



Weather of Appomattox Court House National Historical Park and Booker T. Washington National Monument

Mid-Atlantic Network Summary Report for 2014

Natural Resource Report NPS/MIDN/NRR—2016/1110



ON THE COVER

Jones Law Office, Appomattox Court House National Historical Park.
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Natural Resource Report NPS/MIDN/NRR—2016/1110

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List of Key Acronyms

APCO	Appomattox Court House National Historical Park
ASOS	Automated Surface Observation System
BOWA	Booker T. Washington National Monument
CASTNET	Clean Air Status and Trends Network
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
FAA	Federal Aviation Administration
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
NHP	National Historical Park
NM	National Monument
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 objective:

- 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 observing 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. This report includes a summary of several of these indicators for the period of record of selected stations (ending on December 31, 2013). These key indicators are further described in the protocol (Marshall et al. 2012) and are summarized in the body of this report.

Climate of the Western Piedmont Region of Virginia

Appomattox Court House National Historical Park (NHP) and Booker T. Washington National Monument (NHP) lie in Virginia Climate Division 3, known as the “Western 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 division is generally considered to have a humid, continental type of climate, but the varied physiographic features have a marked effect on the weather and climate of the various parts of this region. The prevailing westerly winds carry most of the weather disturbances that affect the region from the interior of the continent through the Ohio Valley, so that the Atlantic Ocean has only some 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. Infrequently, storms of tropical origin can have a significant effect, causing severe floods in some instances.

Temperatures are moderately continental, with the tempering effects of the nearby mountains contributing to cloud production in the winter and mountain-valley circulation clouds reducing the heat at times during the summer. The lowest readings in the winter occur with polar air masses of Canadian origin settling over the region after a fresh snowfall. On average, Appomattox Court House NHP tends to have a greater number of sub-freezing nights than Booker T. Washington NM (~92 to ~75). 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 will direct hot, humid air from the Gulf region into the Western Piedmont. The humid southwest winds descending the crest of the Appalachians will raise the temperature several more degrees. The last freeze and first frost typically occur in mid-April and late October, respectively.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 36–52 in (914–1,321 mm), while the majority of places receive 38–44 in (965–1,118 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 is somewhat greater in the mountains. During the warm season, the uneven heating over the irregular terrain leads to thunderstorms which typically form over the mountains and dissipate as they reach the Piedmont.

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, but flash floods and damaging thunderstorm winds affect parts of the region 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 hurricanes and tropical storms occur most years and some have contributed to the region’s worst floods. Ice storms, which can cause significant disruption, occur at irregular intervals but are primarily confined to the months between December and March (Kocin and Uccellini 2004).

Observing Stations

A total of five weather observing stations comprising two weather observing networks were selected as the most representative weather stations around Appomattox Court House NHP and Booker T. Washington NM 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. A total of five stations were ultimately used for this 2014 report: Lynchburg, Roanoke, Rocky Mt., Appomattox, and Huddleston (Figure 1, Table 1).

Two stations, Lynchburg Airport (1945-current) and Roanoke Airport (1948-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-normal 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 be the 30-year normal or the pseudo-normal calculated on a shorter time frame.

All five stations have a Period of Record (POR) sufficiently long for a 30-year normal (normals calculated from years 1981–2010); however, Huddleston lacks temperature data. Monthly averages and deviations from normal are presented for all five stations for precipitation, and for all except Huddleston for temperature.

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 Appomattox Court House National Historical Park and Booker T. Washington National Monument selected as most representative of the parks in 2014.

Station	Observ- ing Network ¹	Station 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
KLYH	ASOS	Lynchburg Regional Airport/Preston Glenn Field	02/01/1945	Present	99.5	100.0	96.3	96.3
KROA	ASOS	Roanoke Regional Airport/Woodrum Field	02/01/1948	Present	100.0	100.0	96.0	96.0
RYMV2	COOP	Rocky Mt.	01/01/1951	Present	93.4	97.3	94.5	94.4
APXV2	COOP	Appomattox	11/01/1937	Present	95.9	99.7	94.5 ²	95.9
HUDV2	COOP	Huddleston 4 SW	01/01/1960	Present	-	100.0	-	99.2

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

² Percentage of time reporting temperature for Appomattox Court House NHP is based upon a Period of Record beginning on 11/01/1961. The station did not report temperature prior to this date.

Temperature Summary

Average annual temperatures in 2014 were slightly below the 30-year normal for the area around Appomattox Court House NHP and Booker T. Washington NM (Table 2). Despite a warm spring, and a mild October and December, the remainder of the months were cooler than average (Tables 3 and 4). Average monthly temperatures were chilliest (largest negative departures from normal) in January, March and November (Table 4 and Figures 2 and 3)¹.

January was much cooler than average, with mean temperatures ranging from -5.4 to -6.5°F (-3.0 to -3.6°C) from the long-term values (Tables 3 and 4). The lowest readings of the year occurred on January 7th (Roanoke and Appomattox) and 24th (Lynchburg) with values as low as 1.0°F (-17.2°C), which are lower than the typical annual minimums (Table 2). February was warmer with mean temperatures varying from 37.2°F (2.9°C) at Lynchburg to 38.2°F (3.4°C) at Rocky Mt. (Table 3). March had negative temperature anomalies, with magnitudes in between January and February for each respective station, leading to a winter that ranked the 13th coolest in 120 years for the Western Piedmont (Table 5). There were also an above average number of cold days during the winter (Table 2).

Spring was relatively mild, as May noted substantial positive anomalies at each of the representative weather stations (Table 4). May's positive departures from normal reached 3.3°F (1.8°C) at Rocky Mt. (Table 4). For the spring months of April-June, both maximum and minimum temperatures were generally above normal (Figures 2 and 3). Overall, this spring season ranked as tied for the 20th warmest on record for the Western Piedmont (Table 5).

The summer months of July and August were cooler-than-average while September readings rebounded to near normal levels. In August, temperature anomalies ranged from -2.3 to -3.5°F (-1.3 to -1.9°C) below average (Table 4). The number of hot days was notably below normal, with Lynchburg seeing only half of the normal number (Table 2). However, the highest readings of 2014 did reach the normal values of 96°F (36.5°C) on July 2nd and 3rd at Roanoke (Table 2). The summer of 2014 ranked as the 31st coolest in the last 120 years for the Western Piedmont (Table 5).

A cool November was spliced between two autumn months that had mainly positive departures from normal. The number of sub-freezing days were above normal for the year (Table 2). December's departure from normal varied from +2.7°F (1.5°C) at Appomattox to +3.7°F (2.1°C) at Rocky Mt. (Table 4). The autumn tied as the 47th warmest in 120 years for the Western Piedmont (Table 5). Overall, the length of the growing season was very close to the 1981–2010 average (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/>.

Table 2. Status of 2014 temperature indicators compared to the 30-year normal (1981–2010) and the station period of record at the Lynchburg Airport (KLYH) and Roanoke Airport (KROA) stations.

Temperature Indicator	Lynchburg Airport 2014	Lynchburg Airport 1981–2010	Lynchburg Airport 1945-2013 Mean (± 1 SD)	Roanoke Airport 2014	Roanoke Airport 1981–2010	Roanoke Airport 1948-2013 Mean (± 1 SD)
Average Annual Temperature	55.0°F 12.8°C	55.6°F 13.1°C	56.2 (55.2 – 57.2) °F 13.4 (12.9 – 14.0) °C	55.8°F 13.2°C	57.0°F 13.9°C	56.6 (55.3 – 57.9) °F 13.7 (12.9 – 14.4) °C
Average Annual Maximum Temperature	65.9°F 18.8°C	67.1°F 19.5°C	NA	65.7°F 18.7°C	67.3°F 19.6°C	NA
Maximum Temperature	95°F 35°C	95.9°F 35.5°C	96.3 (93.4 – 99.1) °F 35.7 (34.1 – 37.3) °C	96°F 35.6°C	96.7°F 35.9°C	96.9 (93.6 – 100.3) °F 36.1 (34.2 – 37.9) °C
Hot Days (days with Tmax $\geq$ 90°F/32°C)	11	22	25 (13 – 38)	17	25	30 (16 – 45)
Average Annual Minimum Temperature	44.2°F 6.8°C	44.1°F 6.7°C	NA	45.9°F 7.7°C	46.6°F 8.1°C	NA
Minimum Temperature	1.0°F -17.2°C	3.7°F -15.7°C	5.1 (-0.6 to 10.9) °F -14.9 (-11.7 to -18.1) °C	1.0°F -17.2°C	6.0°F -14.4°C	6.4 (0.4 - 12.3) °F -14.2 (-10.9 to -17.6) °C
Cold Days (days with Tmax $\leq$ 32°F/0°C)	7	6	NA	12	7	NA
Sub-freezing Days (days with Tmin $\leq$ 32°F/0°C)	108	99	91 (78 – 103)	94	78	86 (73 – 98)
Sub-zero Days (days with Tmin $\leq$ 0°F/-17.8°C)	0	0	NA	0	0	NA
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	198	201	194 (177 – 211)	204	208	194 (178 – 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
Lynchburg Airport	KLYH	29.7°F	37.2°F	43.8°F	58.4°F	65.7°F	73.2°F	74.1°F	71.3°F	67.8°F	56.7°F	42.0°F	40.4°F	55.0°F
		-1.3°C	2.9°C	6.6°C	14.7°C	18.7°C	22.9°C	23.4°C	21.8°C	19.9°C	13.7°C	5.6°C	4.7°C	12.8°C
Roanoke Airport	KROA	30.2°F	37.5°F	43.7°F	56.5°F	67.4°F	74.7°F	74.6°F	71.9°F	68.8°F	58.7°F	43.0°F	42.3°F	55.8°F
		-1.0°C	3.1°C	6.5°C	13.6°C	19.7°C	23.7°C	23.4°C	22.2°C	20.4°C	14.8°C	6.1°C	5.7°C	13.2°C
Rocky Mt	RYMV2	29.1°F	38.2°F	41.0°F	55.4°F	65.9°F	73.7°F	73.6°F	71.2°F	M	M	M	41.6°F	M
		-1.6°C	3.4°C	5.0°C	13.0°C	18.8°C	23.2°C	23.1°C	21.8°C	M	M	M	5.3°C	M
Appomattox	APXV2	29.0°F	M	M	56.3°F	66.3°F	73.9°F	74.9°F	71.9°F	69.3°F	58.4°F	42.3°F	41.0°F	M
		-1.7°C	M	M	13.5°C	19.1°C	23.3°C	23.8°C	22.2°C	20.7°C	14.7°C	5.7°C	5.0°C	M

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
Lynchburg Airport	KLYH	-5.4°F	-1.0°F	-2.1°F	3.0°F	2.6°F	1.6°F	-1.2°F	-2.8°F	0.8°F	0.5°F	-4.8°F	2.8°F	-0.5°F
		-3.0°C	-0.6°C	-1.2°C	1.7°C	1.4°C	0.9°C	-0.7°C	-1.6°C	0.4°C	0.3°C	-2.7°C	1.6°C	-0.3°C
Roanoke Airport	KROA	-6.4°F	-2.1°F	-3.6°F	-0.2°F	2.8°F	1.8°F	-2.1°F	-3.5°F	0.7°F	1.0°F	-5.1°F	3.3°F	-1.1°F
		-3.6°C	-1.2°C	-2.0°C	-0.1°C	1.6°C	1.0°C	-1.2°C	-1.9°C	0.4°C	0.6°C	-2.8°C	1.8°C	-0.6°C
Rocky Mt ¹	RYMV2	-6.5°F	-0.1°F	-4.4°F	0.7°F	3.3°F	2.6°F	-1.3°F	-2.3°F	M	M	M	3.7°F	M
		-3.6°C	-0.1°C	-2.4°C	0.4°C	1.8°C	1.4°C	-0.7°C	-1.3°C	M	M	M	2.1°C	M
Appomattox	APXV2	-6.1°F	M	M	0.9°F	3.0°F	1.7°F	-1.0°F	-2.8°F	1.7°F	1.6°F	-4.9°F	2.7°F	M
		-3.4°C	M	M	0.5°C	1.7°C	0.9°C	-0.6°C	-1.6°C	0.9°C	0.9°C	-2.7°C	1.5°C	M

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 departure 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 Western Piedmont (NOAA 2015).

