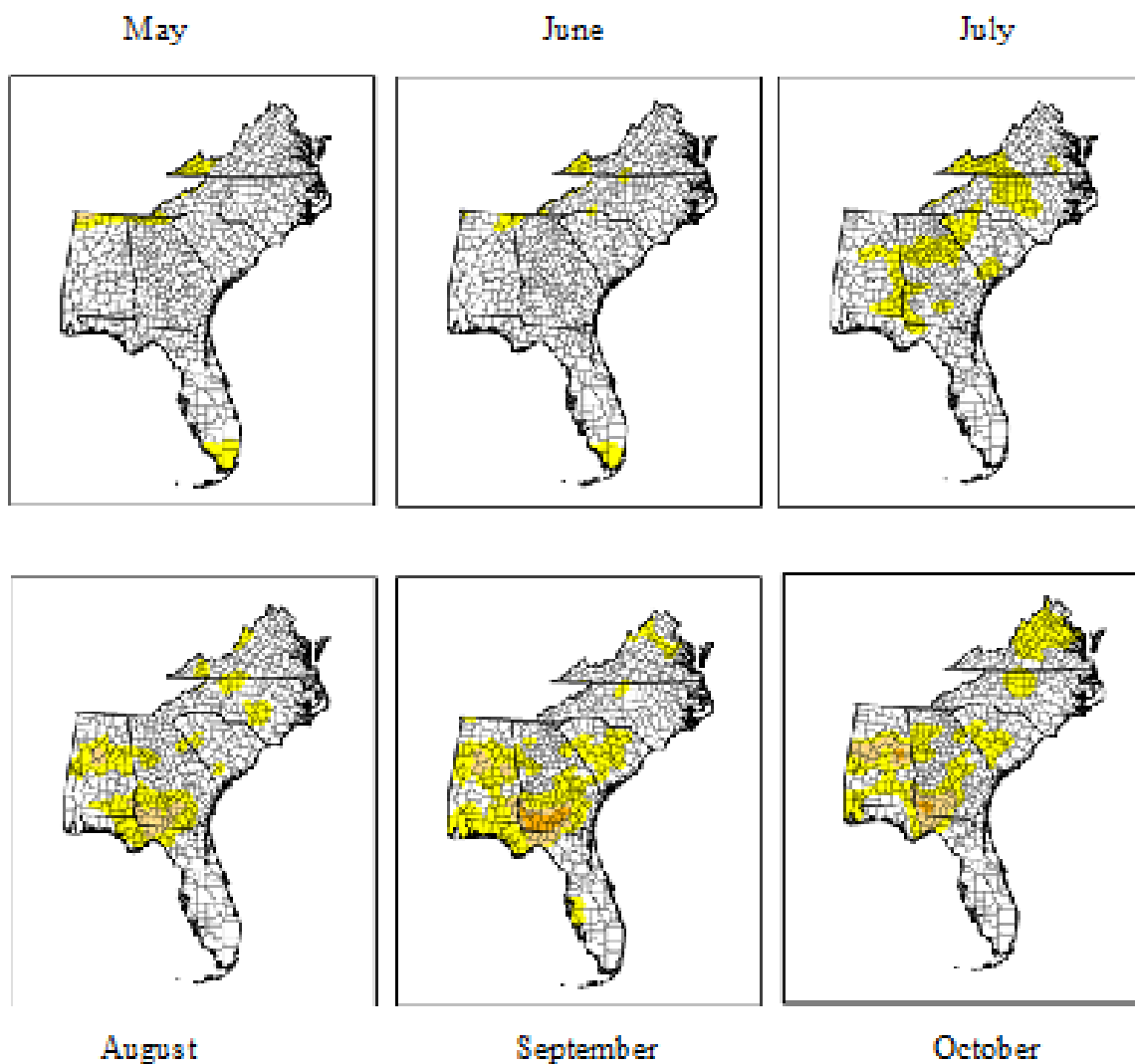


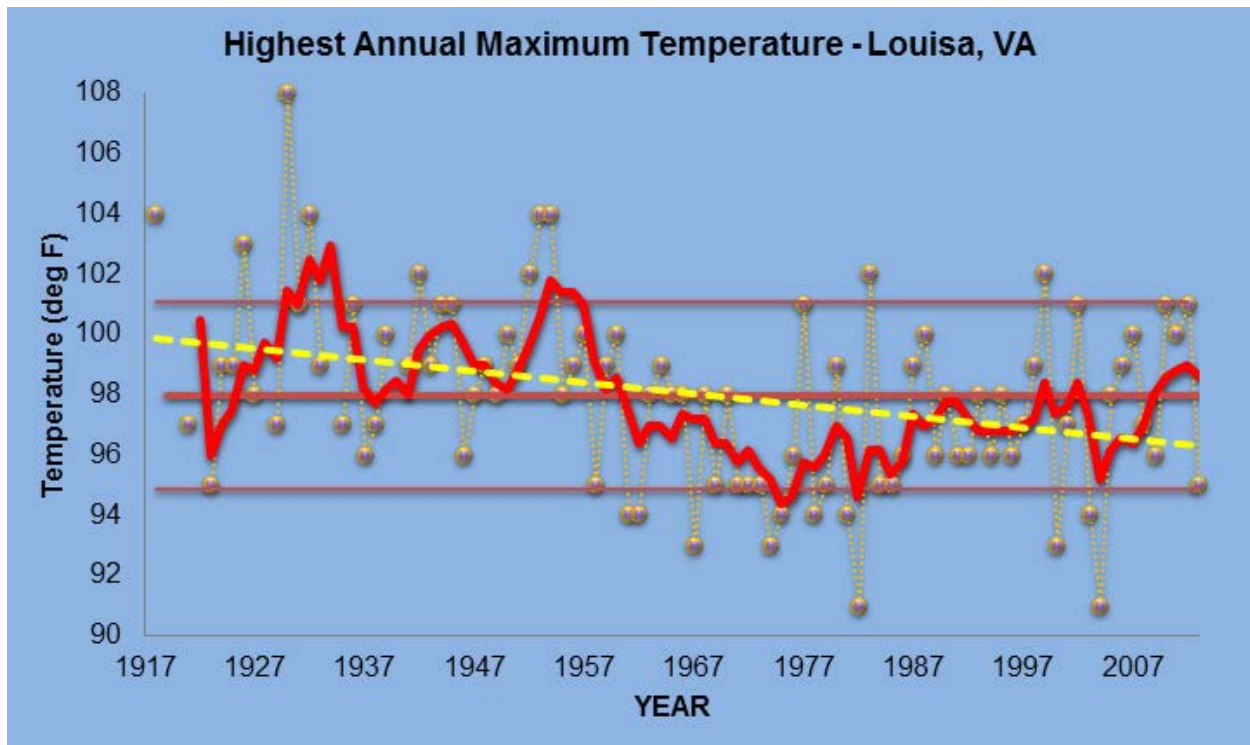
Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Southeast in 2014.

References

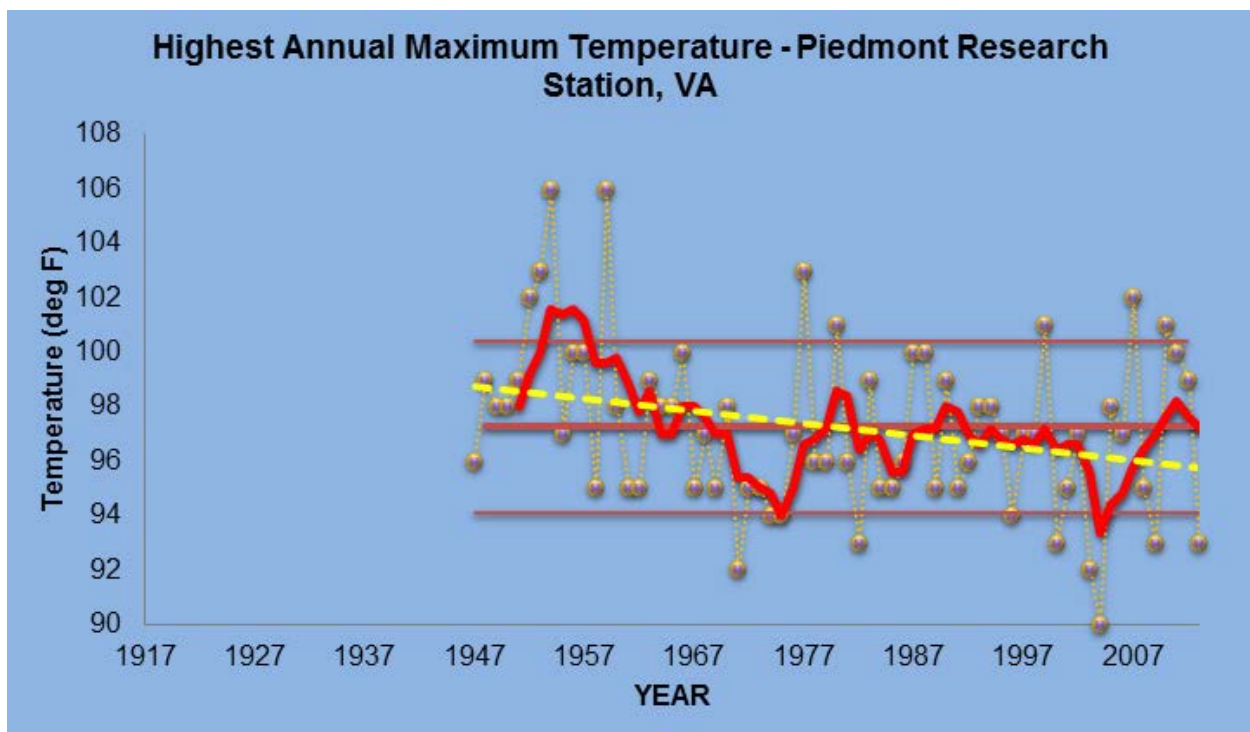
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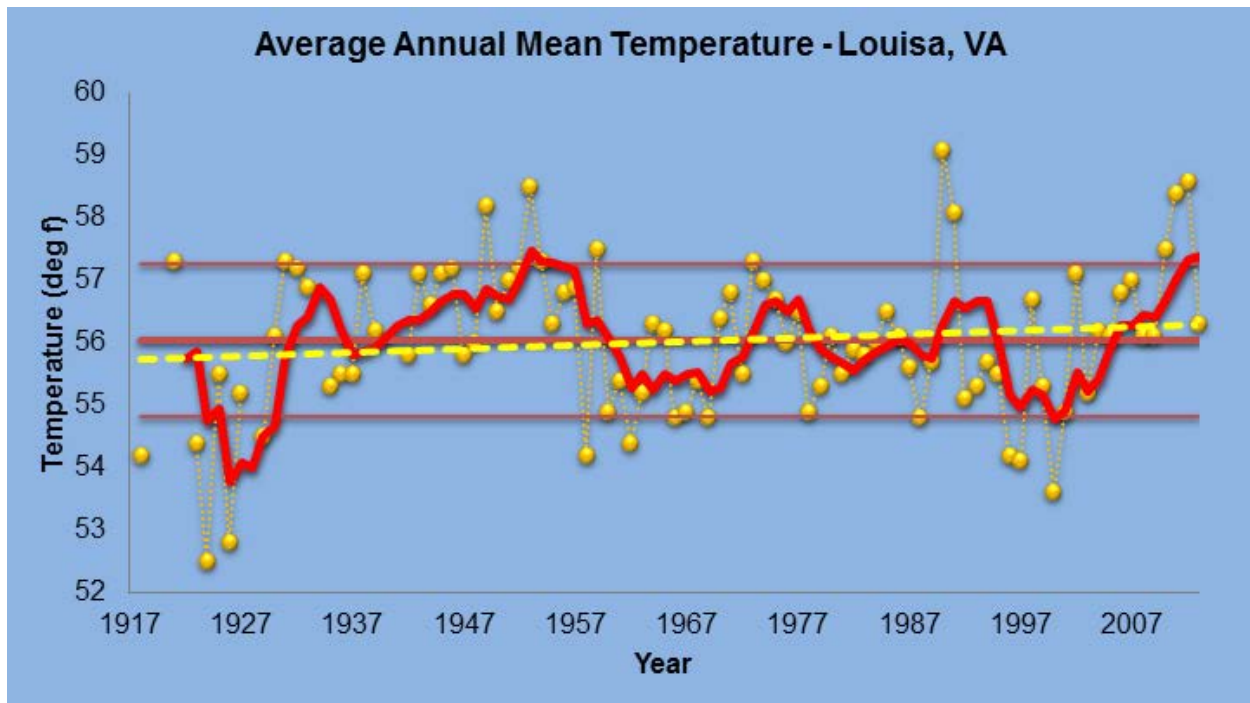
Appendix

