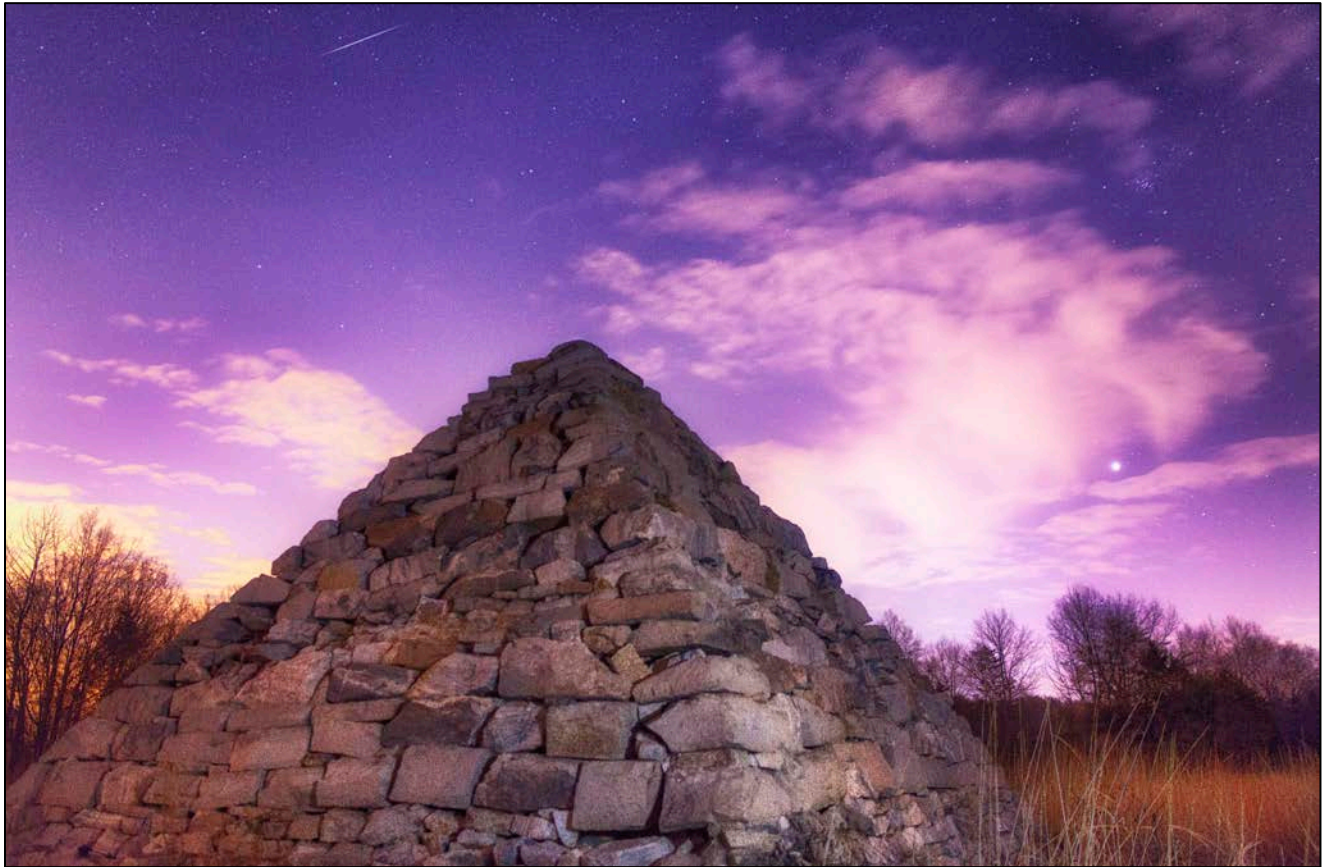




Weather of Fredericksburg and Spotsylvania National Military Park

Mid-Atlantic Network Summary Report for 2015

Natural Resource Report NPS/MIDN/NRR—2016/1325



ON THE COVER

Photograph of Fredericksburg and Spotsylvania National Military Park.
Photograph courtesy of Buddy Secor.