	Climate Division 3 Rankings — Western Piedmont				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2014	108-T	20-T	90	47-T	89-T
Precipitation-2014	63-T	49	66-T	49	61

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

Appomattox Court House National Historical Park
and Booker T. Washington National Monument
Departure from Average Monthly Maximum Temperature
2014 vs. 1981–2010

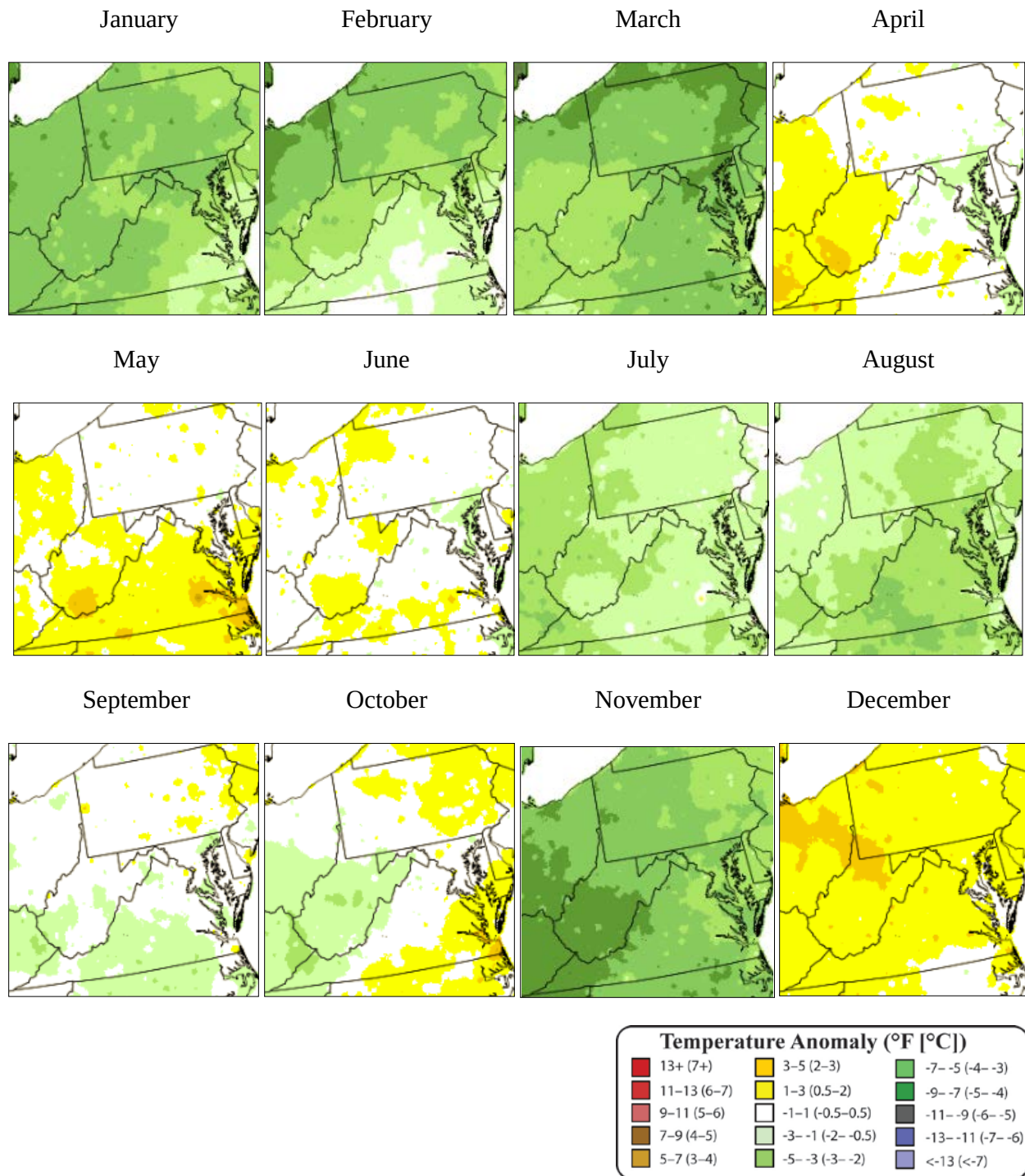


Figure 2. Maps showing departure from average monthly maximum temperature in 2014 compared to the 30-year normal (1981–2010).

Appomattox Court House National Historical Park
and Booker T. Washington National Monument
Departure from Average Monthly Minimum Temperature
2014 vs. 1981–2010

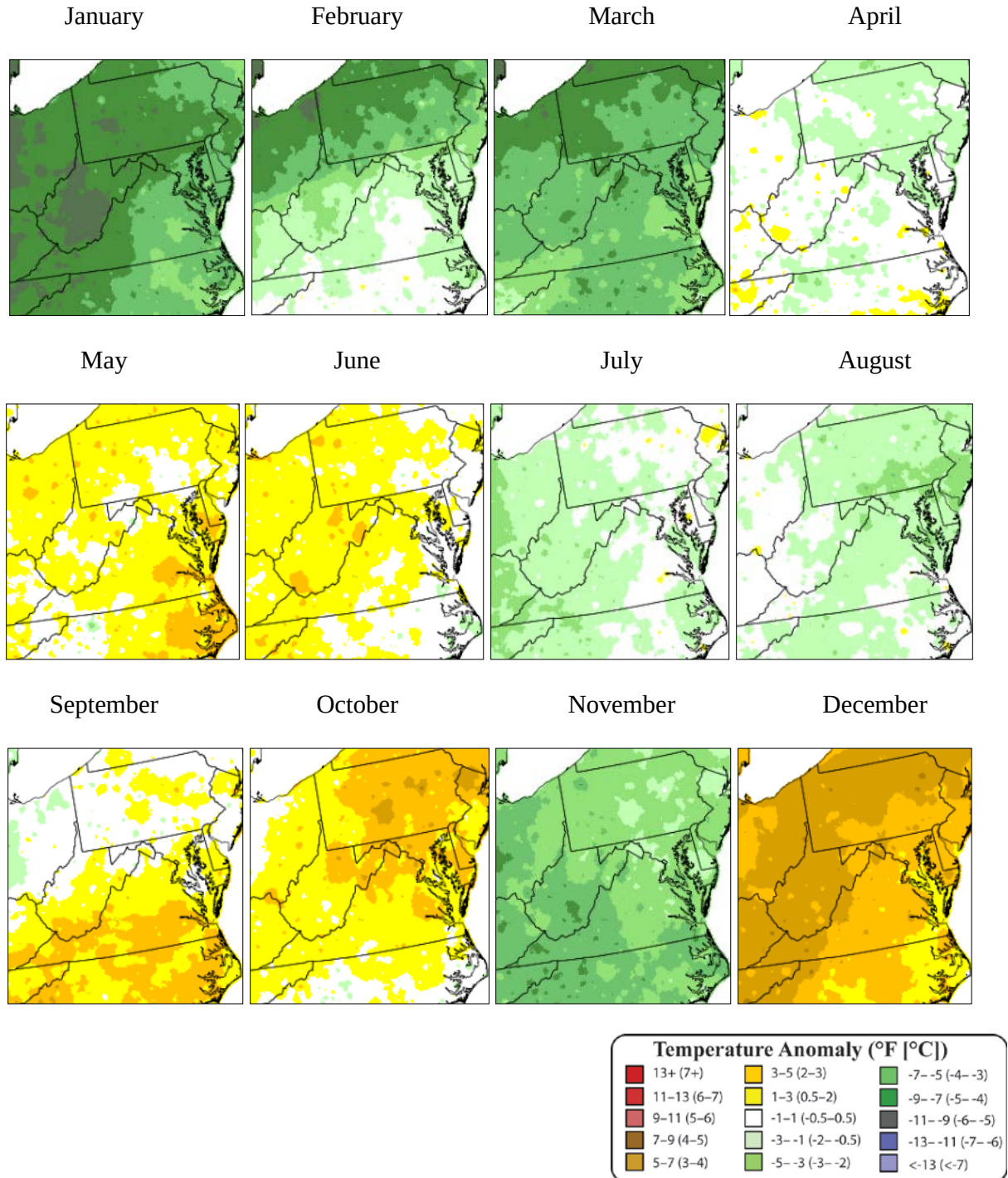


Figure 3. Maps showing departure from average monthly minimum temperature in 2014 compared to the 30-year normal (1981–2010).

Precipitation Summary

The year's precipitation at Appomattox Court House NHP and Booker T. Washington NM started near normal in January followed by a mix of wet and dry months. Annual precipitation ranged from 1.9 in (48 mm) below normal precipitation at Roanoke to 5.3 in (134 mm) above normal at Lynchburg (Table 6). The number of heavy precipitation days was near-to-below the long-term average (Table 6).

February was noted by above normal precipitation: a total of 4.5 in (114 mm) fell the entire month at Roanoke, 155 percent of normal (Tables 8 and 9). Both January and March brought closer to average precipitation, as 3.3 in (83 mm) was tallied at Lynchburg in January (104 percent of normal) and 3.4 in (86 mm) was measured at Huddleston in March (91 percent of normal) (Tables 8 and 9). Overall, the winter months (January, February and March) tied as the 58th driest in the Western Piedmont since 1895 (Table 5; 60 is the mid-point).

Snowfall for the year was above normal, with Lynchburg and Roanoke reporting 21.4 and 28.5 in (54.4 and 72.4 cm), respectively, versus the long-term averages of 16.2 to 18.5 in (16.3 to 47 cm) (Table 6). The numbers of moderate to heavy snow days were near to above normal (Table 6).

The spring months of April, May and June were wetter, primarily due to an anomalously moist April, with 5.6 in (143 mm) in Lynchburg, 170 percent of normal precipitation for the month (Tables 8 and 9). Notably, there were two consecutive days in May that were extremely wet with 3.1 in (79 mm) and 3.5 in (89 mm) of rain on May 15th and 16th, respectively. One long dry spell was noted from April 16-28, however, during which no measurable precipitation was reported (Table 7). Overall, the spring in the Western Piedmont ranked as the 49th wettest in 120 years of records (Table 5).

Summer rainfall varied across the region, as evidenced by the range of precipitation during July. This month brought only 1.5 in (43 mm) at Huddleston, 38 percent of normal, whereas 5.8 in (147 mm) fell at Lynchburg, 133 percent of normal (Tables 8 and 9). As in 2013, there were no effects from hurricanes or tropical storms this season. Overall, this season averaged the closest to normal and ranked as the 55th driest in 120 years for the Western Piedmont (Table 5). The wettest day of the year occurred during this season with 3.90 in (99 mm) falling on July 24 (Table 7).

The last quarter of the year was similar to spring in its close proximity to normal precipitation (Table 5). All stations reported near normal precipitation during all three months. November was the driest month, with precipitation amounts ranging from 66 to 104 percent of normal (Table 9). The autumn precipitation totals ranged from 9.1 in (231 mm) at Lynchburg to 9.6 in (244 mm) at Roanoke (Table 6).