Below are graphs illustrating long-term trend analysis for multiple climate indicators at the Louisa and Piedmont weather stations. For temperature indicators, yearly values are marked by the dotted orange line, the 5-year moving average is indicated by the thick red line, the long-term linear trend is shown by the dotted yellow line, the long-term mean is marked by the thick orange line, and the first standard deviation above and below the long-term mean are delineated by the solid orange lines. Similarly for precipitation indicators, yearly values are marked by the dotted teal line, the 5-year moving average is indicated by the thick green line, the long-term linear trend is shown by the dotted yellow line, and the long-term mean is delineated by the thick light blue line.

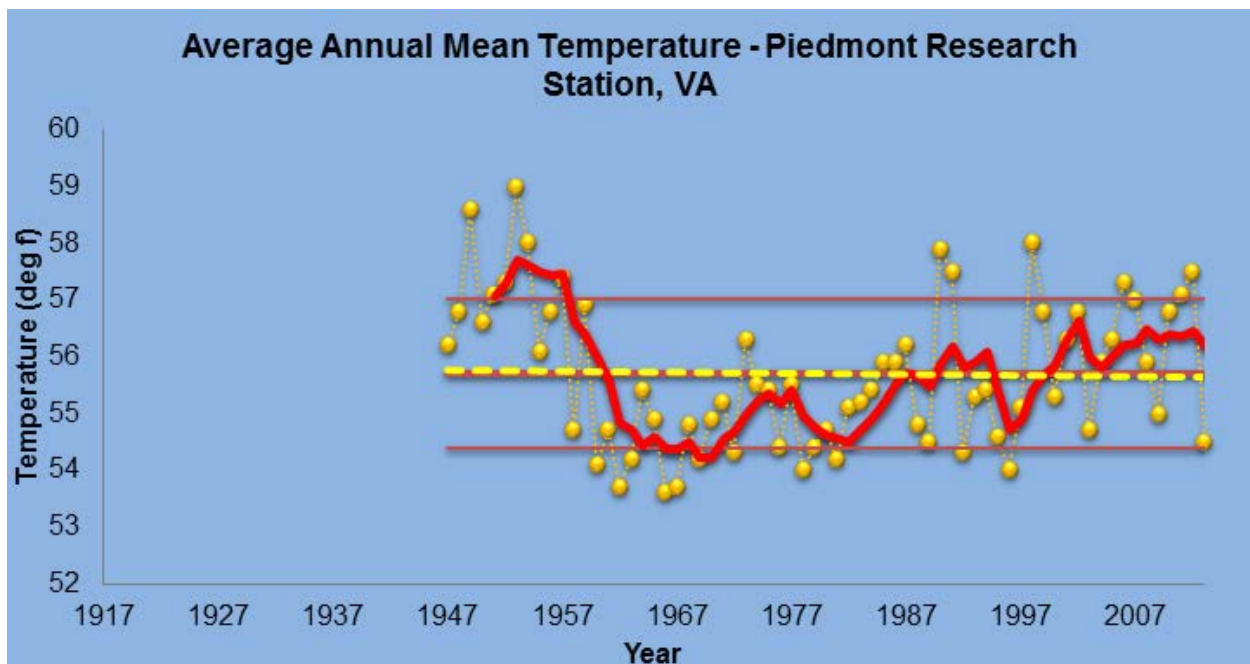


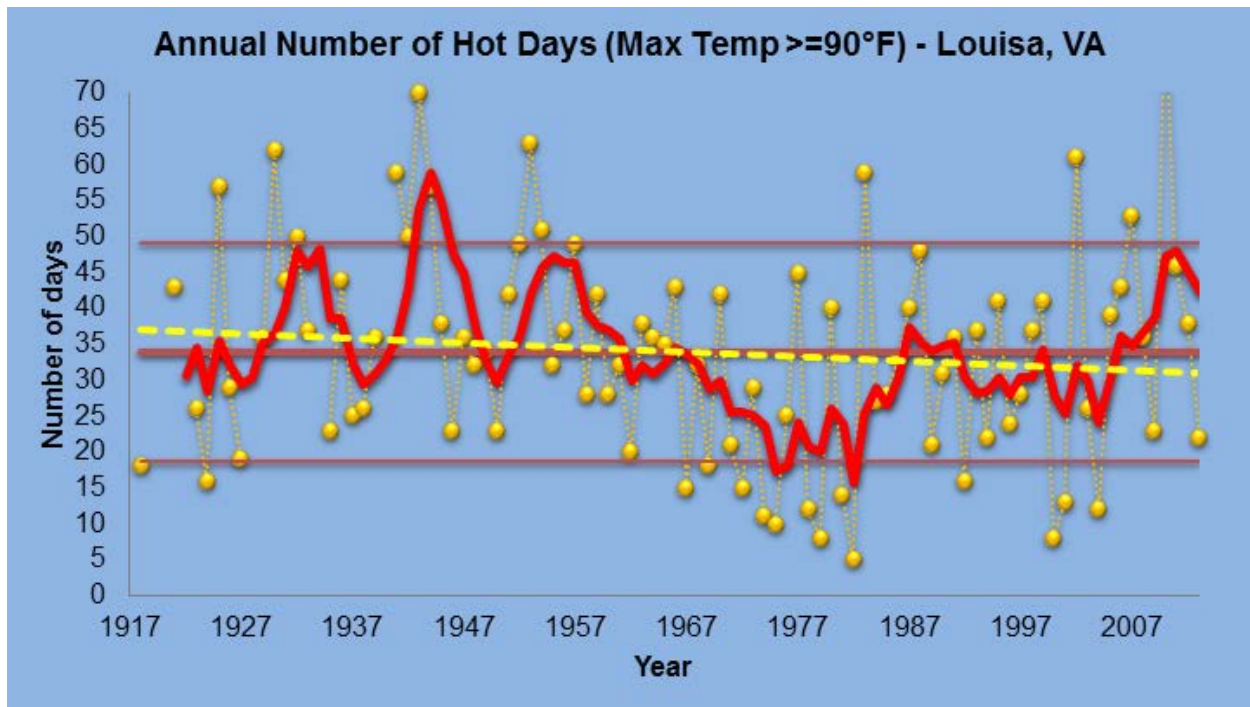
Annual Maximum Trends: The trends are modest (less than 2°F per 50 years) and both show a decrease. The average annual maximum temperature is 97.9°F (± 1 SD ranges from 94.9-101.1°F) at Louisa and 97.3°F (± 1 SD ranges from 94.1-100.4°F) at Piedmont Research Station (Table 2).