Weather of Fredericksburg and Spotsylvania National Military Park

Mid-Atlantic Network Summary Report for 2015

Natural Resource Report NPS/MIDN/NRR—2016/1325

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Abstract

The Mid-Atlantic Network (MIDN) Weather and Climate Monitoring protocol supports the objective to document the current status and long-term trends in air temperature and precipitation at multiple temporal and spatial scales. The purpose of this report is to provide a concise weather and climate summary for Fredericksburg and Spotsylvania National Military Park for the time period of January 1 to December 31, 2015. The park is located in the Eastern Piedmont climate division of Virginia. A total of seven weather stations were selected as representative of local weather and climate conditions, and a large suite of precipitation and temperature metrics were summarized. Ultimately, 2015 was a very warm year and ranked as the 10th warmest since records began in 1895. In fact, the autumn of 2015 was the warmest autumn ever recorded in the Western Piedmont. The year was also very wet, being the 18th wettest on record. No drought conditions were reported during 2015.

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, 2015, 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 2015'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 (for the most recent trend report, see Knight et al. 2016). These key indicators are further described in the protocol (Marshall et al. 2012) and summarized in this report.

Climate of the Eastern Piedmont Region 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. The Eastern Piedmont 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), though 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, and 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 and Climate Indicators

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 2015 (Figure 1). Representative stations within a 100-km range of the 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 2015 report: Culpepper Regional Airport, Shannon Airport, Piedmont Research Station, Corbin, Fredericksburg Sewage Plant, Louisa, and Fredericksburg Battlefield (Table 1, Figure 1).

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 2013) 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

Figure 1. Location of weather observing stations around Fredericksburg and Spotsylvania National Military Park selected as most representative of the park in 2015. See Table 1 for station names.

Table 1. List of weather observing stations around Fredericksburg and Spotsylvania National Military Park selected as most representative of the parks in 2015.

Station	Observing Network ¹	Name	Period of Record (POR)	Percentage of Time Reporting Temperature for 2015	Percentage of Time Reporting Precipitation for 2015	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	98.1	98.1	97.5	38.7
KEZF	ASOS	Shannon Airport	01/01/1996 - Present	100.0	100.0	92.7	27.0
ORGV2	COOP	Piedmont Research Station	11/01/1946 - Present	100.0	100.0	99.8	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	93.7	96.7	95.7	95.4
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	99.7

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.

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 2015 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>.

Temperature Summary

Annual average temperatures during the calendar year 2015 were above normal around Fredericksburg and Spotsylvania NMP, ranking 2015 as the 10th warmest on record (Tables 2 and 3). Both average daytime maximum temperatures and average nighttime minimum readings did not stray far from their long-term averages (Table 4).

The winter months of January-February-March were very chilly across the region (Figures 2 and 3)¹. The largest departures from normal occurred during the month of February where readings were between 8.0°F and 9.6°F (4.5°C to 5.3°C) below normal (Table 2). All reporting stations reported below average temperatures in all three months of the season (Table 2). Winter, as a whole, ranked as the 14th coolest in 121 years in the Eastern Piedmont (Table 3).

Spring would turn rather mild, primarily due to a very warm May (Figures 2 and 3). The weather station at Corbin reported an average temperature of 69.5°F (21.8°C) during the month of May, which is 5.7°F (3.1°C) above the historical average (Tables 2 and 5). The highest maximum temperature for the year of 93.0°F (33.9°C) occurred on June 24th at Piedmont Research Station (Table 4). Primarily due to such a mild May, the spring months of April through June ranked as the 2nd warmest since records began in 1895 (Table 3).

The summer months temperatures were generally a bit below average, though temperatures rose to above normal levels in September (Tables 2 and 5). The vast majority of the season saw near-normal temperatures, with departures ranging from -2.9°F (-1.7°C) at Louisa, VA during July to +3.2°F (+1.7°C) at Fredericksburg Sewage Plant during September (Table 2). The number of hot days was below normal at both Louisa and Piedmont Research Station for the calendar year, primarily due to a slightly cool July and August (Table 4). Ultimately, the summer season tied as the 36th warmest in 121 years of records in the Eastern Piedmont (Table 3).

October 2015 was another near-normal month for temperatures, but very mild weather ensued for the final two months of the year (Figures 2 and 3). November was a warm month for the region, ranking 6th warmest since records began in the Eastern Piedmont, but December had the more exceptional warmth. December brought anomalies ranging from 10.4°F to 13.1°F (5.7°C to 7.3°C) above normal (Table 2). The autumn season, along with the month of December, ranked as the warmest on record for the region (Table 3).