Appomattox Court House National Historical Park
and Booker T. Washington National Monument
Percent of Average Monthly Precipitation

2014 vs. 1981–2010

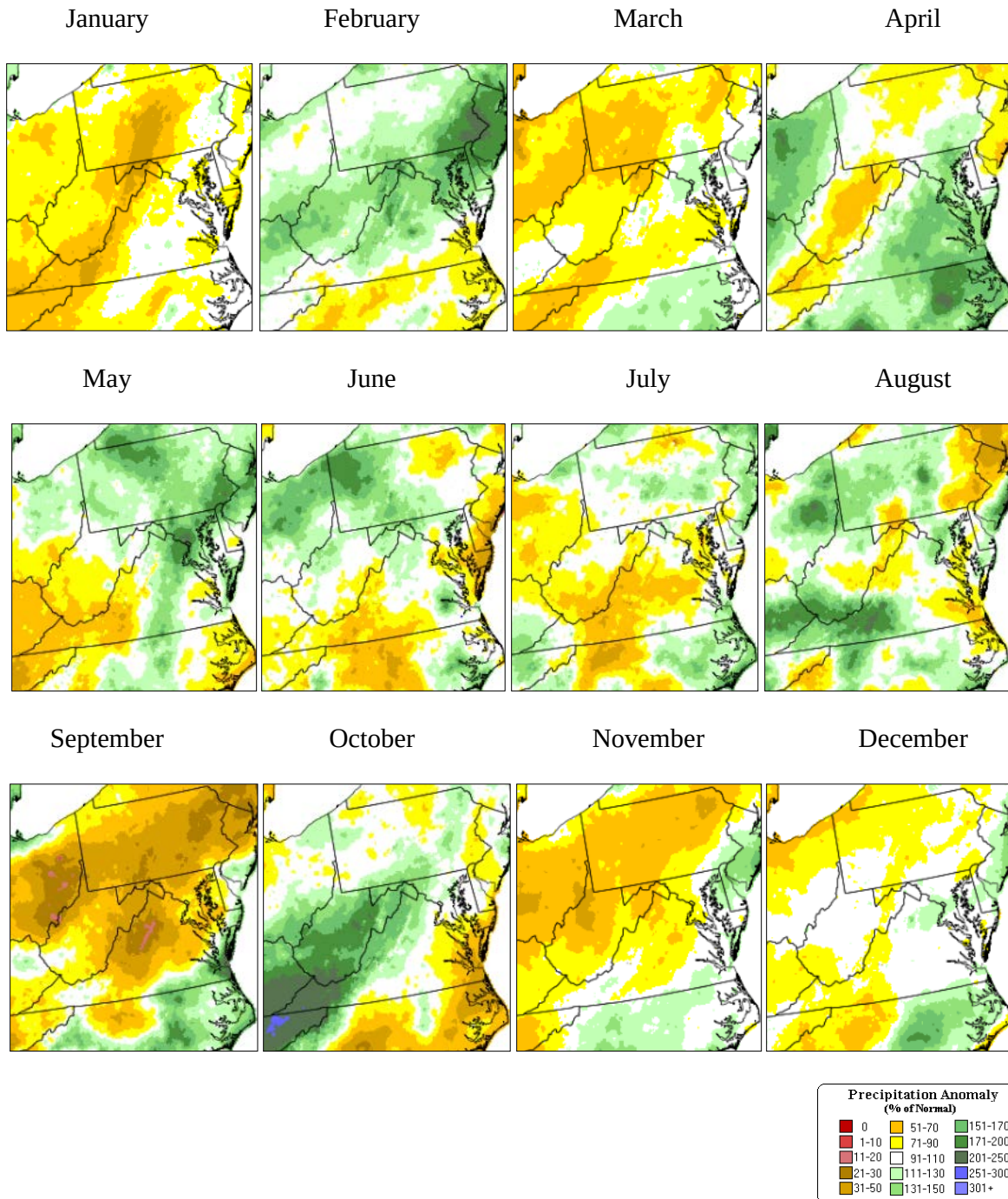


Figure 4. Maps showing percent of average monthly precipitation in 2014 compared to the 30-year normal (1981–2010).

Table 6. Status of 2014 precipitation indicators compared to the 30-year normal (1981–2010) and the station period of record at the Lynchburg Airport (KLYH) and Roanoke Airport (KROA) stations.

Precipitation Indicator	Lynchburg Airport 2014	Lynchburg Airport 1981–2010	Lynchburg Airport 1945–2013 Mean (min – max)	Roanoke Airport 2014	Roanoke Airport 1981–2010	Roanoke Airport 1948–2013 Mean (min – max)
Annual Precipitation	44.7 in 1,135 mm	39.4 in 1,001 mm	40.8 (26.6 – 59.7) in 1,036 (676 – 1,516) mm	39.4 in 1,001 mm	41.3 in 1,049 mm	40.8 (24.9 – 58.8) in 1,036 (632 – 1,493) mm
Autumn (Oct, Nov, Dec) Precipitation	9.1 in 231 mm	9.8 in 249 mm	9.5 (2.8 – 18.2) in 241 (71 – 462) mm	9.6 in 244 mm	9.2 in 234 mm	9.1 (3.5 – 18.3) in 231 (89 – 465) mm
Heavy Precipitation Days (days with ≥ 1.0 in [25 mm] rain)	10	10	NA	8	10	NA
Extreme Precipitation Days (days with ≥ 2.0 in [51 mm] rain)	2	1	1 (0 – 4)	0	2	2 (0 – 5)
Micro-drought (periods of 7+ days without rain)	7	7	NA	7	5	NA
Annual Snowfall	21.4 in 54.4 cm	16.2 in 16.3 cm	16.1 (0 – 56.0) in 40.9 (0 – 142.2) cm	28.5 in 72.4 cm	18.5 in 47.0 cm	20.2 (0.4 – 72.5) in 51.3 (1.0 – 184.1) cm
Measurable Snow Days (days with ≥ 0.1 in [0.3 cm] snow)	9	8	NA	10	9	NA
Moderate Snow Days (days with ≥ 3.0 in [7.6 cm] snow)	3	2	NA	2	2	NA
Heavy Snow Days (days with ≥ 5.0 in [12.7 cm] snow)	2	1	NA	2	1	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 Lynchburg (KLYH), Roanoke (KROA), Rocky Mt (RYMV2), Appomattox (APXV2) and Huddleston (HUDV2).

Wettest Days in 2014	Dry Spells in 2014
Jul. 24: 3.9 in (99 mm)	Oct. 16–30
May 16: 3.5 in (89 mm)	May 15–28
May 15: 3.1 in (79 mm)	Apr. 16–28
Feb. 13: 1.9 in (48 mm)	Dec. 9–19
Feb. 3: 1.9 in (48 mm)	Nov. 6–16

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lynchburg Air- port	KLYH	3.3 in	3.8 in	2.9 in	5.6 in	5.4 in	2.4 in	5.8 in	4.8 in	1.6 in	3.6 in	2.4 in	3.1 in	44.7 in
		83 mm	97 mm	74 mm	143 mm	137 mm	61 mm	147 mm	121 mm	41 mm	91 mm	62 mm	79 mm	1136 mm
Roanoke Airport	KROA	1.8 in	4.5 in	2.8 in	4.2 in	2.4 in	3.1 in	3.4 in	6.5 in	1.2 in	3.6 in	3.5 in	2.5 in	39.4 in
		46 mm	114 mm	70 mm	106 mm	60 mm	77 mm	86 mm	166 mm	31 mm	90 mm	89 mm	65 mm	1002 mm
Rocky Mt	RYMV2	3.1 in	3.7 in	3.6 in	4.8 in	1.6 in	2.1 in	2.2 in	8.5 in	M	M	3.4 in	3.1 in	M
		80 mm	95 mm	91 mm	122 mm	41 mm	53 mm	55 mm	106 mm	M	M	85 mm	78 mm	M
Appomattox	APXV2	3.7 in	4.0 in	3.1 in	5.3 in	4.7 in	2.9 in	3.0 in	4.2 in	2.0 in	4.7 in	2.6 in	3.6 in	43.8 in
		93 mm	102 mm	80 mm	134 mm	118 mm	74 mm	76 mm	106 mm	50 mm	119 mm	67 mm	91 mm	1111 mm
Huddleston 4 SW	HUDV2	2.9 in	4.3 in	3.4 in	4.5 in	2.6 in	1.7 in	1.5 in	6.5 in	3.2 in	3.2 in	3.0 in	3.3 in	40.0 in
		72 mm	108 mm	86 mm	115 mm	66 mm	43 mm	39 mm	166 mm	80 mm	81 mm	75 mm	84 mm	1015 mm

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

Table 9. Summary of 2014 percent of normal precipitation 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
Lynchburg Air- port	KLYH	104	130	82	170	145	66	133	147	42	115	71	96	108
Roanoke Airport	KROA	62	155	80	124	59	80	84	183	32	123	104	86	96
Rocky Mt ¹	RYMV2	93	121	84	127	40	46	45	198	M	M	94	88	M
Appomattox	APXV2	117	131	79	154	98	74	62	105	46	125	66	105	94
Huddleston 4 SW	HUDV2	84	146	91	135	71	48	38	185	77	93	83	101	94

¹Indicates a station's Period of Record does not cover the period of 1981-2010 but is five years or more. In these cases the departure 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).

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 the Western Piedmont in 2014 are shown in Figure 5.

According to the PDSI, moist conditions persisted in the Western Piedmont through the spring but then dropped to near normal for the rest of the year (Figure 5). When compared to the previous two years, 2013 was more consistently moist throughout the year and was very moist during the summer months. In contrast, 2012 was a drier year than 2013 or 2014. PDSI values remained below 0 for the duration of 2012 and entered into moderate drought conditions during the autumn.

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.

The DM – Drought Severity Index across the state and the region shows a pattern similar to the PDSI for the growing season (May through October); no drought, only abnormally dry, in the region during the warm season in the Western Piedmont.

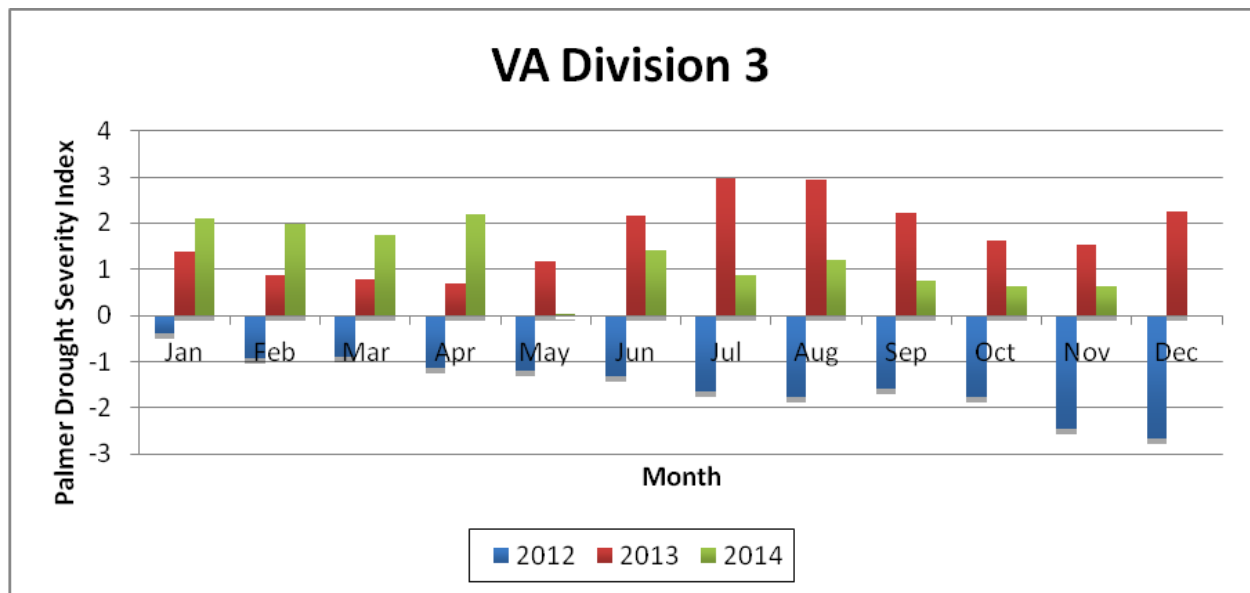


Figure 5. Palmer Drought Severity Index (PDSI) for the Western Piedmont, 2012–2014.