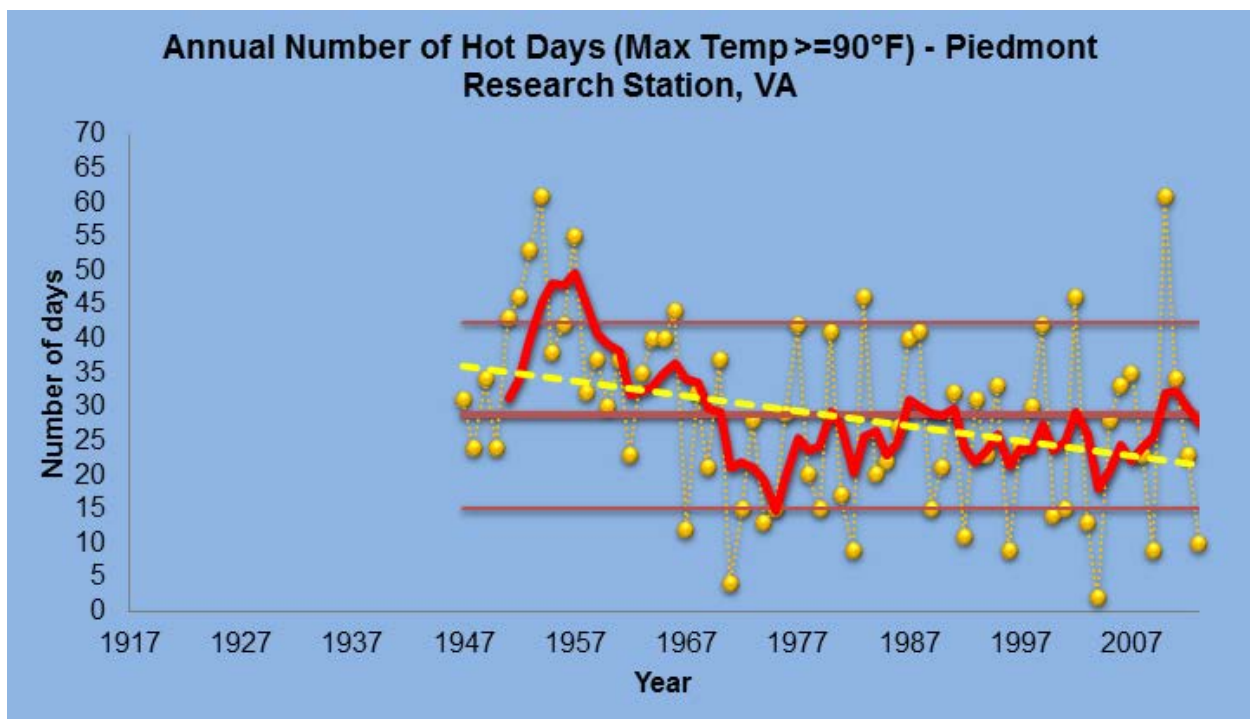


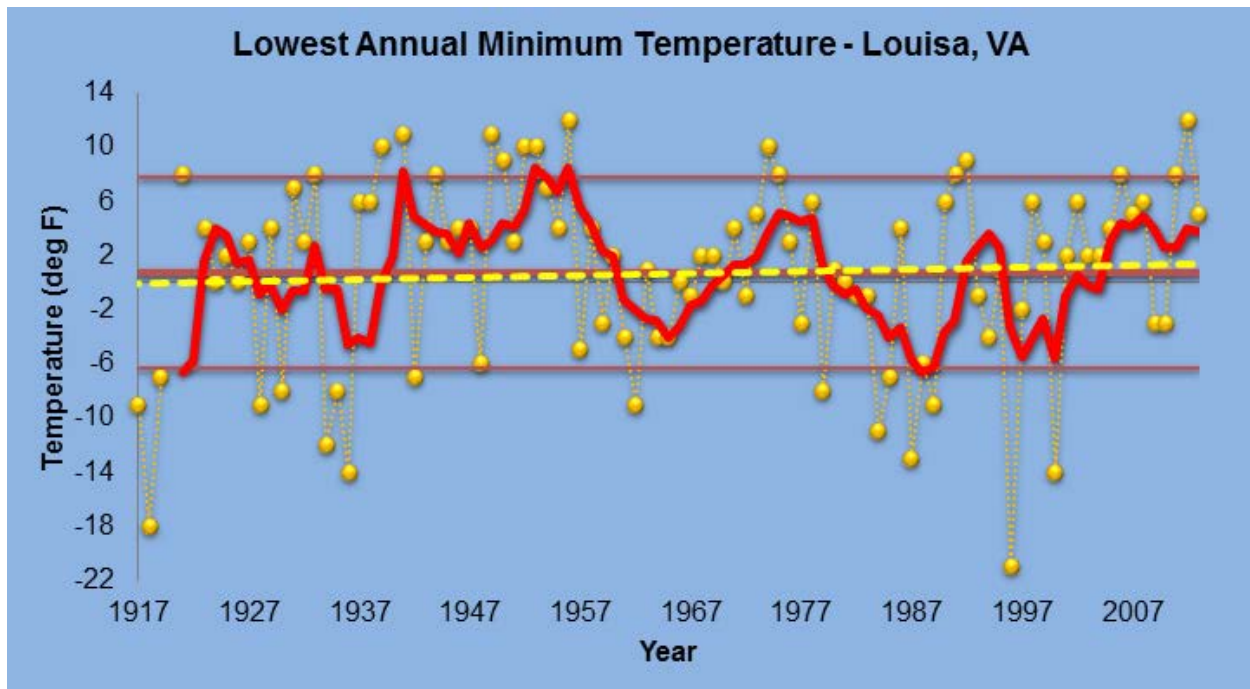
Annual Mean Trends: The annual temperature (average of maximum and minimum) shows a slight rise (about 1°F over POR at Louisa), consistent with long-term warming. The Piedmont Research Station shows no trend for its shorter POR. The average annual mean temperature at Louisa is 56.0°F (± 1 SD ranges from 54.8-57.3°F) and 55.7°F (± 1 SD ranges from 54.4-57.0°F) at Piedmont Research Station (Table 2).



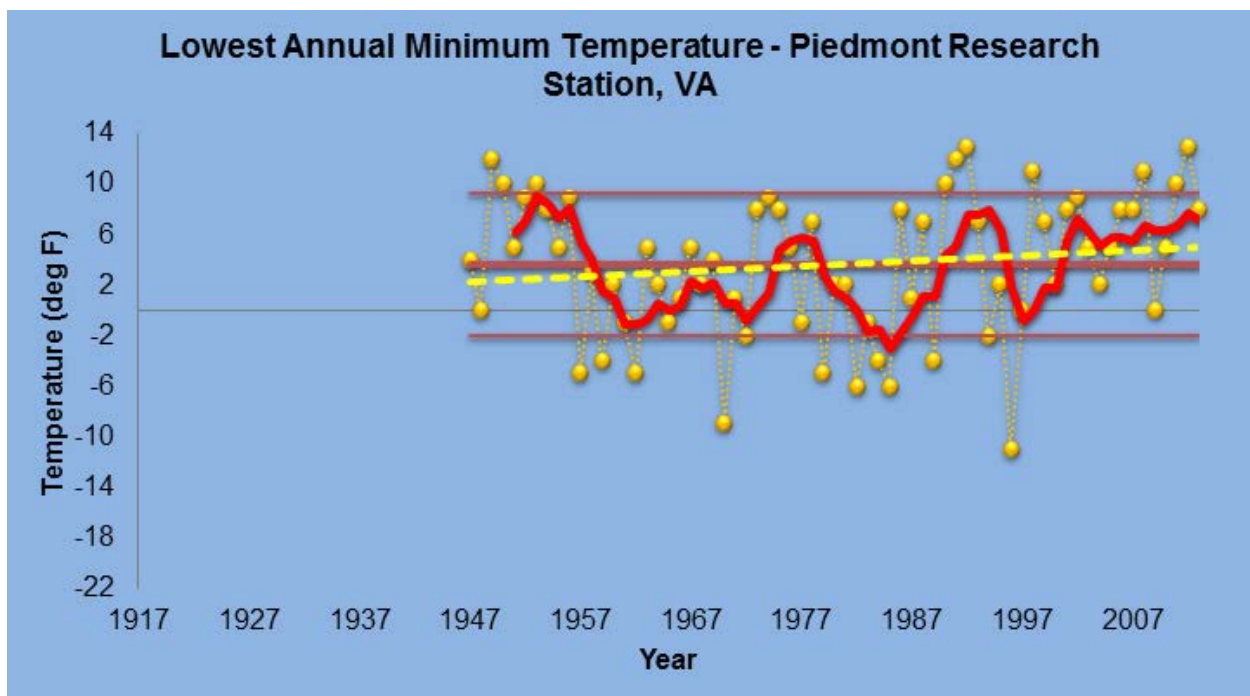


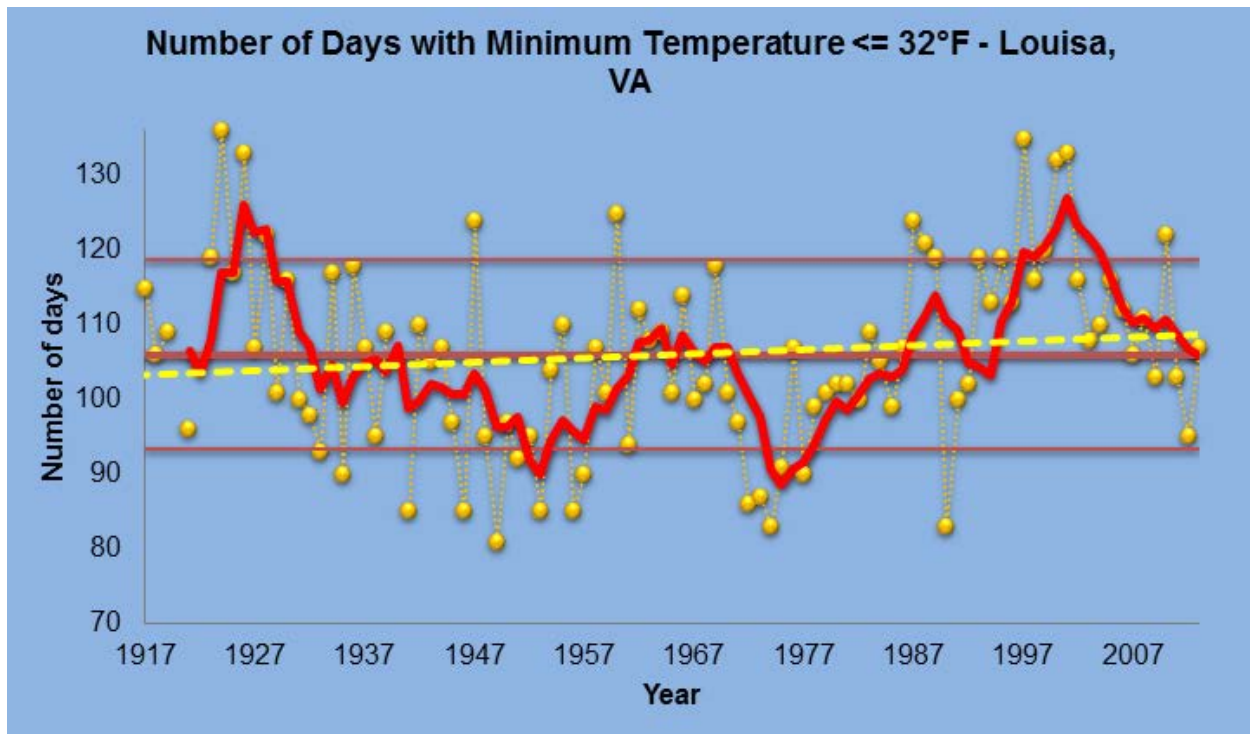
Annual Number of Hot Days: Both stations shows a decrease (about 5-10 days over the past ~50 years) with Louisa showing the least change in hot summer days. The average number of annual hot days is $34 (\pm 1\text{SD ranges from } 19-49)$ at Louisa and $29 (\pm 1\text{SD ranges from } 15-42)$ at Piedmont Research Station (Table 2).