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. Summary of 2015 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	-2.1°F	-9.6°F	-3.3°F	0.0°F	4.1°F	0.9°F	-0.8°F	-0.7°F	2.2°F	-0.3°F	4.1°F	11.2°F	0.6°F
		-1.2°C	-5.3°C	-1.8°C	0.0°C	2.3°C	0.5°C	-0.4°C	-0.4°C	1.2°C	-0.2°C	2.3°C	6.2°C	0.4 °C
Corbin	CORV2	-0.6°F	-8.0°F	-1.4°F	2.0°F	5.7°F	2.0°F	-0.2°F	-0.5°F	3.1°F	0.0°F	4.5°F	13.1°F	1.8°F
		-0.3°C	-4.5°C	-1.2°C	1.1°C	3.1°C	1.1°C	-0.1°C	-0.3°C	1.7°C	0.0°C	2.5°C	7.3°C	1.0 °C
Fredericksburg Sewage Plant ¹	FEDV2	-1.1°F	-9.0°F	M	1.1°F	4.6°F	1.8°F	-1.0°F	-0.7°F	3.2°F	M	3.3°F	11.5°F	1.1 °F
		-0.7°C	-5.0°C	M	0.6°C	2.5°C	1.0°C	-0.5°C	-0.4°C	1.7°C	M	1.8°C	6.4°C	0.6°C
Louisa	LOUV2	-1.0°F	-8.2°F	-1.1°F	0.8°F	1.7°F	-0.7°F	-2.9°F	-2.2°F	0.9°F	-1.8°F	2.6°F	10.4°F	0.1 °F
		-0.5°C	-4.5°C	-0.6°C	0.4°C	1.0°C	-0.4°C	-1.7°C	-1.3°C	0.5°C	-1.0°C	1.5°C	5.7°C	0.1 °C

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

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.

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Table 3. Seasonal and annual temperature and precipitation rankings for 2015 over 121 years for the Eastern Piedmont (NOAA 2015).

Parameter	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-2015	107	2	36-T	1	10
Precipitation-2015	65	33	70	10	18

1 = warmest/wettest year and 121 = coldest/driest year. T = tie between multiple years

Table 4. Status of 2015 temperature indicators compared to the 30-year normal (1981-2010) Louisa (LOUV2) and Piedmont Research Station (ORGV2) weather observing stations¹.

Temperature Indicator	Louisa, VA 2015	Louisa, VA 1981–2010	Piedmont Research Station, VA 2015	Piedmont Research Station, VA 1981-2010
Average Annual Temperature	56.8°F 13.8°C	56.8°F 13.8°C	56.2°F 13.4°C	55.8°F 13.2°C
Average Annual Maximum Temperature	68.4°F 20.2°C	68.7°F 20.4°C	66.4°F 19.1°C	66.2°F 19.0°C
Maximum Temperature	92.0°F 33.3°C	96.5°F 35.8°C	93.0°F 33.9°C	97.0°F 36.1°C
Hot Days (days with Tmax≥90°F/32°C)	20	31	20	22
Average Annual Minimum Temperature	44.8°F 7.1°C	44.9°F 7.2°C	46.1°F 7.8°C	45.5°F 7.5°C
Minimum Temperature	-5.0°F -20.6°C	0.5°F -17.5°C	-2.0°F -18.9°C	3.5°F -15.8°C
Cold Days (days with Tmax≤32°F/0°C)	9	5	15	9
Sub-freezing Days (days with Tmin≤32°F/0°C)	94	100	86	92
Sub-zero Days (days with Tmin≤-0°F/-18°C)	1	1	1	0
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	188	169	196	210