Drought Intensity in Virginia During 2014

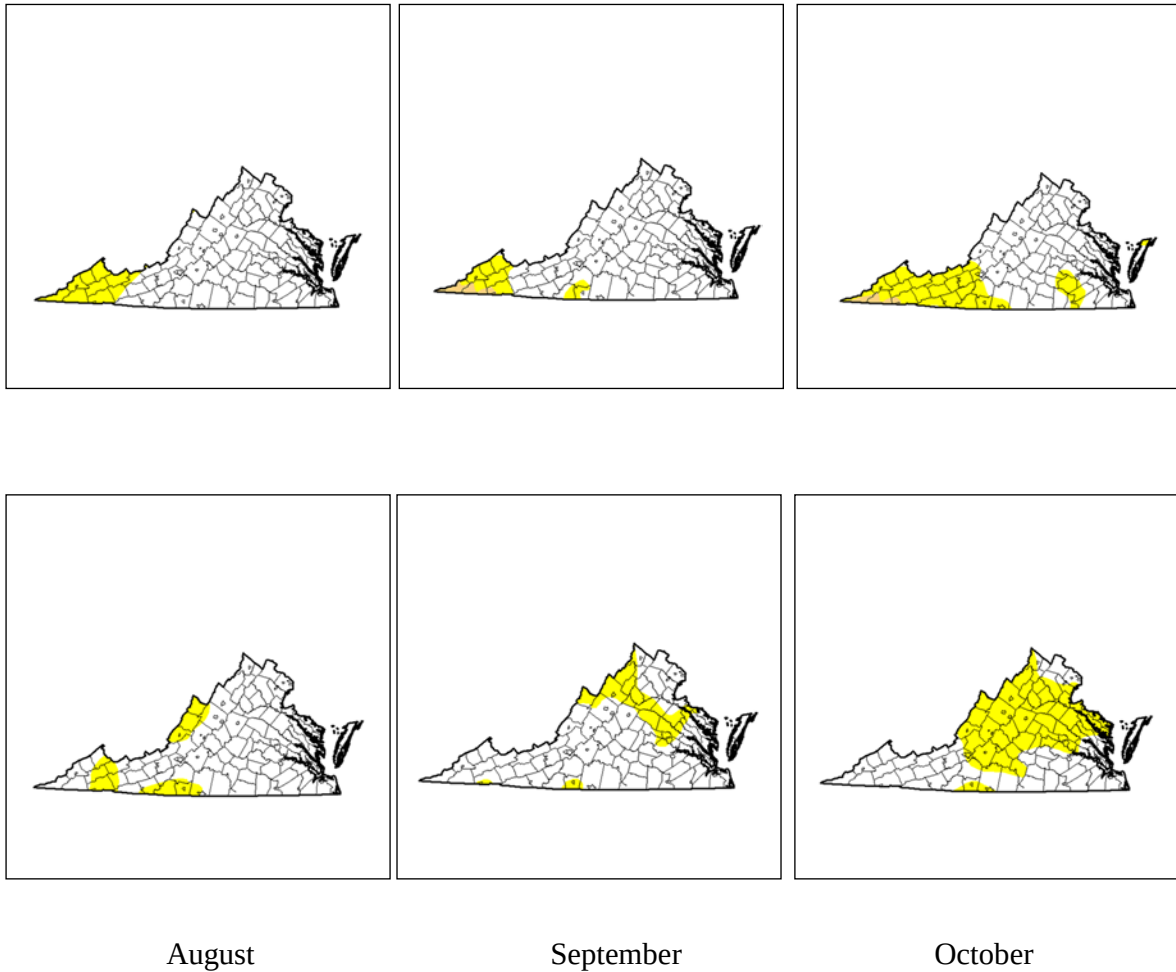


Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Virginia in 2014.

Drought Intensity for the Southeast during 2014

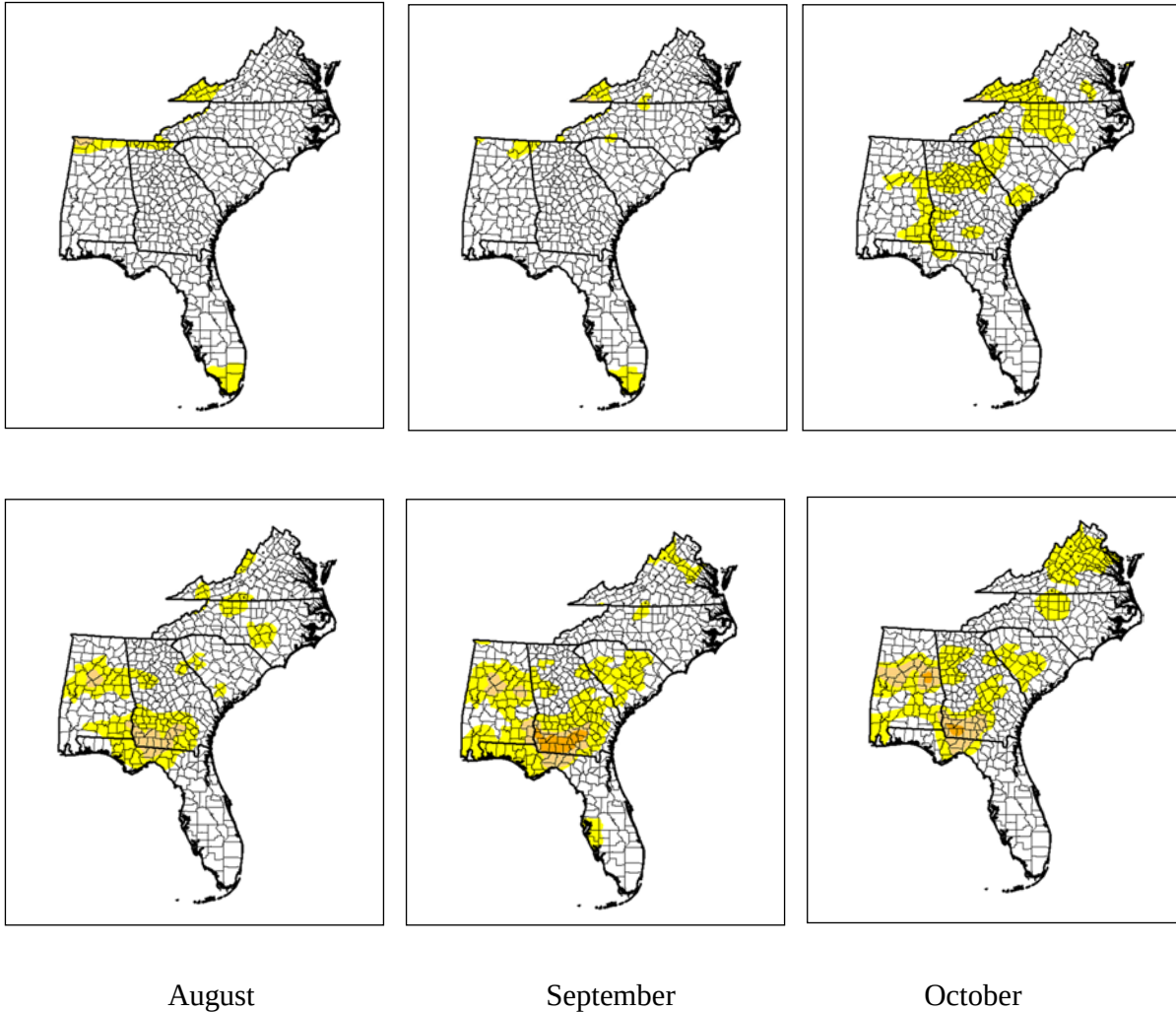


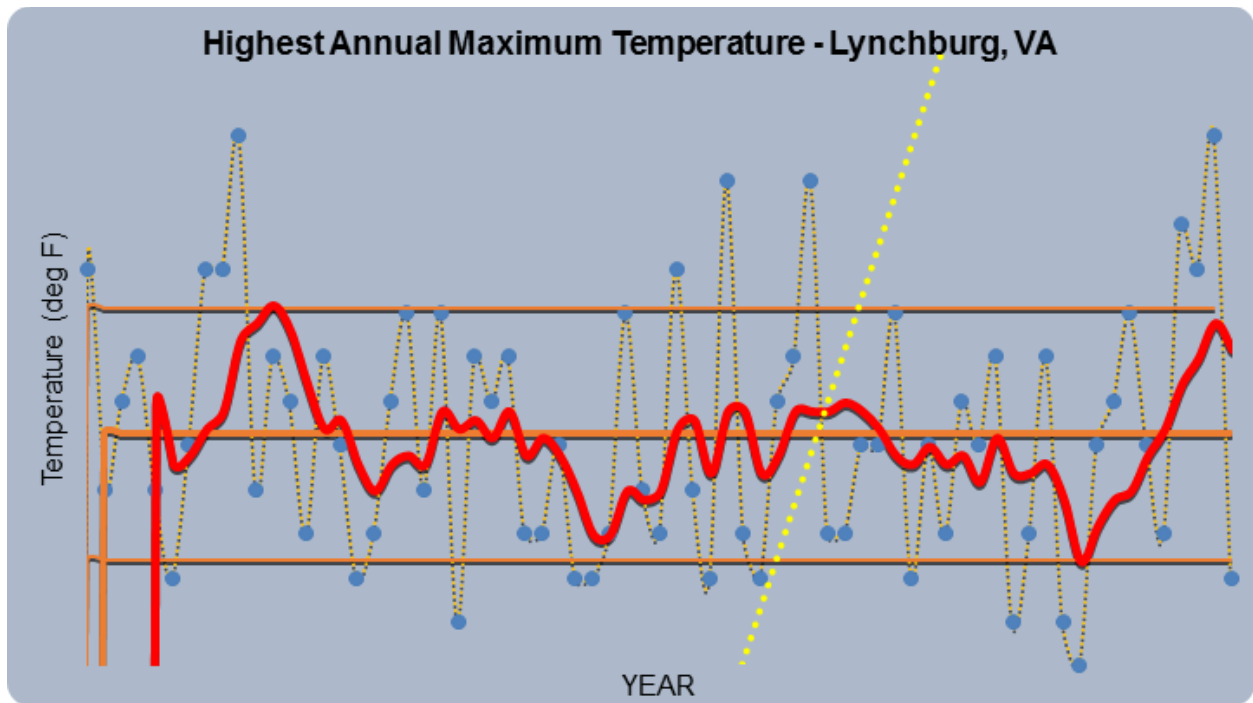
Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Southeast in 2014.

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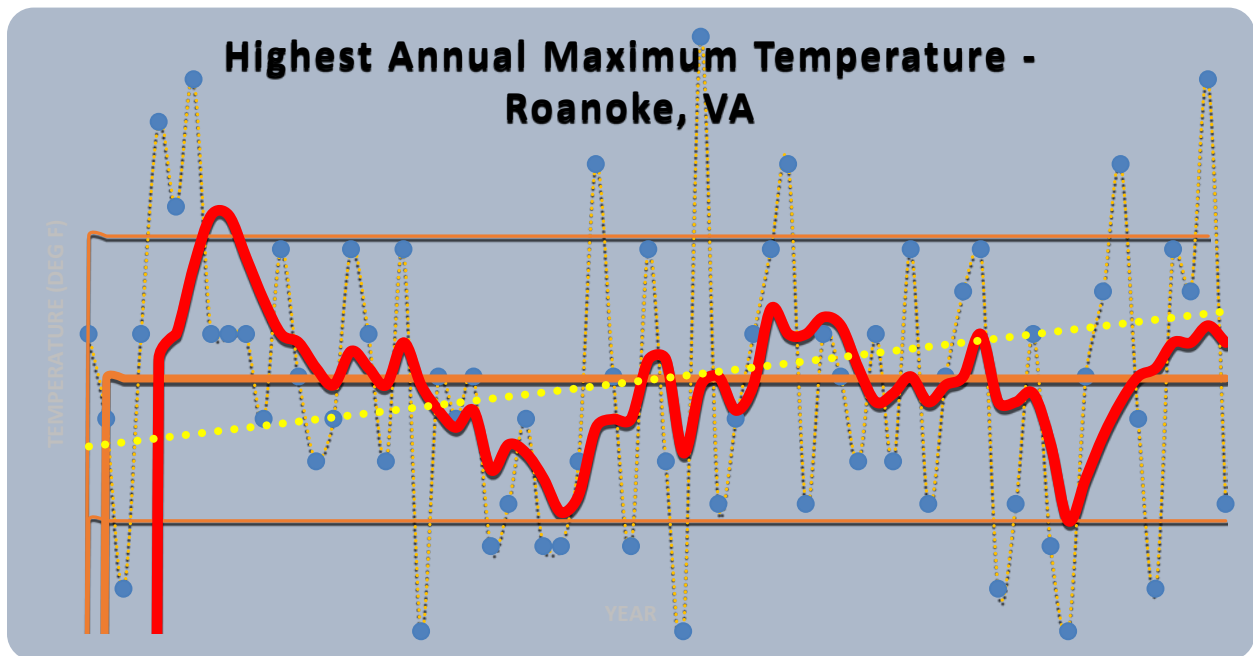
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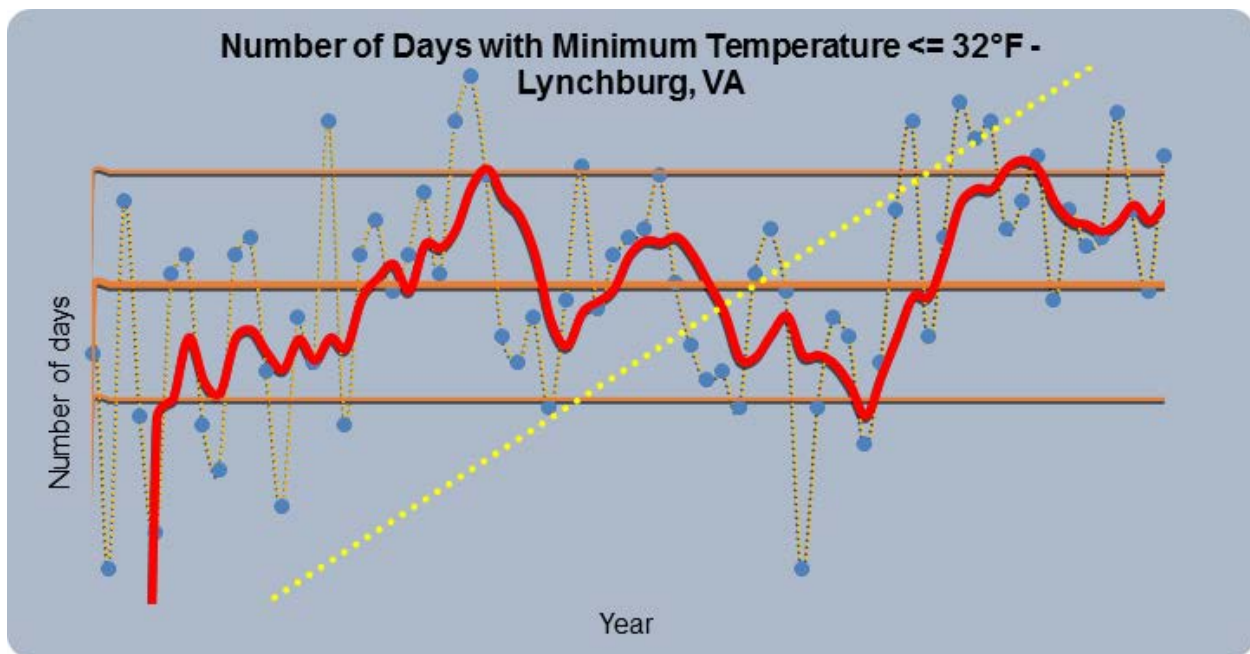
Appendix

Below are graphs illustrating long-term trend analysis for multiple climate indicators at the Lynchburg and Roanoke 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.