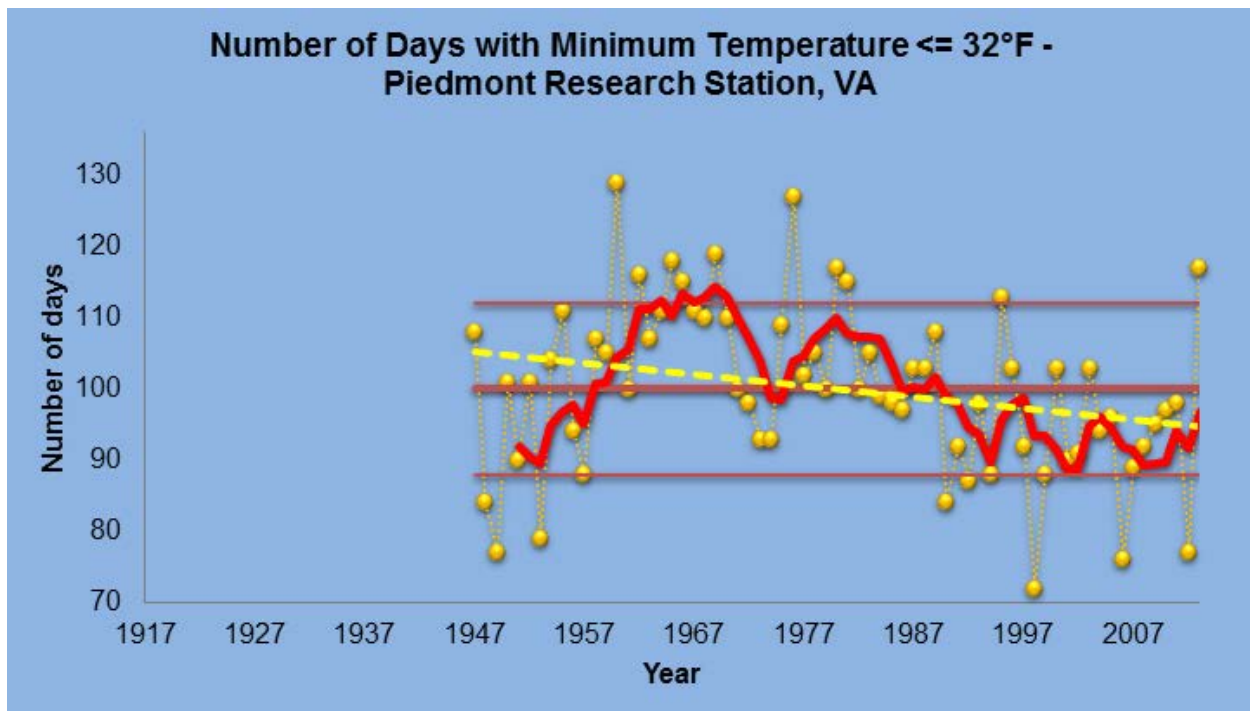


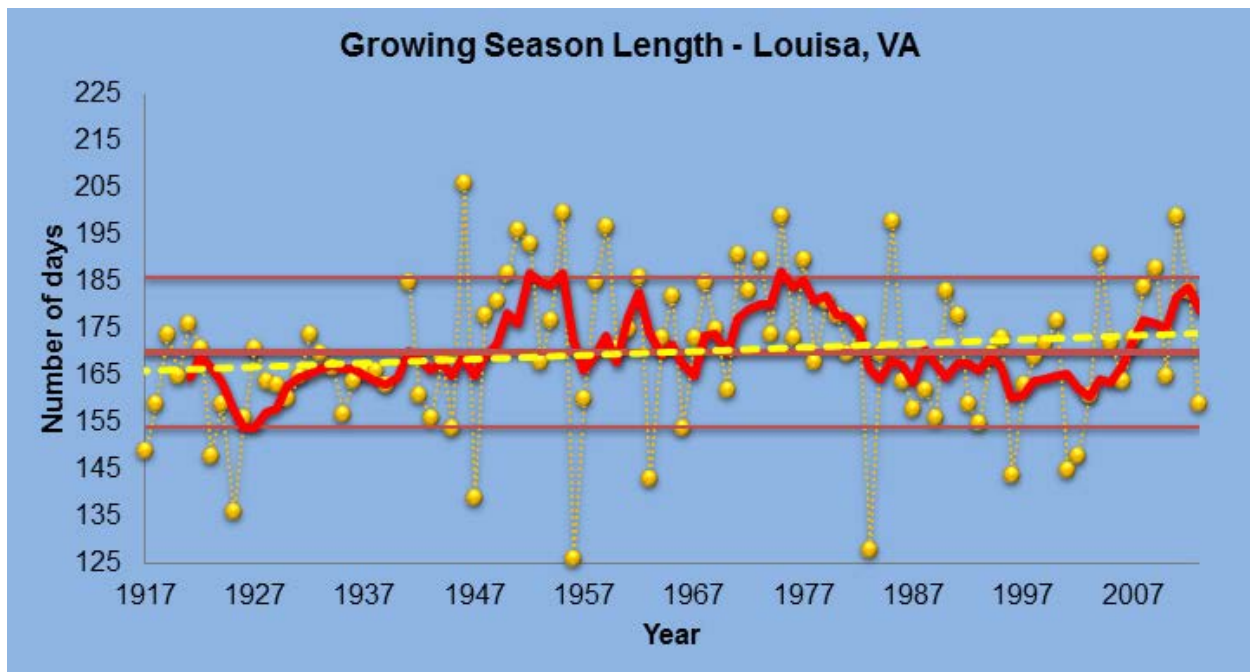
Annual Lowest Minimum Temperature: The slight upward trend (around 3°F over the course of the POR) at both stations explains part of the annual mean temperature rise. The average annual minimum temperature is 0.7°F (± 1 SD ranges from -6.3 to 7.8°F) at Louisa and 3.6°F (± 1 SD ranges from -2.0 to 9.3°F) at Piedmont Research Station (Table 2).