Table 5. Summary of 2015 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	32.5°F	27.7°F	43.4°F	57.3°F	68.0°F	72.5°F	74.3°F	72.1°F	67.9°F	53.5°F	48.6°F	46.7°F	55.4°F
		0.3°C	-2.4°C	6.3°C	14.1°C	20.0°C	23.1°C	23.5°C	22.3°C	19.9°C	11.9°C	9.2°C	8.2°C	14.0°C
Shannon Airport	KEZF	34.8°F	30.4°F	45.0°F	58.7°F	71.6°F	77.1°F	78.5°F	76.8°F	71.1°F	56.1°F	51.1°F	49.5°F	58.4°F
		1.6°C	-0.9°C	7.2°C	14.8°C	22.0°C	25.1°C	25.8°C	24.9°C	21.7°C	13.4°C	10.6°C	9.7°C	14.2°C
Piedmont Research Station	ORGV2	32.2°F	27.7°F	41.7°F	55.3°F	67.8°F	73.5°F	75.6°F	74.2°F	70.2°F	56.4°F	51.6°F	48.7°F	56.4°F
		0.1°C	-2.4°C	5.4°C	12.9°C	19.9°C	23.1°C	24.2°C	23.4°C	21.2°C	13.6°C	10.9°C	9.3°C	13.6°C
Corbin	CORV2	34.1°F	29.9°F	44.1°F	57.5°F	69.5°F	74.7°F	76.6°F	74.8°F	71.4°F	57.2°F	52.4°F	51.4°F	58.0°F
		1.2°C	-1.2°C	6.3°C	14.2°C	20.8°C	23.7°C	24.8°C	23.8°C	21.9°C	14.0°C	11.3°C	10.8°C	14.4°C
Fredericksburg Sewage Plant	FEDV2	33.7°F	28.4°F	M	56.3°F	68.8°F	75.3°F	76.4°F	75.4°F	72.2°F	M	50.8°F	49.7°F	57.4°F
		0.9°C	-2.0°C	M	13.5°C	20.4°C	24.1°C	24.7°C	24.1°C	22.3°C	M	10.4°C	9.8°C	14.1°C
Louisa	LOUV2	35.0°F	30.9°F	45.6°F	57.4°F	66.5°F	72.5°F	74.2°F	73.3°F	69.3°F	55.6°F	50.3°F	48.8°F	56.8°F
		1.7°C	-0.6°C	7.6°C	14.1°C	19.2°C	22.5°C	23.4°C	22.9°C	20.7°C	13.1°C	10.2°C	9.3°C	13.8°C
Fredericksburg Battlefield	VAFSP	27.6°F	29.1°F	44.1°F	57.9°F	69.5°F	74.9°F	76.7°F	74.6°F	71.0°F	56.3°F	51.7°F	50.4°F	57.0°F
		-2.4°C	-1.6°C	6.7°C	14.4°C	20.8°C	23.8°C	24.8°C	23.7°C	21.7°C	13.5°C	10.9°C	10.2°C	13.9°C