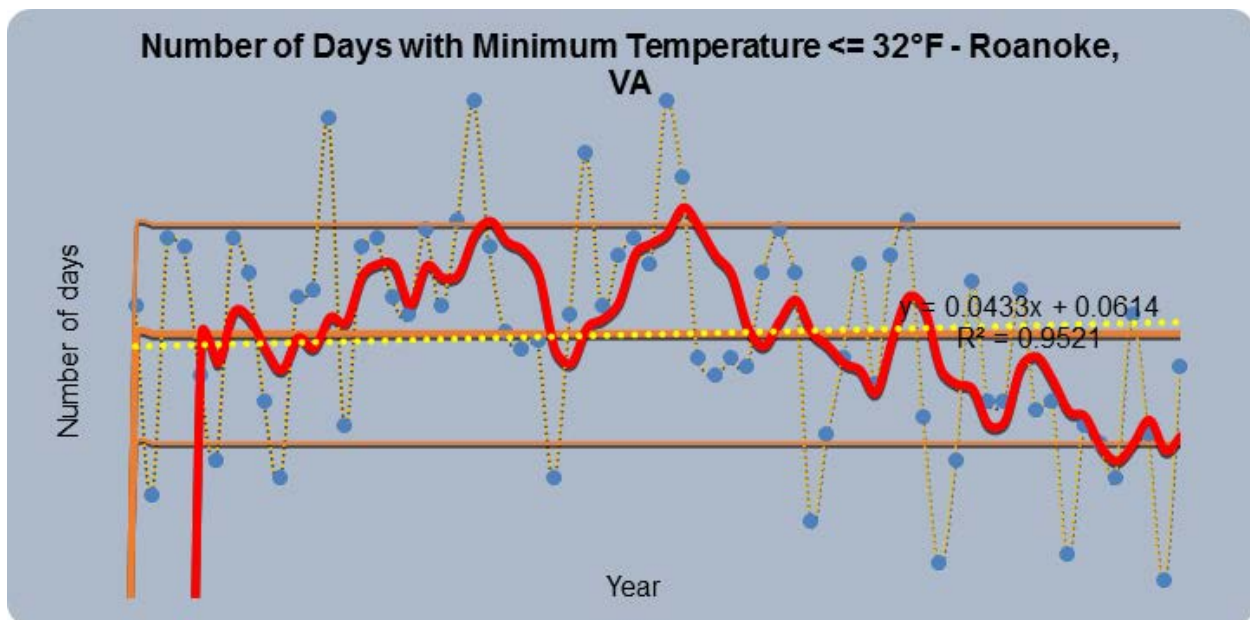


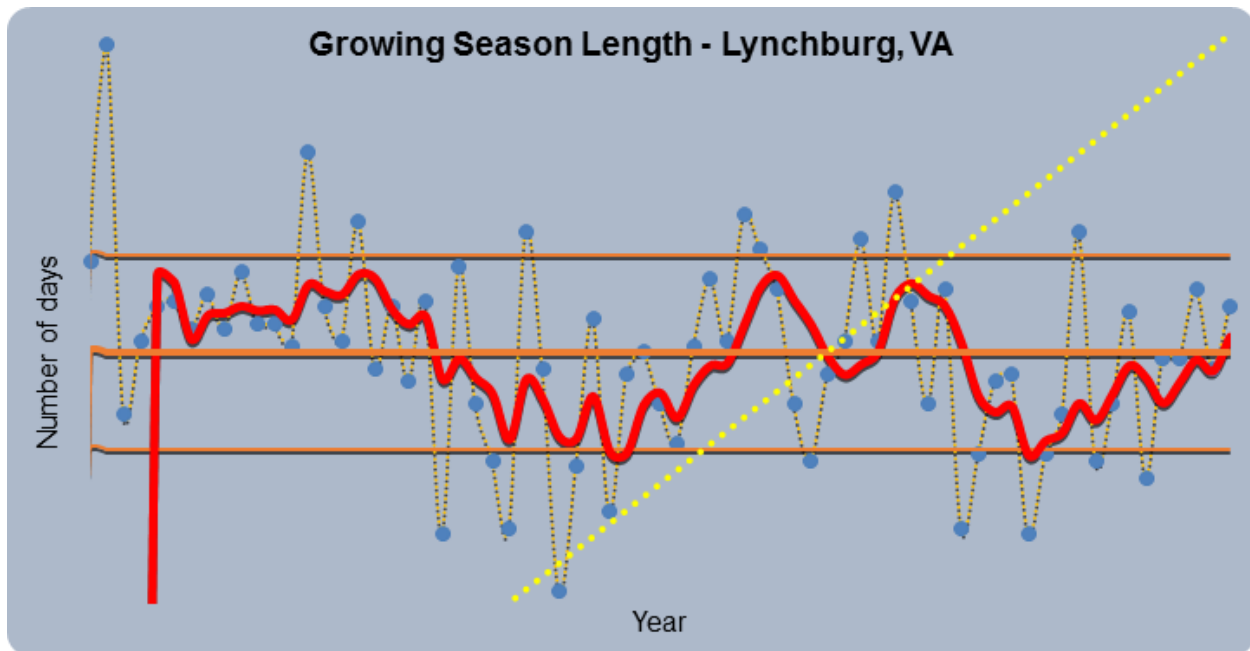
Annual Maximum Trends: The stations are relatively close to each other (only 71.5km apart) and the trends are similarly small and slightly downward (less than 1°F over the POR). This indicates that summer extreme readings are trending a bit less than several decades ago. The average annual maximum temperature is 96.3°F ($\pm 1\text{SD}$ ranges from 93.4-99.1°F) at Lynchburg ($R^2 = 0.73$) and 96.9°F ($\pm 1\text{SD}$ ranges from 93.6-100.3°F) at Roanoke ($R^2 = 0.99$) (Table 2).



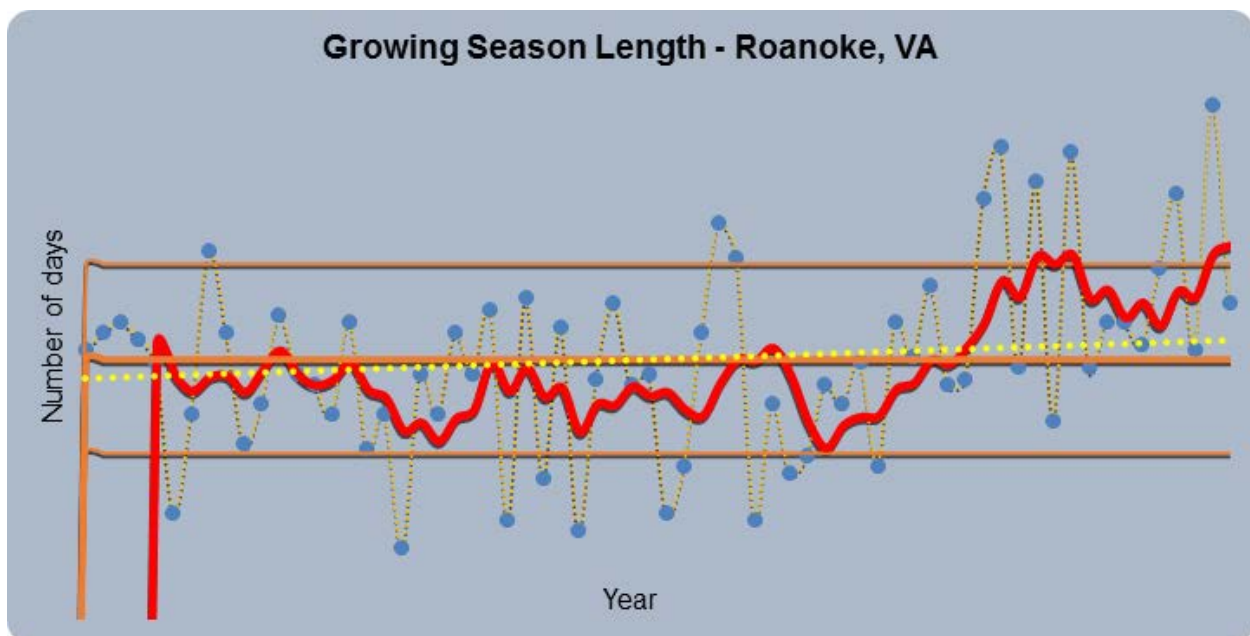


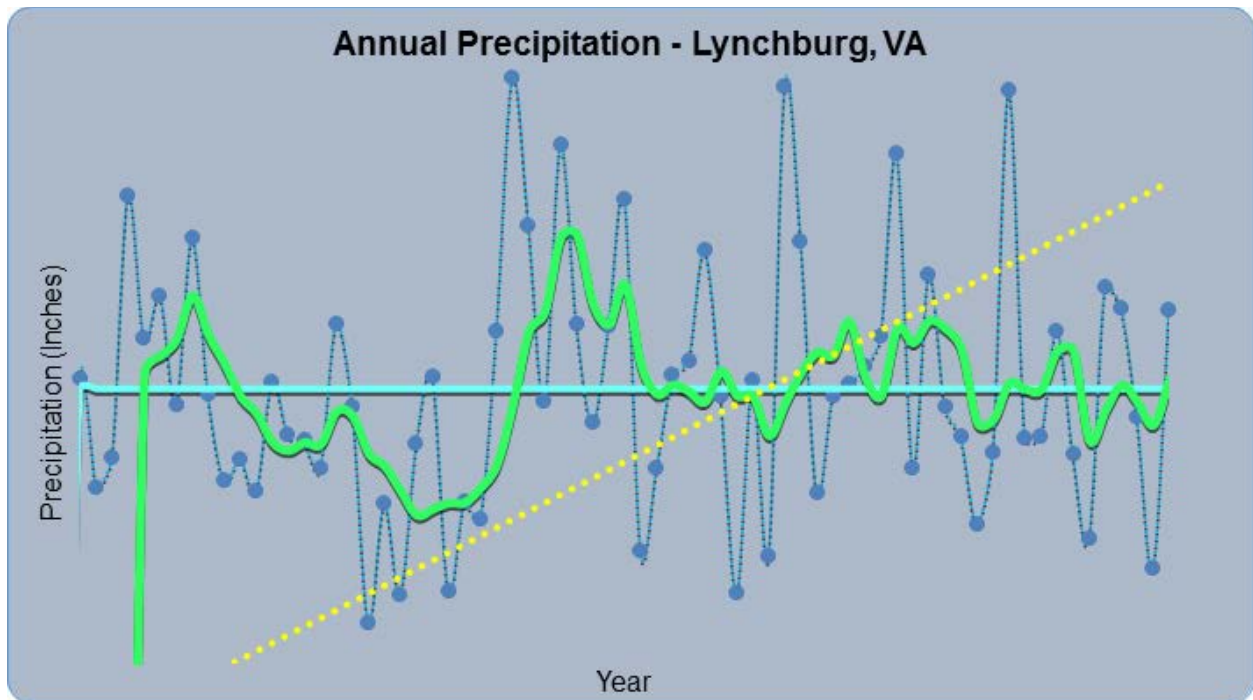
Annual Number of Days with Minimums at or below Freezing: The trend does show a steady increase with about 15 more nights below freezing now compared to 70 years ago at Lynchburg, but oddly about the same number decrease at Roanoke. Minimum temperatures are very sensitive to any changes in the local surroundings. The average number of nights is $91 (\pm 1\text{SD ranges from } 78 - 103)$ at Lynchburg ($R^2 = 0.75$) and $86 (\pm 1\text{SD ranges from } 73 - 98)$ at Roanoke ($R^2 = 0.95$) (Table 2).