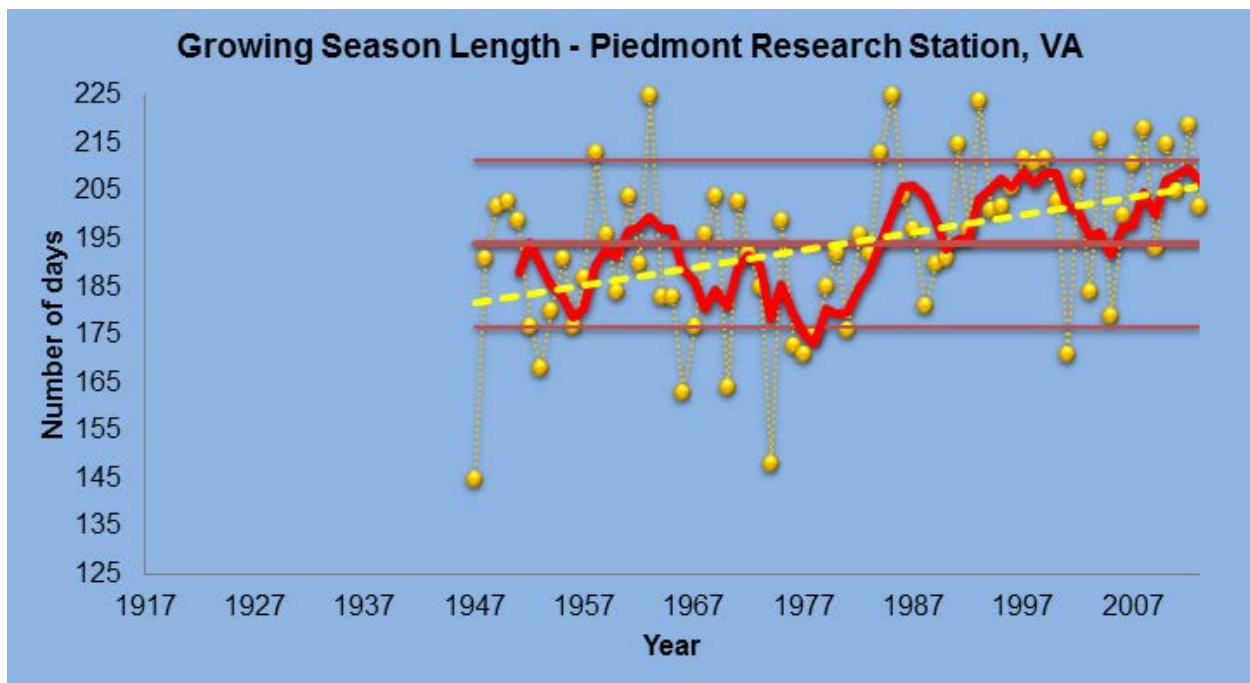


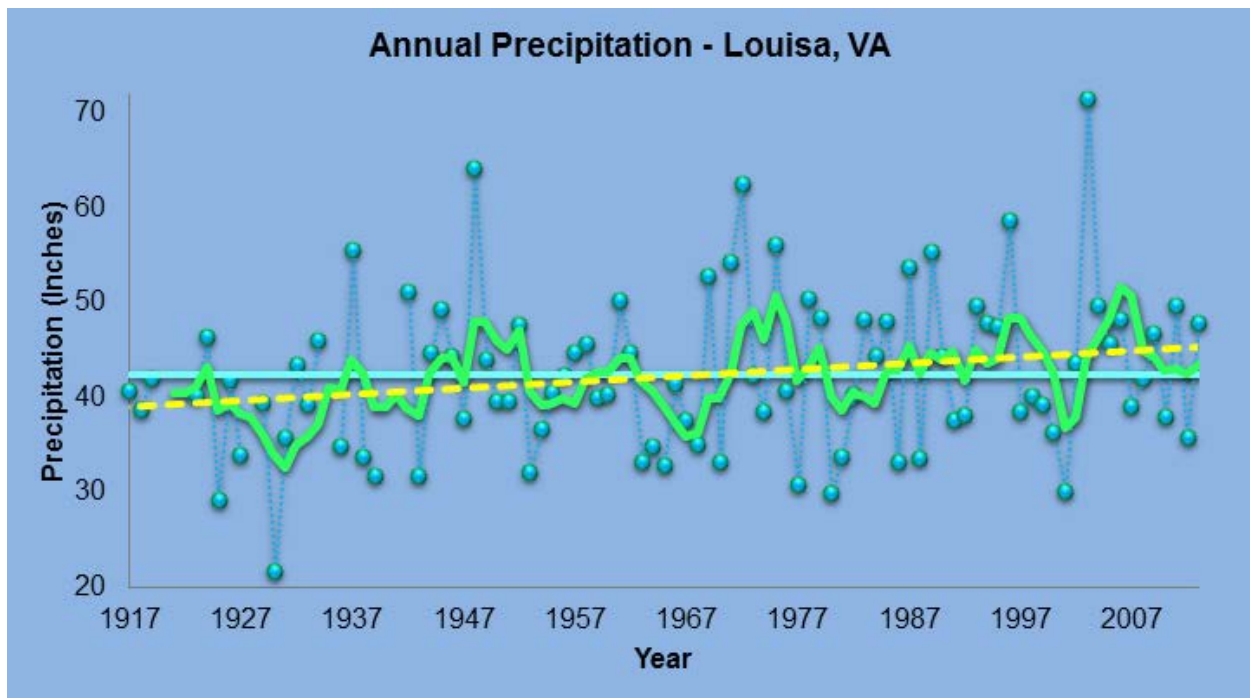
Annual Number of Days with Minimums at or below Freezing: The trend is opposite for this indicator between stations with Louisa showing a slight increase (5 days in 100 years) and Piedmont Research Station trending fewer (a decrease of 15 days in 70 years). The average number of nights is 106 (± 1 SD ranges from 93-119) at Louisa and 100 (± 1 SD ranges from 88-112) at Piedmont Research Station (Table 2).



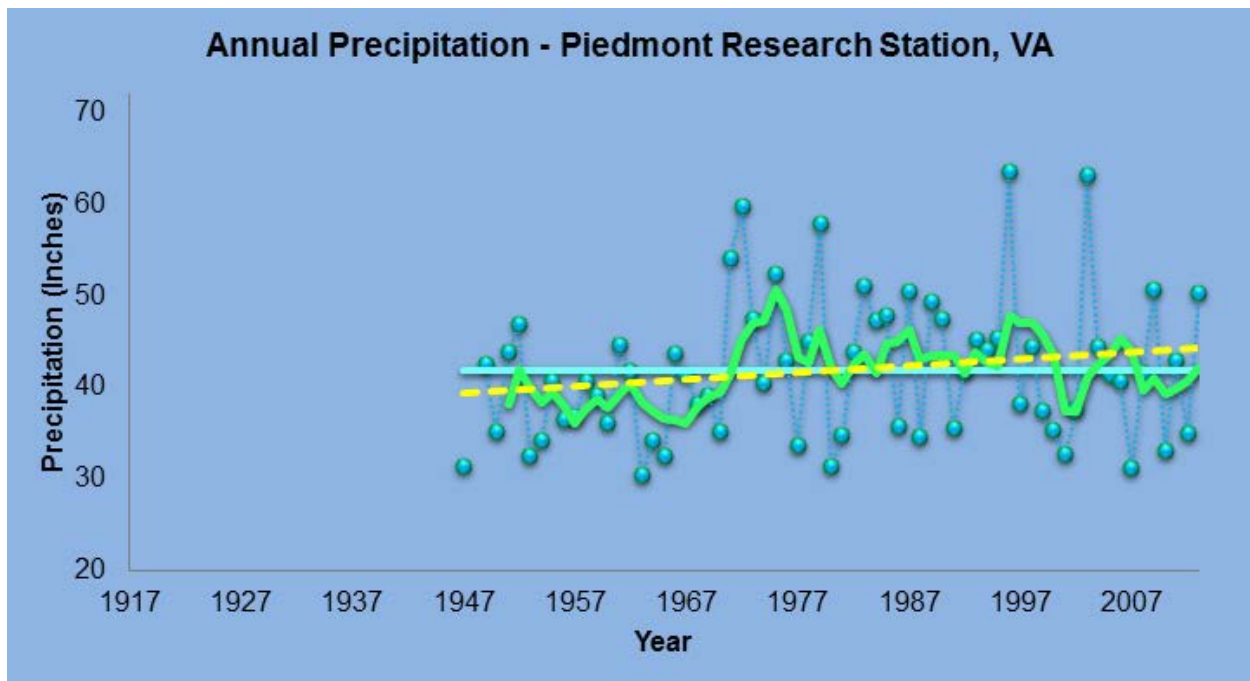


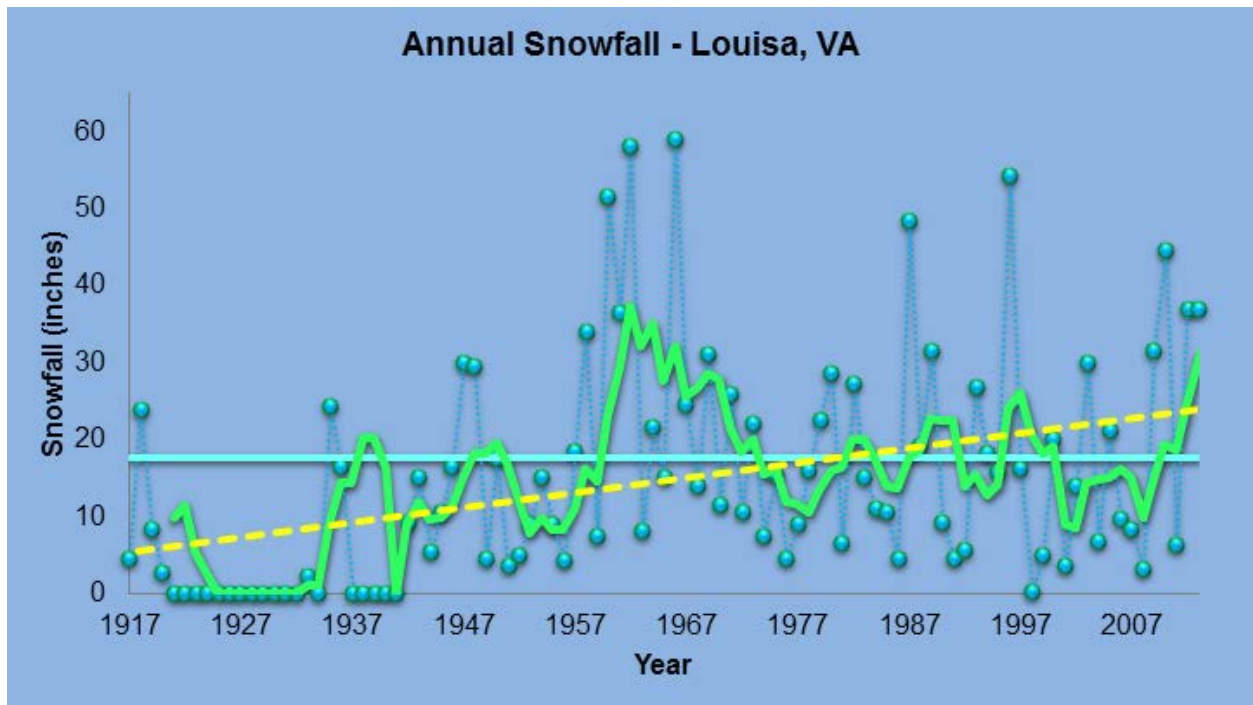
Growing Season Length Trends: Both stations show an increase in the length of the growing season with about a one to three week increase in the past 70 years. The average annual number of days in the growing season is 170 ($\pm 1SD$ ranges from 154-186) at Louisa and 194 ($\pm 1SD$ ranges from 176-211) at Piedmont Research Station (Table 2).