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

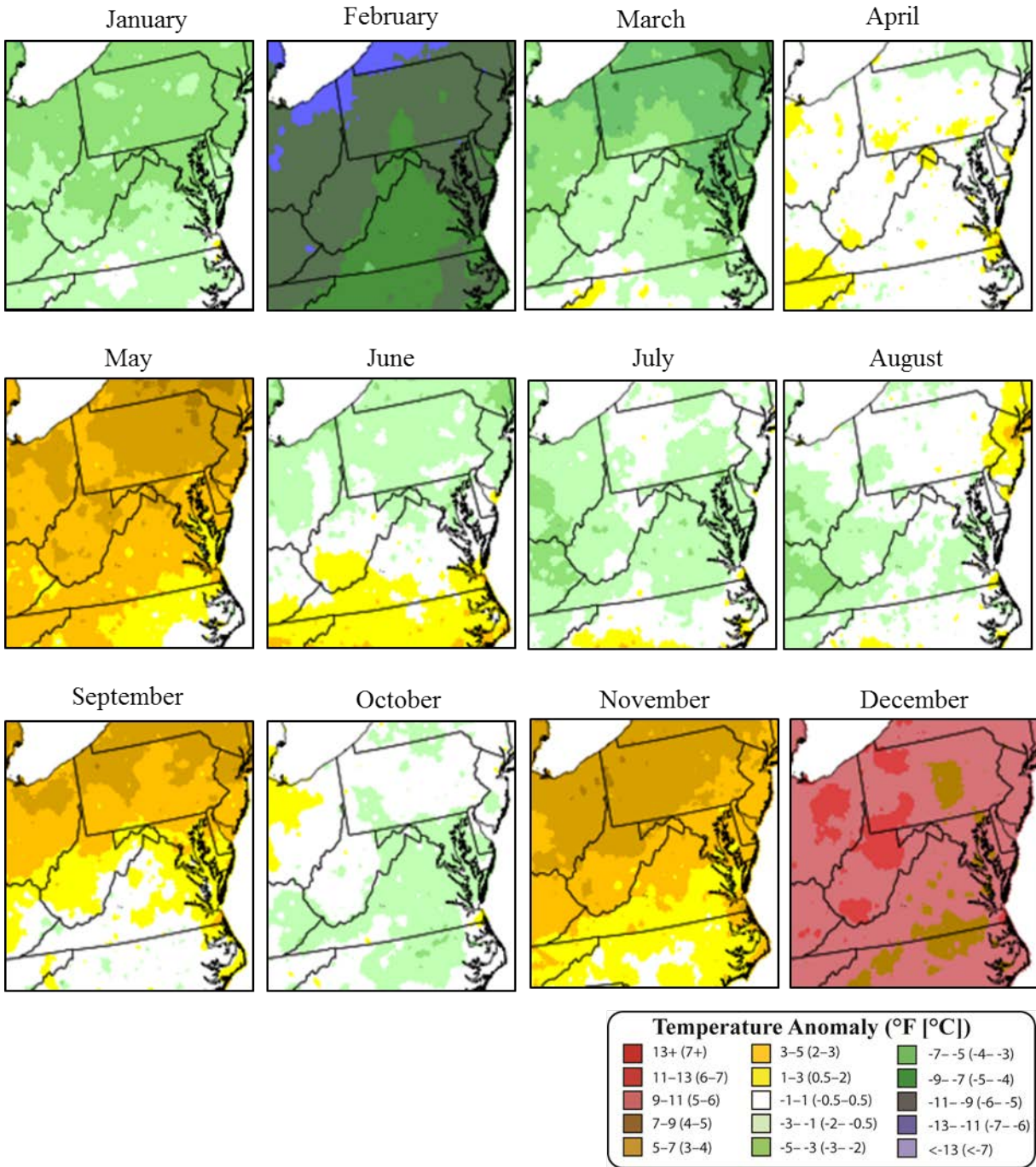


Figure 2. Maps showing departure from average monthly maximum temperature in 2015 compared to the 30-year normal (1981–2010).