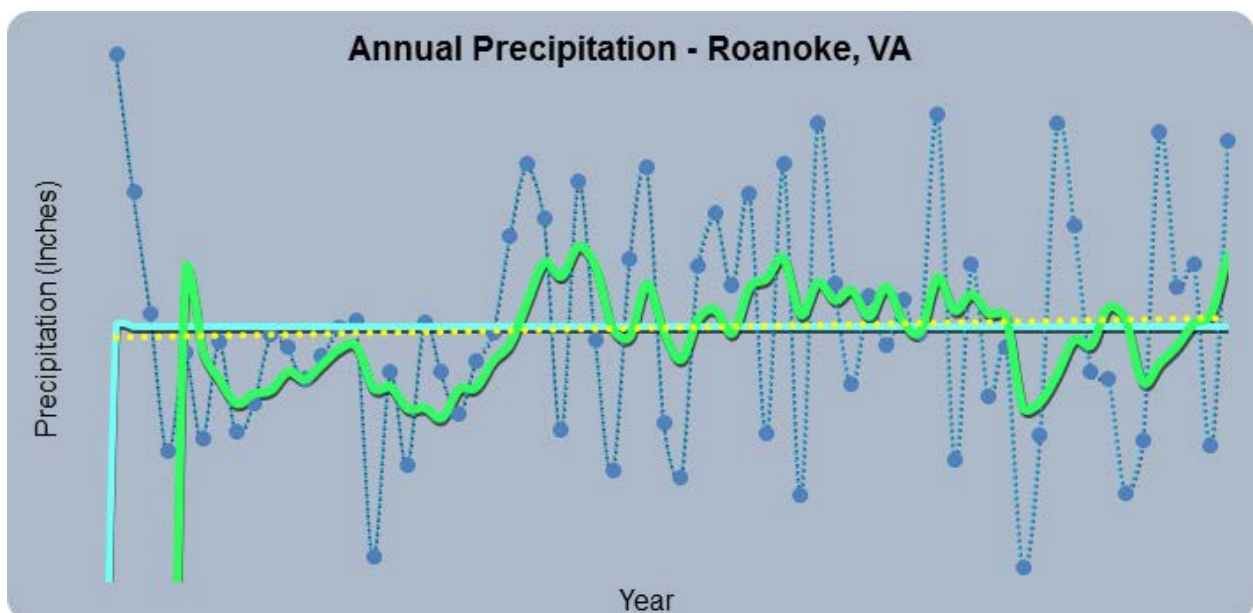


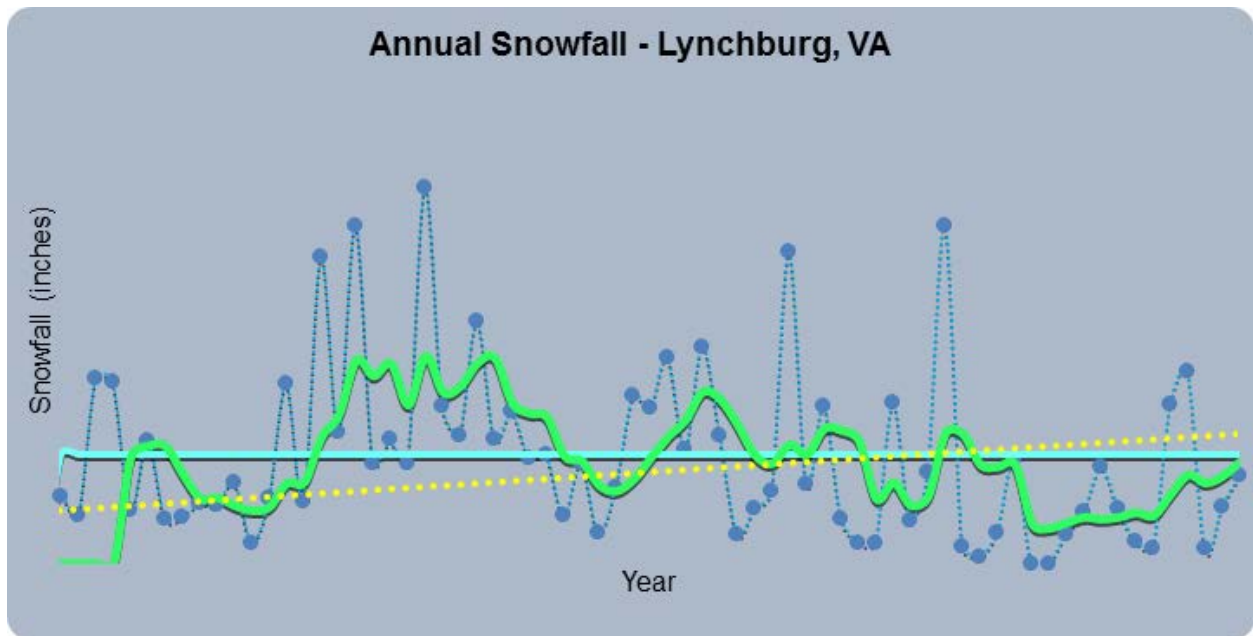
Growing Season Length Trends: Lynchburg displays a modest decrease (about two weeks) in the growing season in the past 70 years. However, Roanoke shows a steady increase in the length of the growing season with about a two to three week increase for the same period. The average annual number of days in the growing season is 194 (± 1 SD ranges from 177-211) at Lynchburg ($R^2 = 0.70$) and 194 (± 1 SD ranges from 178-211) at Roanoke ($R^2 = 0.99$) (Table 2).



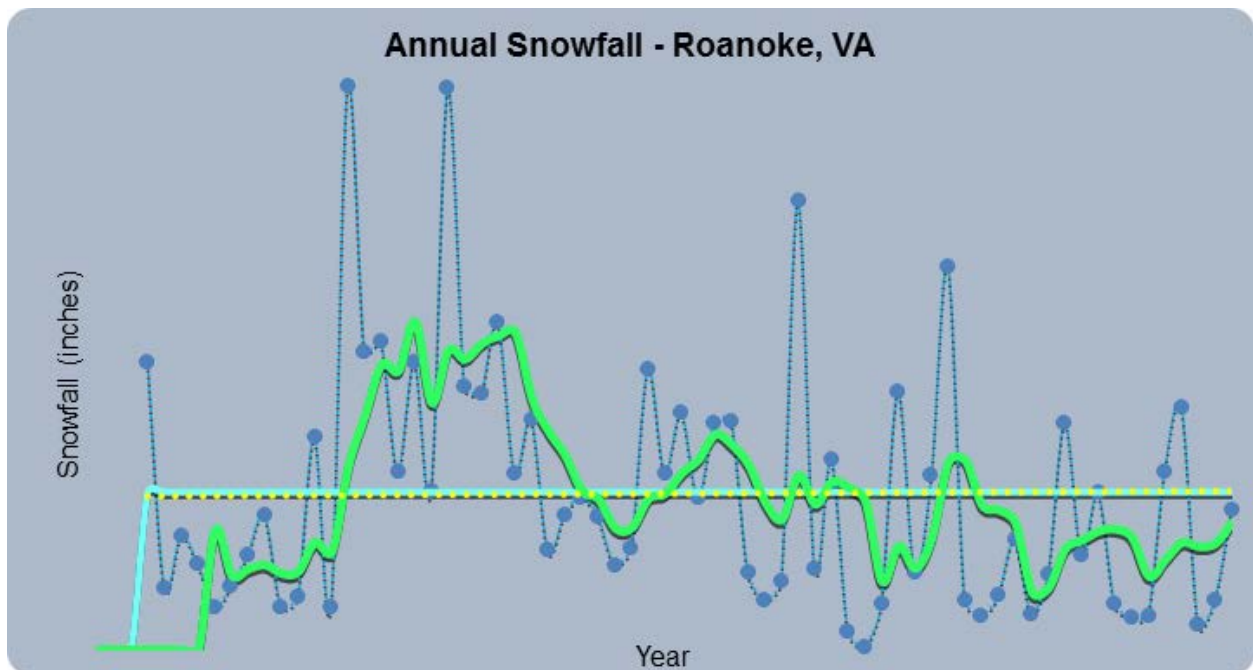


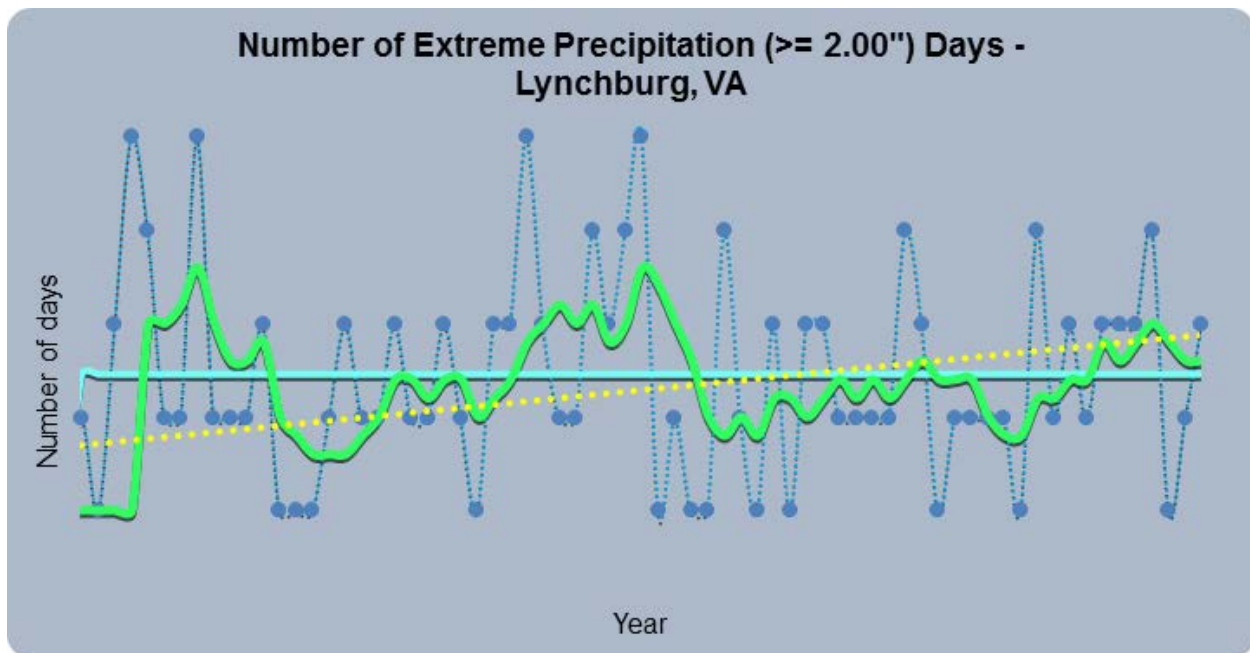
Annual Precipitation Trends: Both stations show a small rise of the order of an additional month's worth of precipitation. The average annual precipitation at Roanoke is 40.8 in. (min of 24.9 in and max of 58.8 in) ($R^2 = 0.69$) and 40.8 in (min of 26.6 in and max of 59.7 in) at Lynchburg ($R^2 = 0.93$) (Table 6).