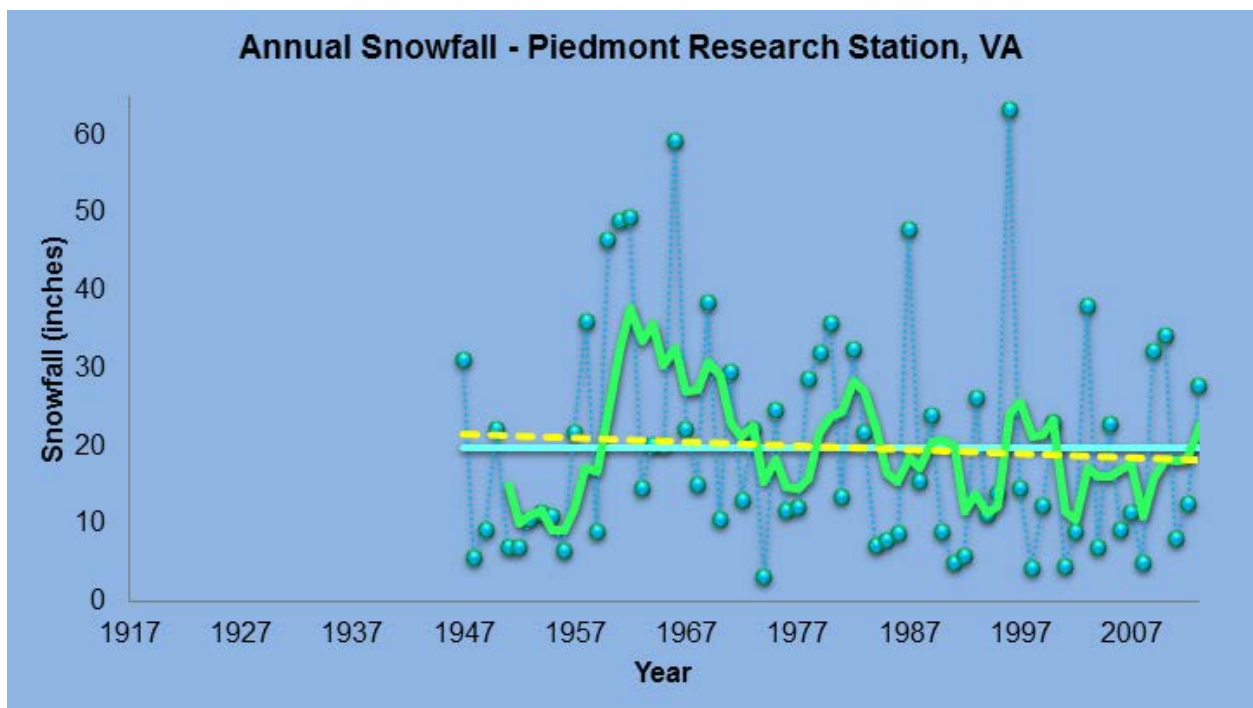


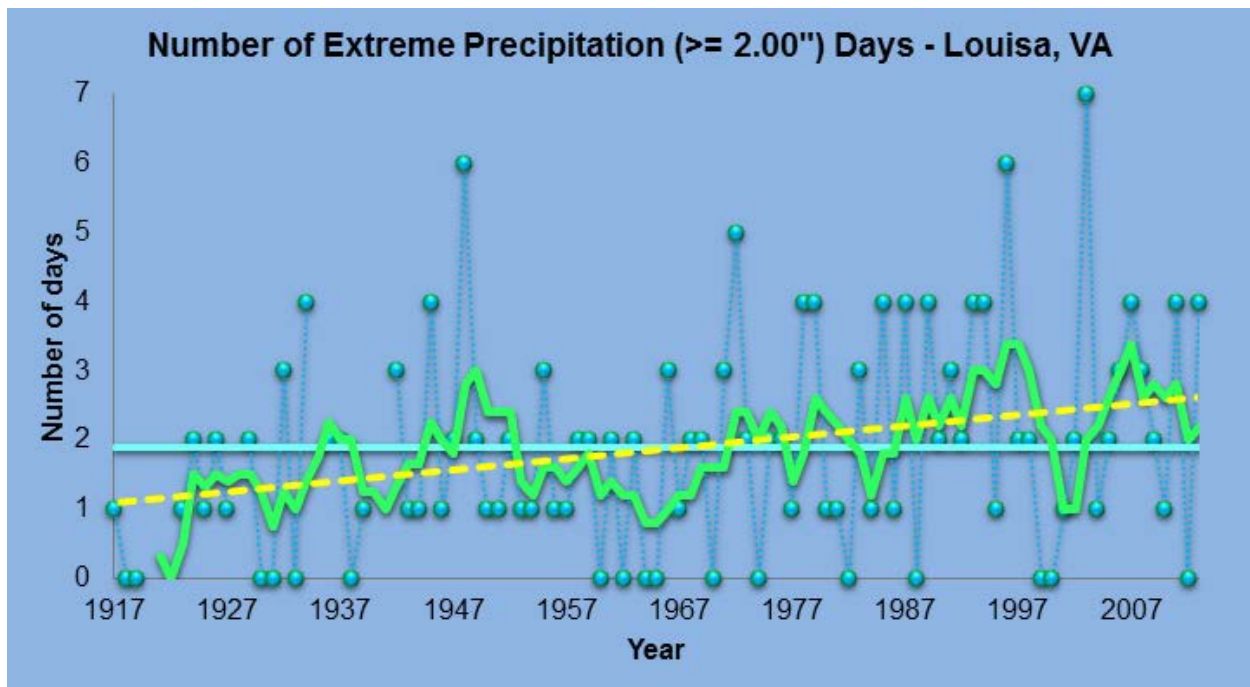
Annual Precipitation Trends: Both stations show a modest rise (approximately 3 in. over the past ~50 years) in annual precipitation. The average annual precipitation at Louisa is 42.4 in. (min of 21.6 in and max of 71.6 in) and 41.8 in (min of 30.4 in and max of 63.5 in) at Piedmont Research Station (Table 6).



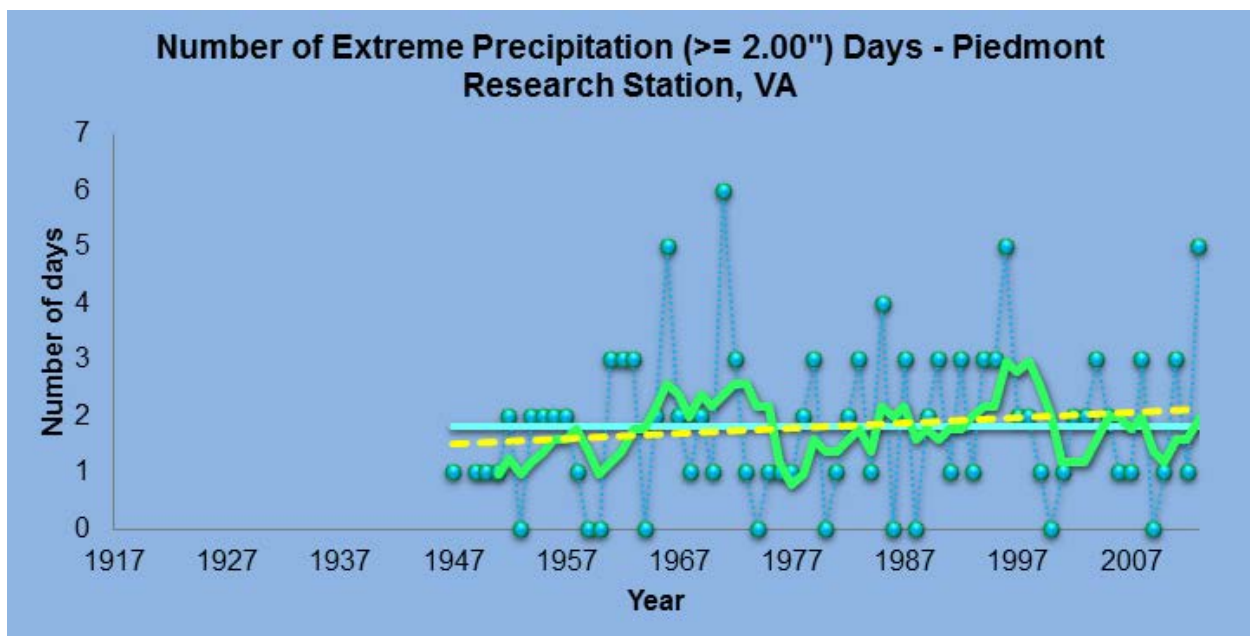


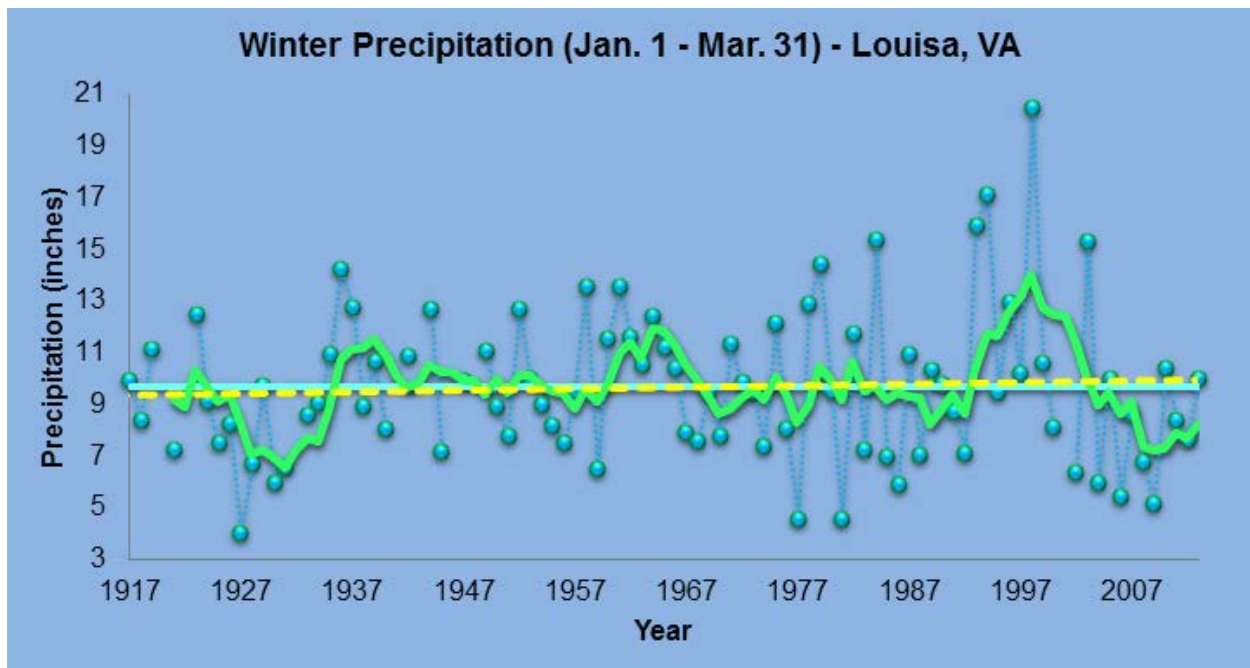
Annual Snowfall Trends: Piedmont Research Station shows a small decline, whereas Louisa displays a marked increase in annual snowfall, approximately a 60% rise. The average annual snowfall amount at Louisa is 17.8 in. (min of 0 in and max of 59.0 in) and 19.9 in (min of 3.0 in and max of 63.3 in) at Piedmont Research Station (Table 6).