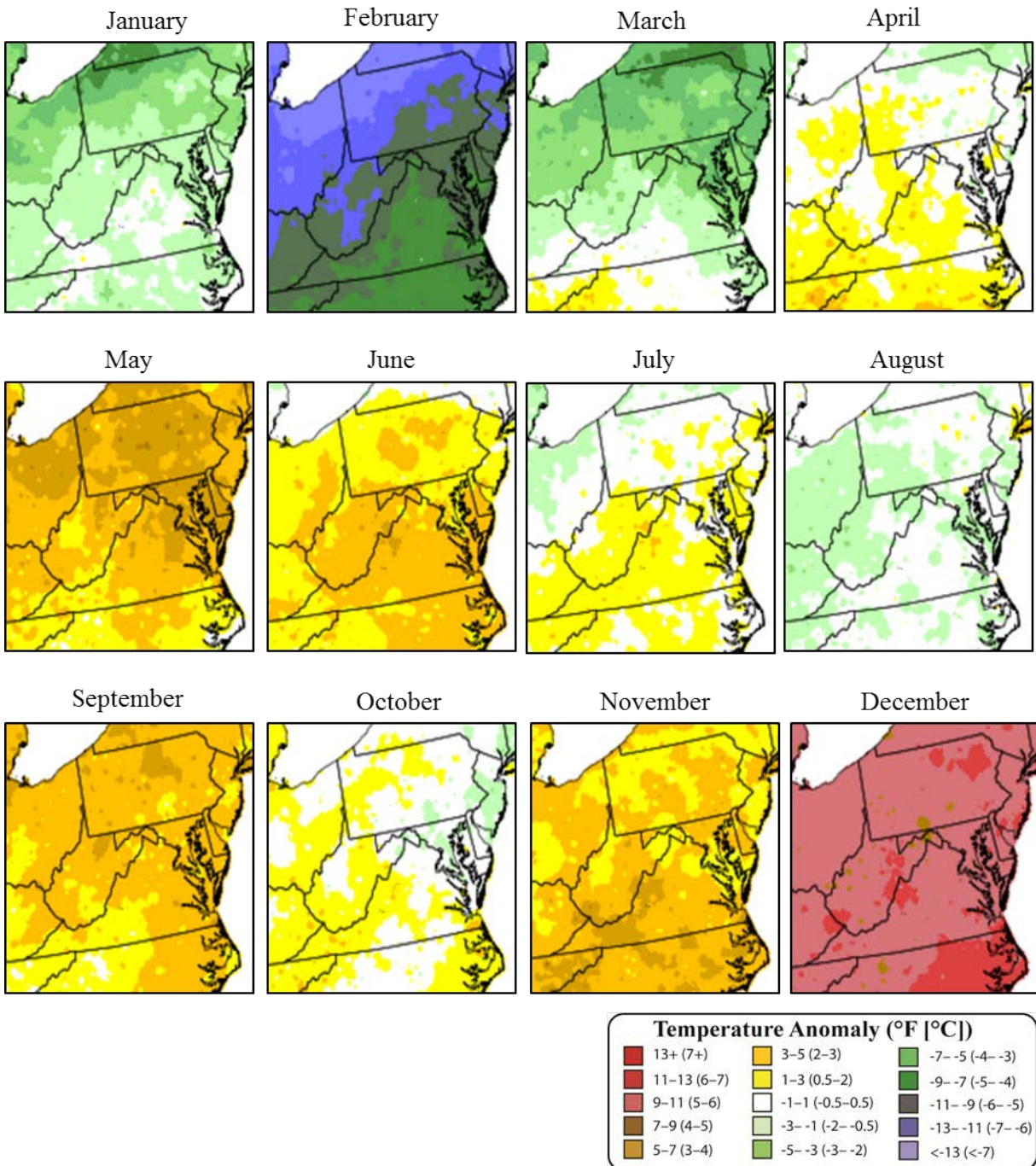


Figure 3. Maps showing departure from average monthly minimum temperature in 2015 compared to the 30-year normal (1981–2010).

Precipitation Summary

Total precipitation during 2015 straddled normal levels at observing stations near Fredericksburg and Spotsylvania NMP, with some reporting amounts slightly below and others slightly above normal (Tables 6 and 7). Louisa, VA reported just 88% of normal precipitation for the year while Piedmont Research Station measured 107% of its annual normal. Nevertheless, due to a moist spring and a very wet fall, the year ranked as the 10th wettest recorded across the entire region of the Eastern Piedmont.

The winter months of January through March were generally drier than normal across the region (Table 7). March was the wettest month of the three, with 4.0 in (101 mm) tallied at Fredericksburg Sewage Plant, matching its long-term average value for the month (Tables 7 and 8). A notable dry spell occurred late in the month, however, from March 29-April 6, a 9-day period without measurable precipitation (Table 9). The first three months of the year were the 57th driest for the Eastern Piedmont (Table 3). Even so, snowfall for the year was 3.5 in (8.6 mm) above normal at Louisa, VA (Table 6).

Spring 2015 was bookended by very wet months in both April and June, with a very dry May in between (Figure 4). May was one of the drier months of the year, in fact, with precipitation totals of between 57 and 87% of normal across all reporting stations (Table 7). After such a dry May and the dry weather that occurred during winter, there were some concerns of drought that arose during this time. The very wet June brought much-needed rains to the region that erased any drought concerns. During June, 6.8 in (173 mm) of rain fell at Fredericksburg Sewage Plant, 172% of the long-term normal for the month (Tables 7 and 8). The back-and-forth between wet and dry during the season resulted in a ranking of 33rd wettest in 121 years of records (Table 3).

The summer months of July through September had widely varying precipitation totals across the region. September precipitation ranged from 2.1 in (52 mm) to 7.2 in (183 mm), a disparity of over 5 inches of rain for the month across the reporting stations near Fredericksburg and Spotsylvania NMP (Table 8). August was an exceptionally dry month, with just 17 to 44% of normal precipitation tallied during this period (Table 7). The longest dry spell of the year began in late August and lasted through early September, a streak of 18 days without measurable precipitation (Table 9). On the other hand, three of the top five wettest days of the year occurred during this season – July 29th, September 29th, and September 30th (Table 9). Summer 2015 was the 52nd driest since records began in 1895 (Table 3).

A sequence of wet month-dry month-wet month occurred during autumn 2015, where October and December were generally wetter than normal, and November was dry (Figure 4). Just 1.9 in (48 mm) of rain fell during the month of November at Fredericksburg Battlefield (Table 8). However, December precipitation ranged between 100 and 126% of normal. Autumn would ultimately rank as the 10th wettest on record, primarily due to contributions from precipitation during October and December (Table 3).