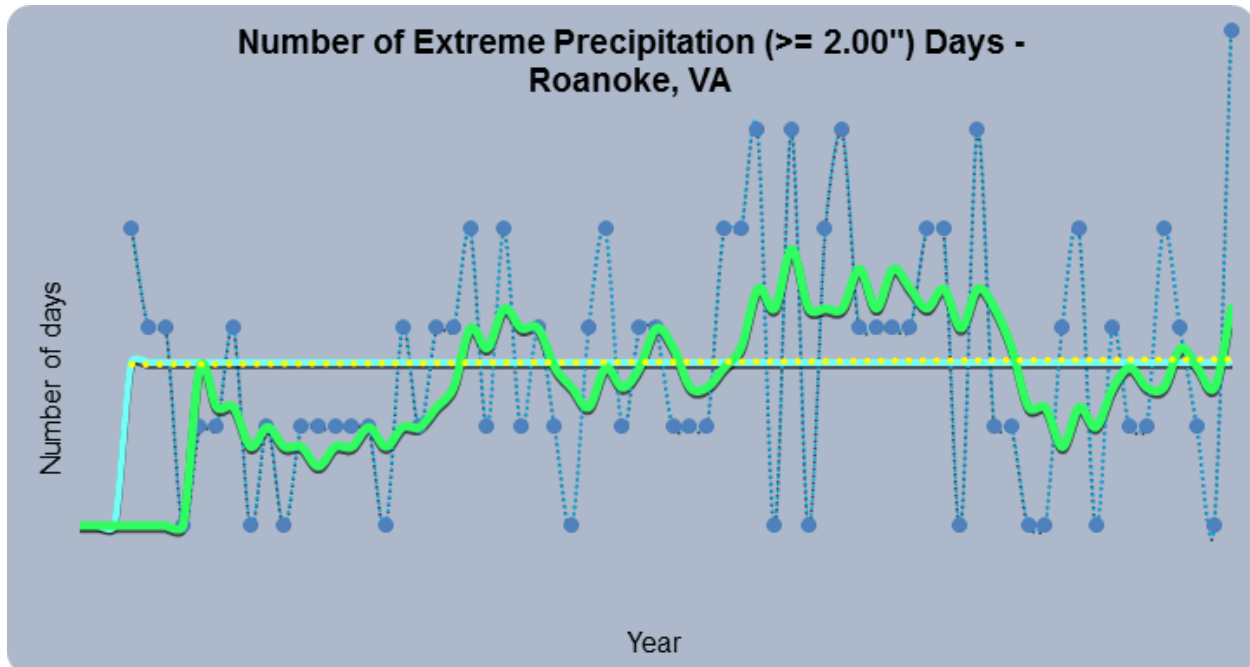


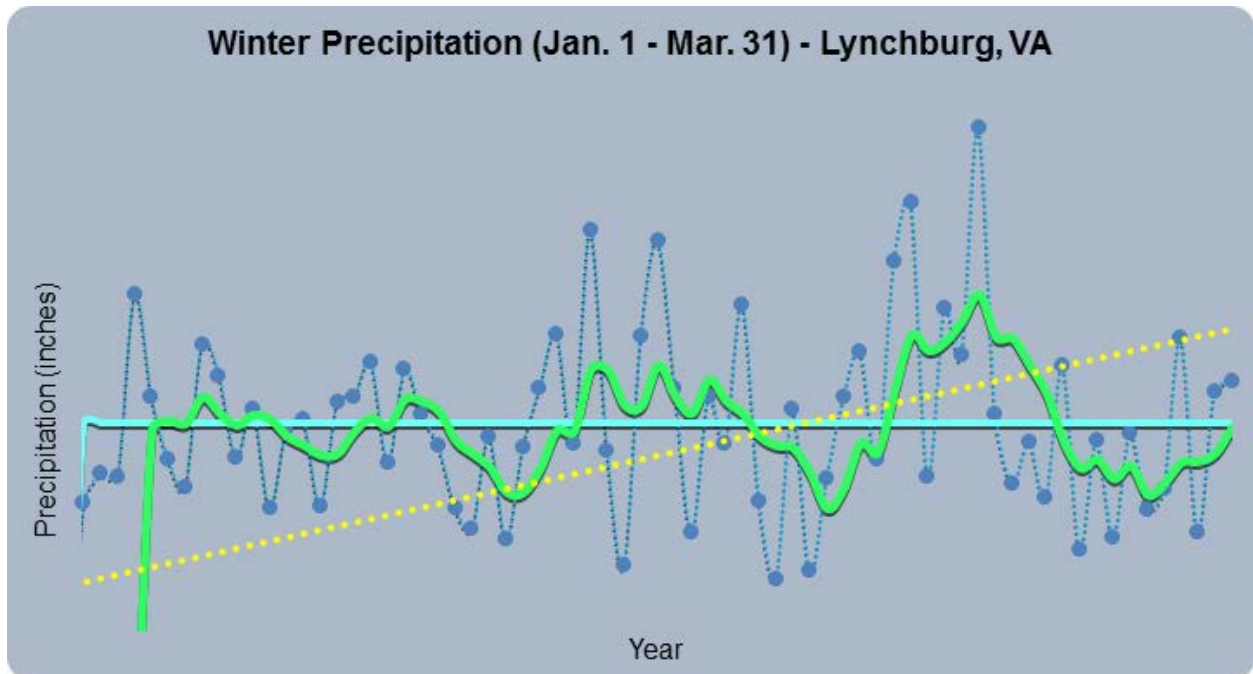
Annual Snowfall Trends: Both stations show a decrease in annual snowfall of about 30%. The average annual snowfall amount at Lynchburg is 16.1 in. (min of 0.0 in and max of 56.0 in) ($R^2 = 0.22$) and 20.2 in (min of 0.4 in and max of 72.5 in) at Roanoke ($R^2 = 0.43$) (Table 6).



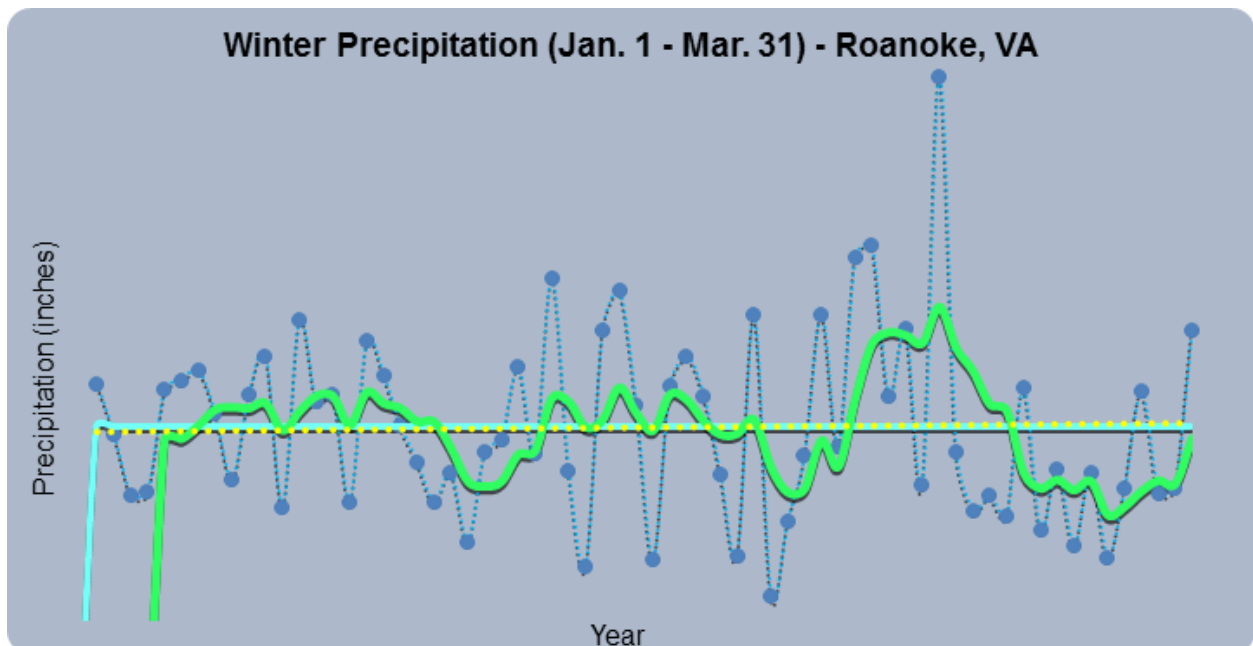


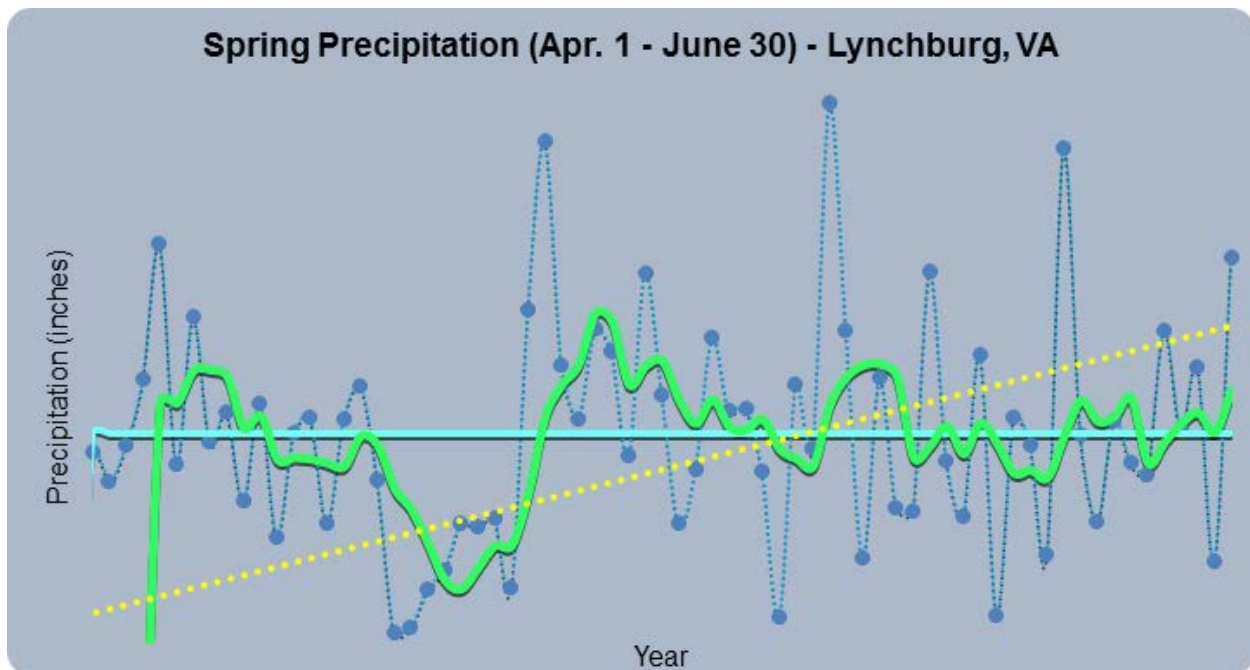
Annual Number of Extreme Precipitation Events: Lynchburg shows no trend, whereas Roanoke displays an upward trend, with an increase of about a day over the past 70 years. The average number of days at Lynchburg is 1 (min of 0 and max of 4) ($R^2 = 0.31$) and 2 (min of 0 and max of 5) at Roanoke ($R^2 = 0.46$) (Table 6).