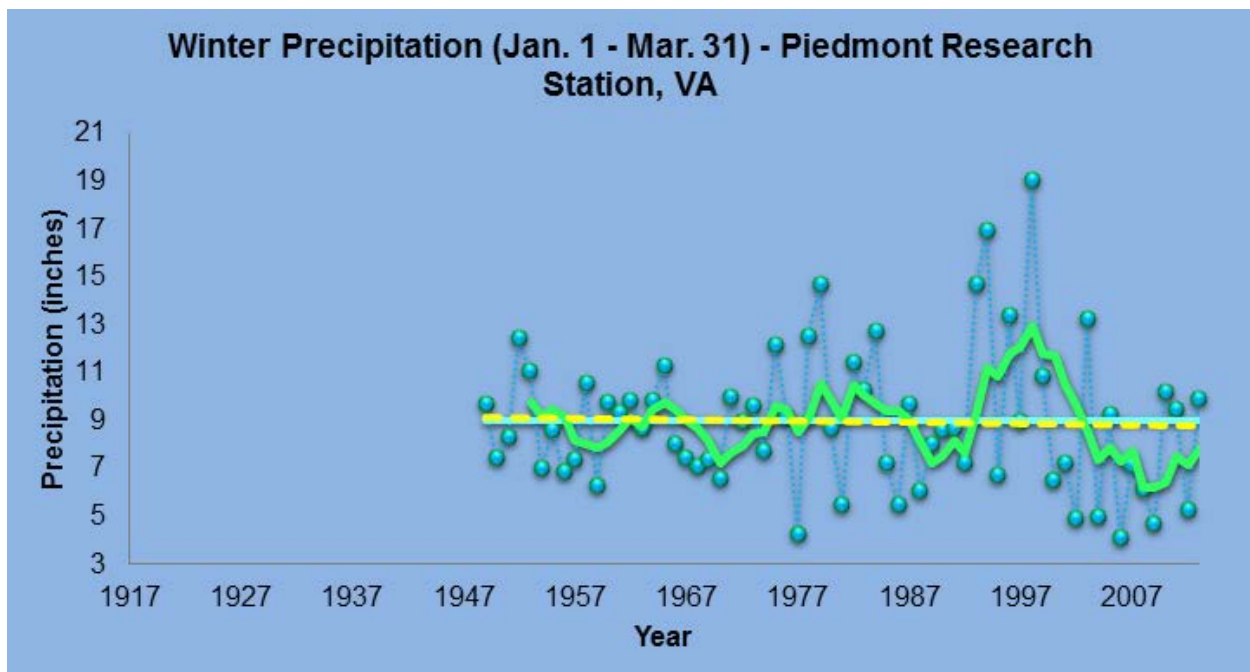


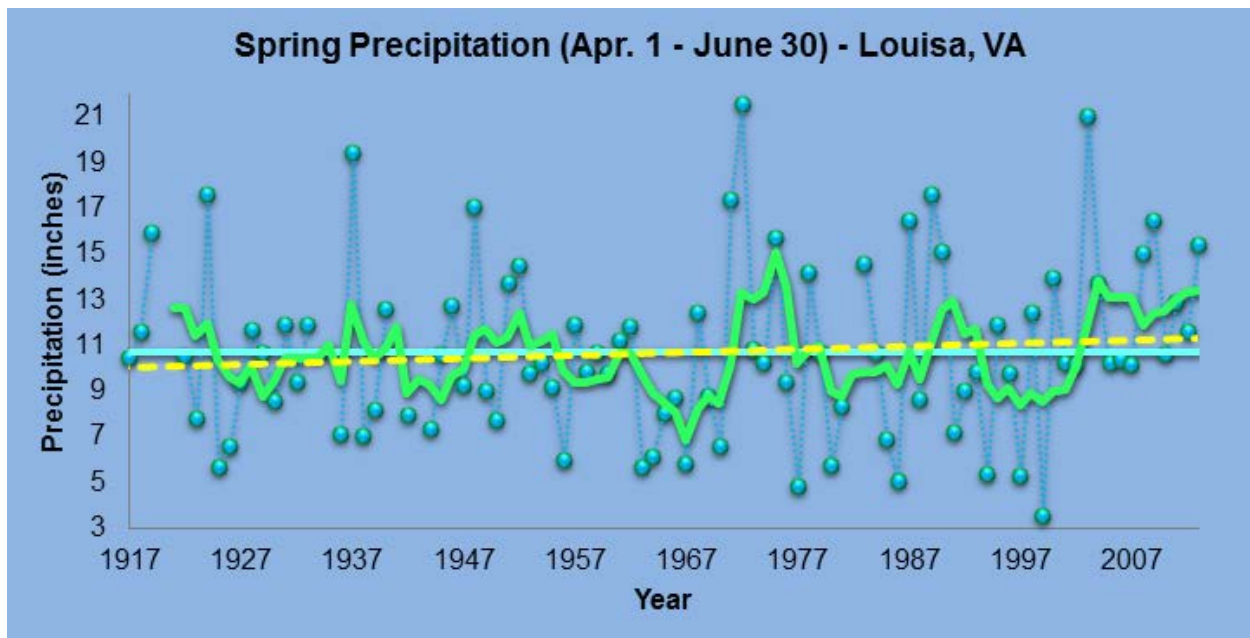
Annual Number of Extreme Precipitation Events: Louisa shows an increasing trend, whereas Piedmont Research Station displays a very small upward trend (about a day over the past ~70 years) in extreme precipitation days. The average number of days at Louisa is 2 (min of 0 and max of 7) and 2 (min of 0 and max of 6) at Piedmont Research Station (Table 6).



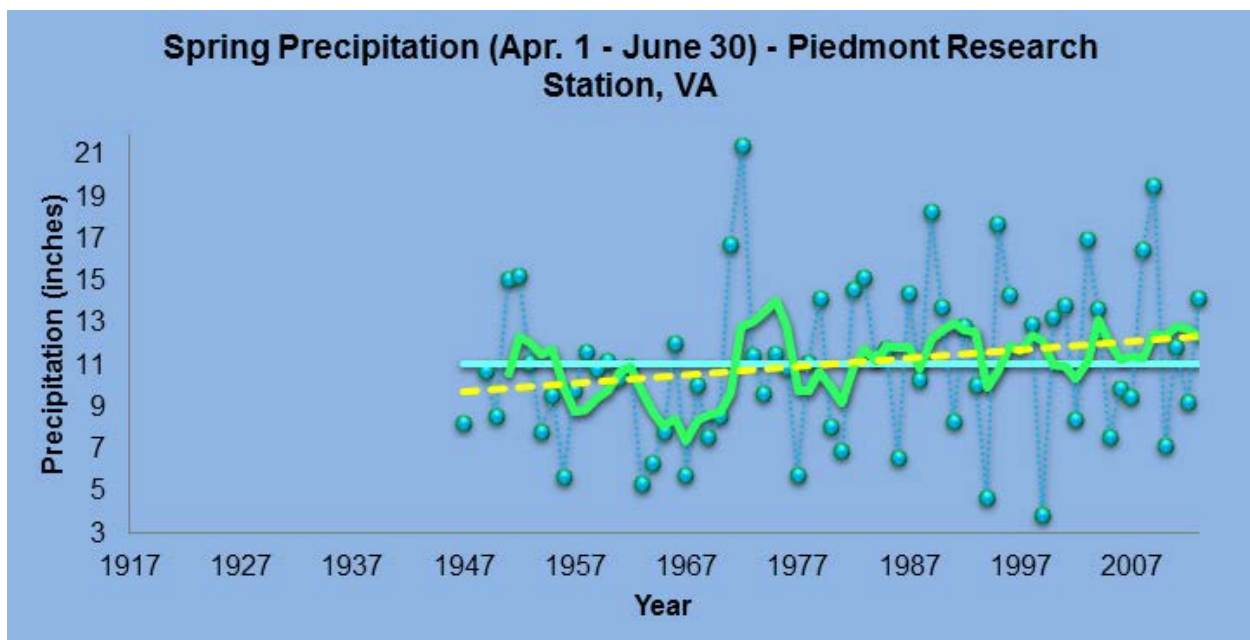


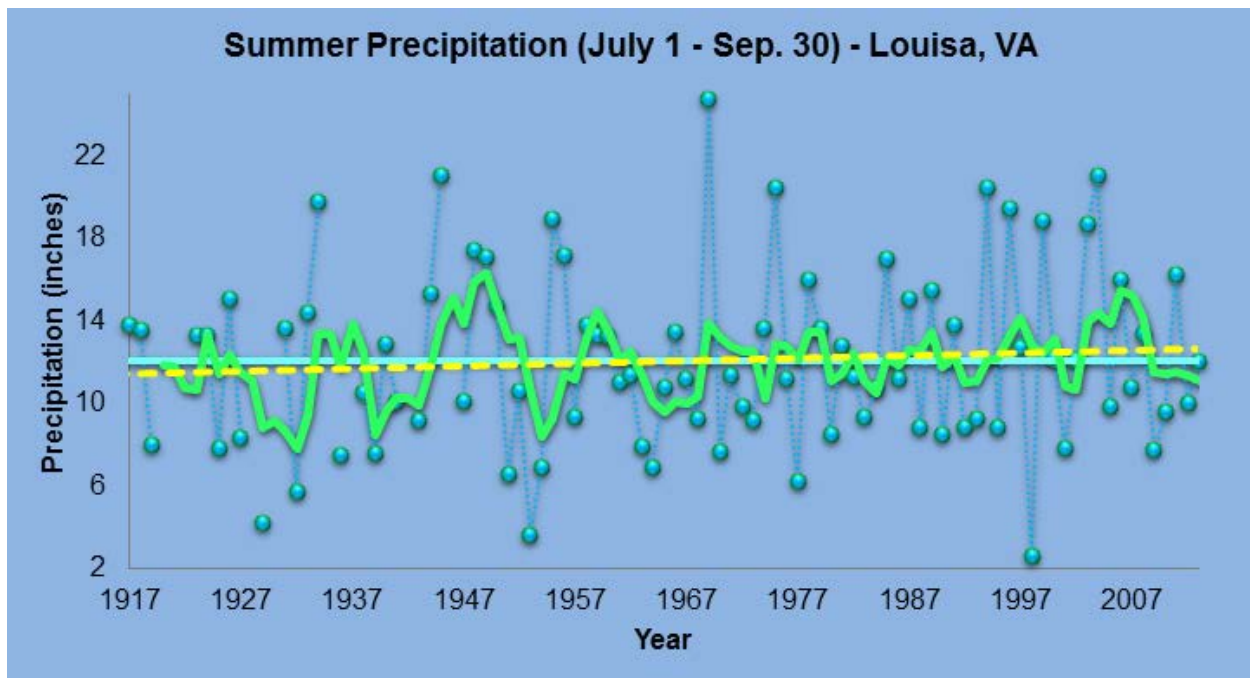
Winter Precipitation Trends: Louisa shows a slight increase, whereas Piedmont Research Station displays a very small downward trend (less than 1 in over the past 70 years) in winter precipitation. Louisa's winter precipitation has ranged between 4.0 in to as much as 20.5 in over its period of record while Piedmont Research Station has ranged from 4.1 in to 19.1 in.