Table 6. Status of 2015 precipitation indicators compared to the 30-year normal (1981-2010) at Louisa (LOUV2) weather observing station.

Precipitation Indicator	Louisa, VA 2015	Louisa, VA 1981–2010
Annual Precipitation	39.0 in 991 mm	44.2 in 1,123 mm
Autumn (Oct, Nov, Dec) Precipitation	9.3 in 236 mm	10.9 in 277 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	9	12
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	1	2
Micro-drought (periods of 7+ days without rain)	11	8
Annual Snowfall	21.1 in 53.6 cm	17.7 in 45.0 cm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	6	6
Moderate Snow Days (days with ≥ 3.0 in (7.6 cm) snow)	4	2
Heavy Snow Days (days with ≥ 5.0 in (15.2 cm) snow)	1	1

Table 7. Summary of 2015 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	100	73	98	143	61	168	95	29	140	129	67	126	103
Fredericksburg Sewage Plant ¹	FEDV2	98	91	100	131	61	172	124	28	58	112	54	112	95
Louisa	LOUV2	54	51	81	108	57	164	61	44	172	96	65	100	88
Piedmont Research Station	ORGV2	76	52	98	128	87	158	125	17	174	152	60	108	107

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 departures from normal values were calculated with normals derived from data spanning the length of the station's Period of Record.

Table 8. Summary of 2015 monthly total rainfall for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Corbin	CORV2	3.1 in	2.2 in	3.9 in	4.7 in	2.4 in	6.2 in	3.8 in	1.0 in	5.7 in	4.8 in	2.4 in	4.2 in	44.6 in
		80mm	56 mm	100 mm	118 mm	61 mm	158 mm	97 mm	25 mm	146 mm	122 mm	112 mm	107 mm	1132 mm
Fredericksburg Sewage Plant	FEDV2	2.8 in	2.3 in	4.0 in	4.4 in	2.5 in	6.8 in	5.6 in	1.0 in	2.5 in	3.8 in	2.0 in	3.6 in	41.2 in
		72 mm	58 mm	101 mm	111 mm	64 mm	173 mm	143 mm	24 mm	63 mm	96 mm	51 mm	90 mm	1047 mm
Louisa	LOUV2	1.7 in	1.5 in	3.1 in	3.5 in	2.4 in	5.9 in	2.9 in	1.6 in	7.2 in	3.5 in	2.7 in	3.2 in	39.0 in
		42mm	38 mm	78 mm	89 mm	60 mm	151 mm	72 mm	40 mm	183 mm	88 mm	68 mm	81 mm	990 mm
Fredericksburg Battlefield	VAFSP	2.5 in	1.4 in	3.4 in	3.2 in	2.3 in	5.1 in	4.8 in	0.7 in	2.1 in	3.1 in	1.9 in	3.0 in	33.5 in
		64 mm	36 mm	87 mm	82 mm	58 mm	130 mm	121 mm	18 mm	52 mm	77 mm	48 mm	77 mm	851 mm
Piedmont Research Station	ORGV2	2.1 in	1.4 in	3.5 in	4.4 in	3.6 in	6.6 in	5.9 in	0.6 in	7.0 in	5.2 in	2.3 in	3.3 in	45.9 in
		53 mm	37 mm	89 mm	111 mm	92 mm	167 mm	150 mm	14 mm	179 mm	132 mm	59 mm	84 mm	1166 mm

Table 9. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2015 from weather observing stations at Fredericksburg Sewage Plant (FEDV2) and Louisa (LOUV2).

Wettest Days in 2015	Dry Spells in 2015
Sept. 29: 2.65 in (67 mm)	Aug. 22 – Sept. 8
Sept. 30: 1.68 in (43 mm)	Oct. 11 - 24
Oct 3: 1.45 in (37 mm)	Dec. 4 - 13
July 29: 1.36 in (35 mm)	Mar. 29 – Apr. 6
Oct 28: 1.31 in (33 mm)	Nov. 20 - 28