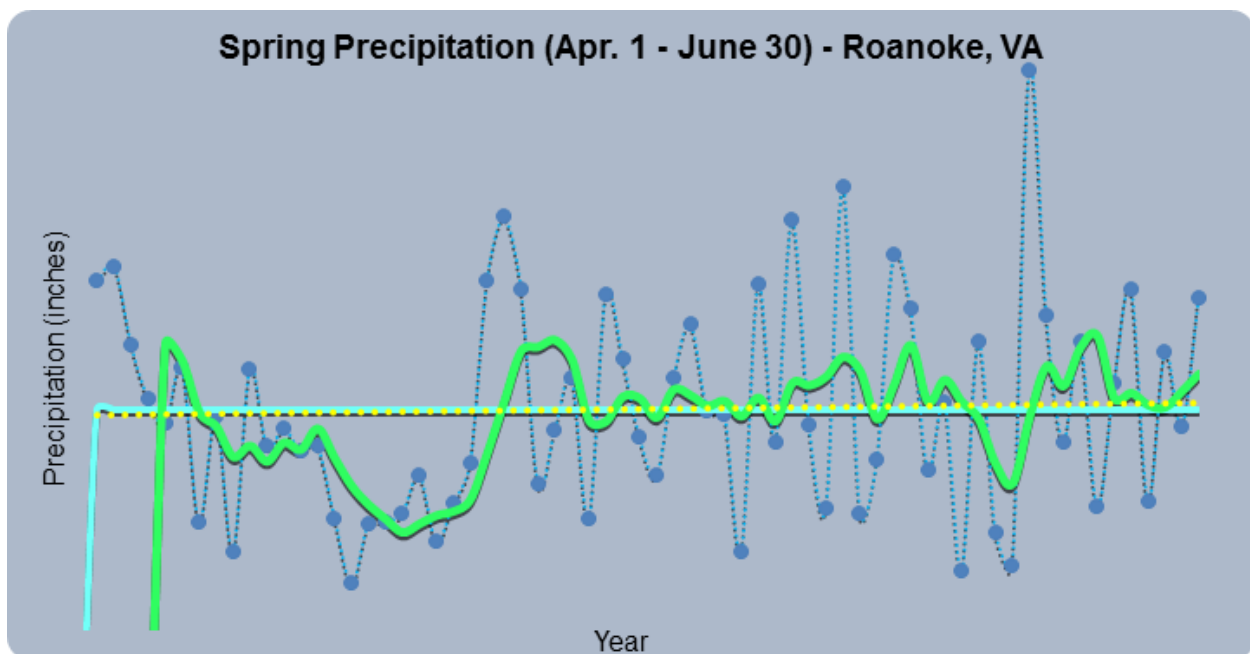


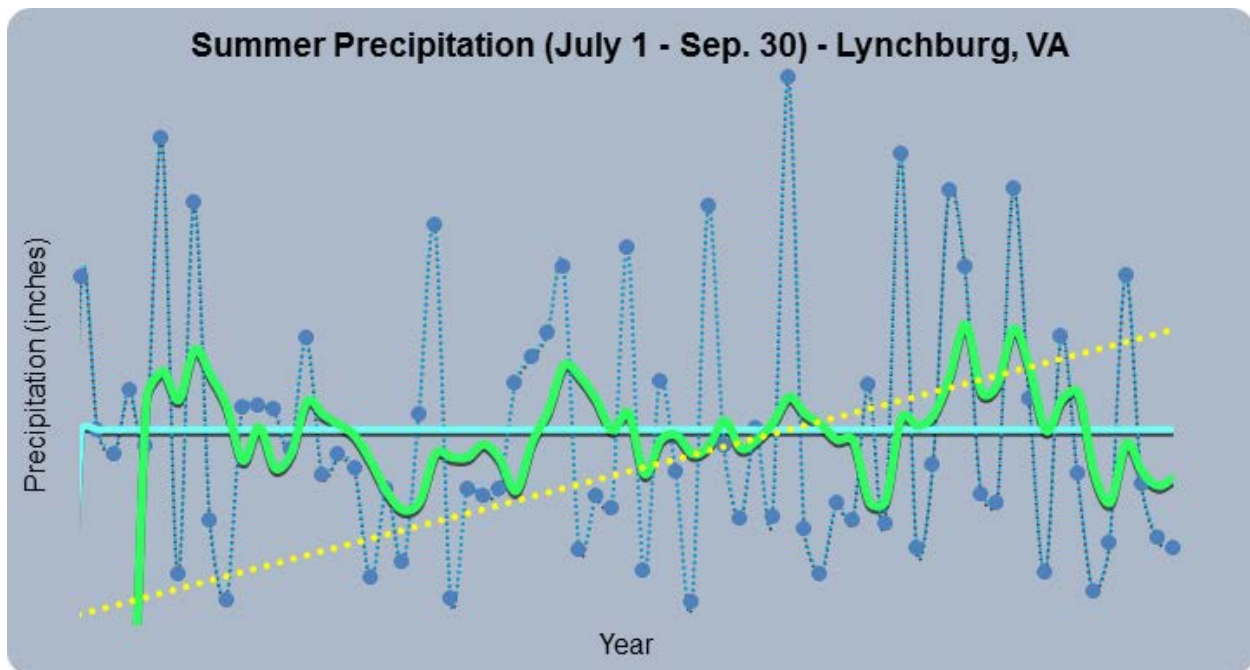
Winter Precipitation Trends: Lynchburg shows a very slight increase, whereas Roanoke displays a small downward trend. Lynchburg's winter precipitation has ranged between 4.7 in to as much as 19.0 in over its period of record ($R^2 = 0.62$) while Roanoke has ranged from 3.8 in to 21.2 in ($R^2 = 0.81$).



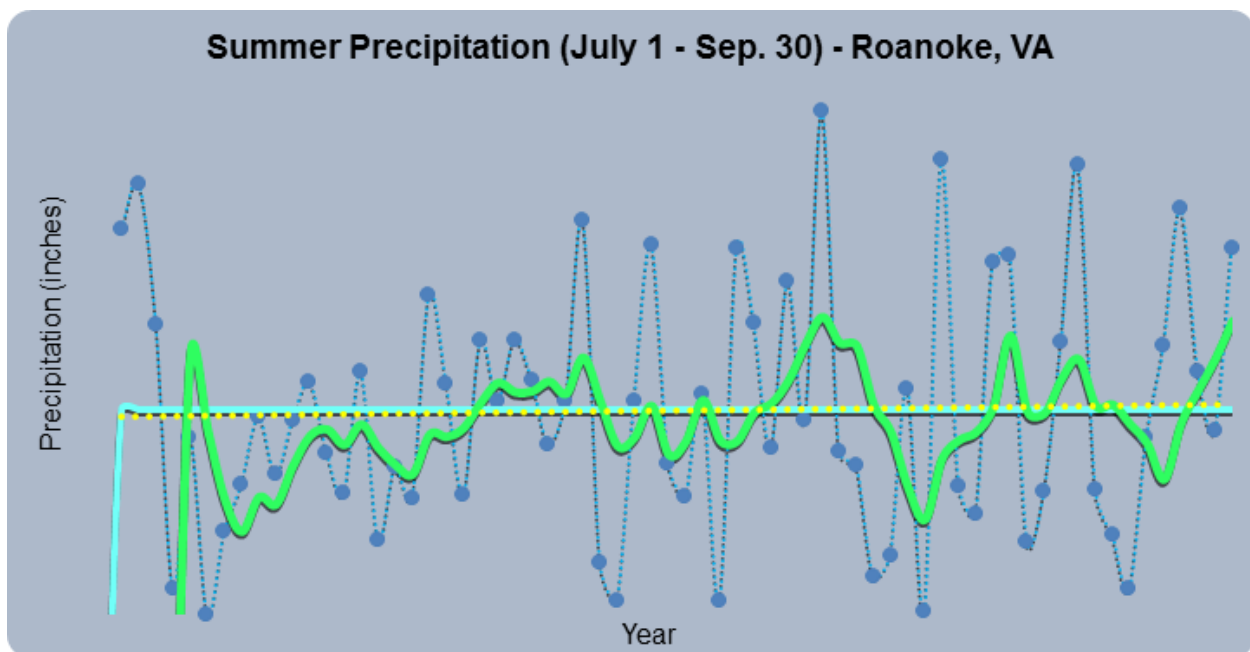


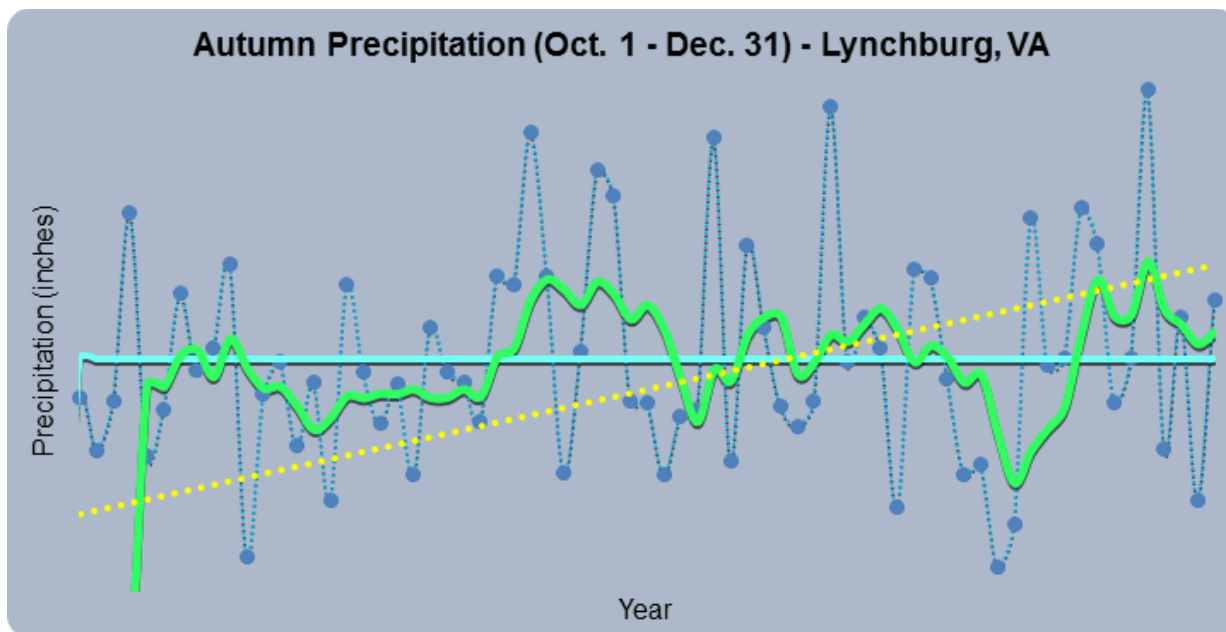
Spring Precipitation Trends: Both stations show a slight increase (about 15%) during the last 70 years. Lynchburg has seen as much as 20.6 in and as little as 4.3 in during the spring ($R^2 = 0.61$) while Roanoke has seen between 5.4 and 21.4 in ($R^2 = 0.83$).



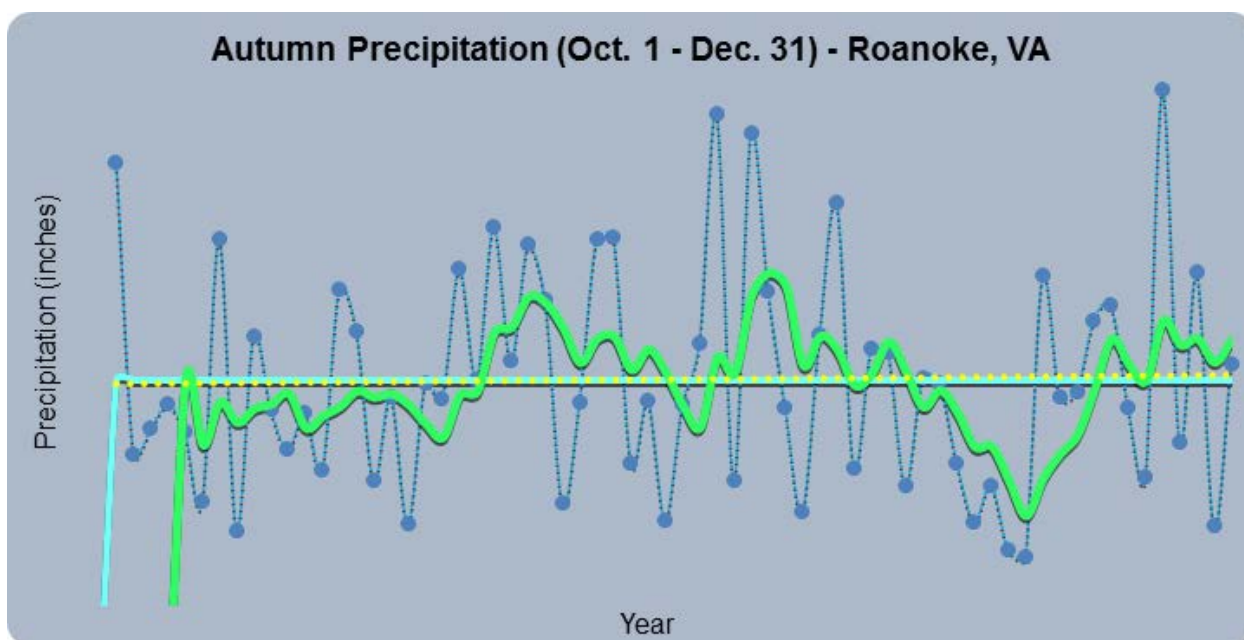


Summer Precipitation Trends: Lynchburg shows a small decrease, whereas Roanoke displays a slight increase. Lynchburg's summer precipitation has ranged between 5.7 to 22.6 in ($R^2 = 0.54$) while Roanoke has seen a minimum of 5.0 in to a maximum of 20.7 in ($R^2 = 0.80$).





Autumn Precipitation Trends: Lynchburg shows a small increase in autumn precipitation with Roanoke demonstrating no change. The average total of precipitation during the autumn is 9.5 in (min of 2.8 and max of 18.2 in) at Lynchburg ($R^2 = 0.60$) compared to an average of 9.1 in (min of 3.5 and max of 18.3 in) at Roanoke ($R^2 = 0.76$) (Table 6).



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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