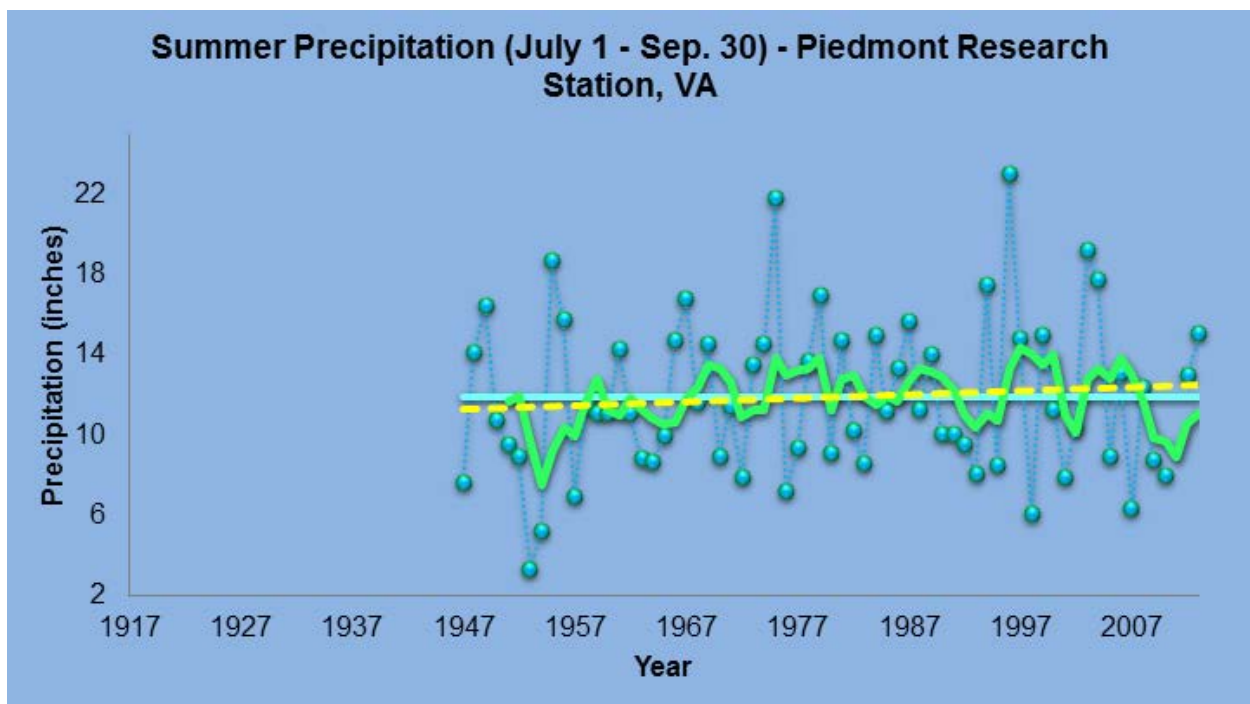


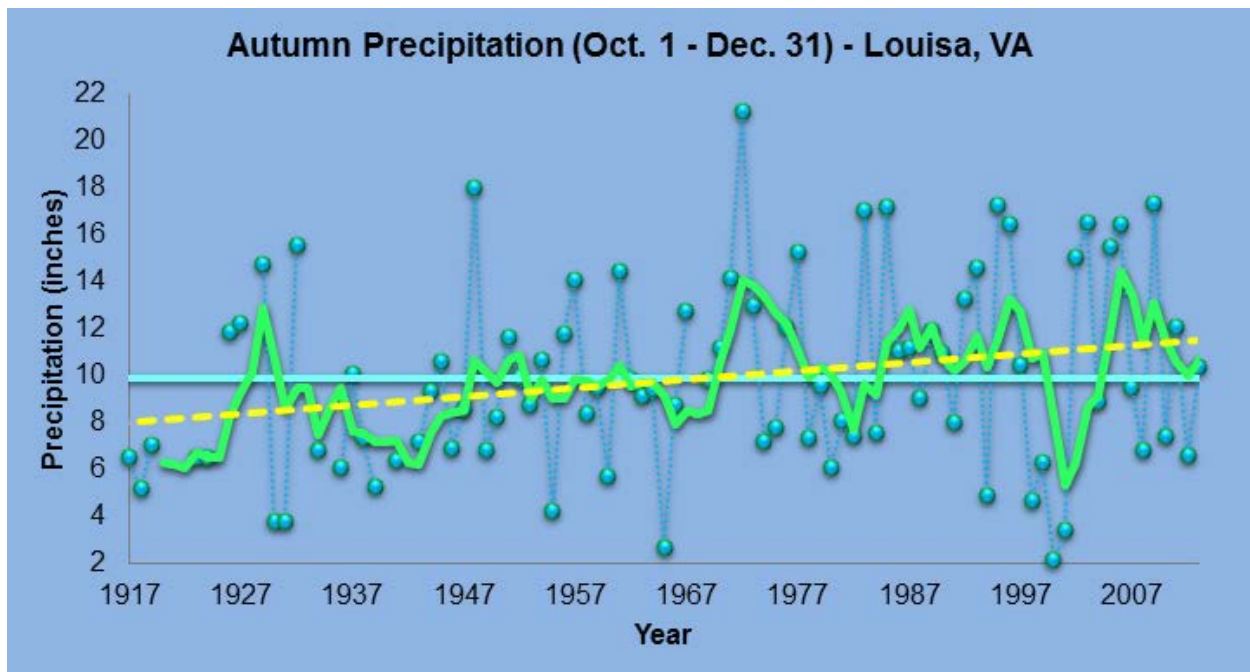
Spring Precipitation Trends: Louisa shows a slight increase (approximately 1 in over the past ~100 years), whereas Piedmont Research Station displays a more pronounced upward trend in spring precipitation (approximately 2 in over 70 years). Louisa has experienced as much as 21.5 in and as little as 3.5 in during the spring while Piedmont Research Station has experienced between 3.9 and 21.5 in.



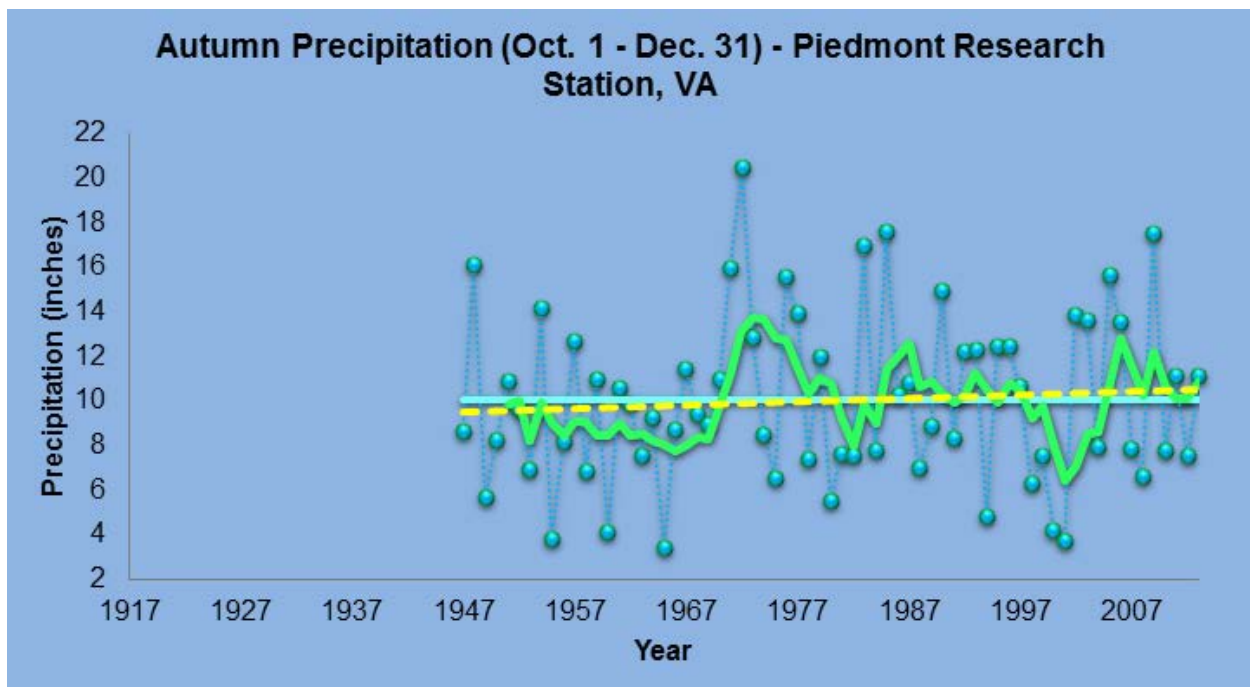


Summer Precipitation Trends: Only a very slight increase exists in summer precipitation at both locations. Louisa's summer precipitation has ranged between 2.6 to 24.8 in. while Piedmont Research Station has seen a minimum of 3.3 in to a maximum of 23.1 in.





Autumn Precipitation Trends: Both locations show an increase in autumn precipitation with Louisa demonstrating a more rapid rise (approximately 2 in over the past 50 years). The average sum of precipitation during the autumn is 9.9 in (min of 2.1 in and max of 21.7 in) at Louisa which is close to an average of 10.0 in (min of 3.4 and max of 20.5 in) at Piedmont Research Station.



The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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