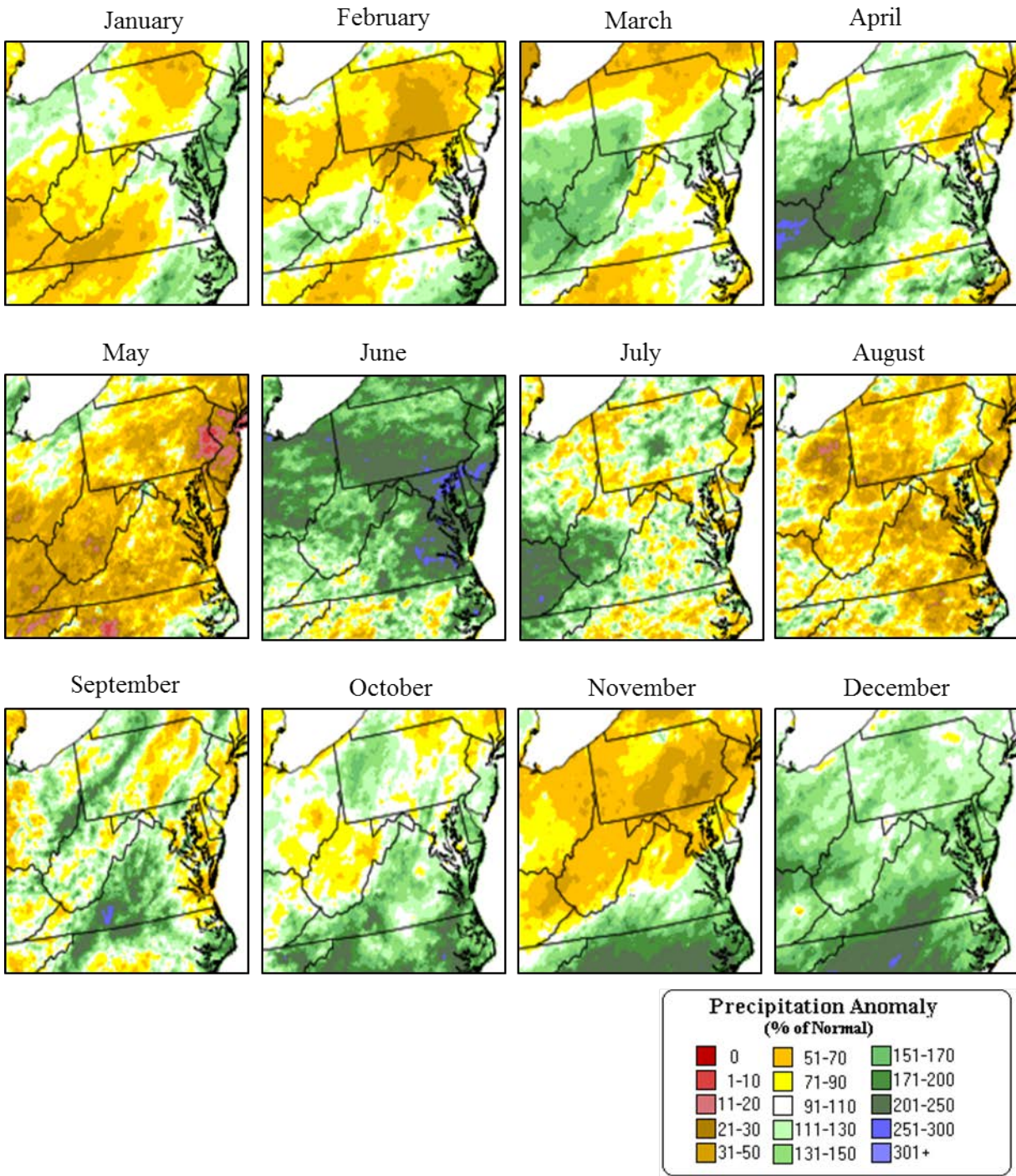


Figure 4. Maps showing percent of average monthly precipitation in 2015 compared to the 30-year normal (1981–2010).

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 2015 are shown in Figure 5.

According to the PDSI, 2015 began just slightly below average as negative PDSI values persisted through the end of May. The wet June reversed PDSI values from negative to positive but would quickly drop back to 0 by July. The remainder of the year would see steadily rising PDSI values, but no months of the year ever exceeded “normal” values. Compared to prior years, 2015 was almost a complete opposite of 2014, where values were highly positive in the early half of the year and dipped below 0 for the latter half of the year.

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 2015). 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 2015.

Based on the DM, although parts of Virginia were abnormally dry during certain seasons, no droughts occurred in the state during 2015 (Figure 6). Nevertheless, within the larger Southeast region some droughts did occur during the year (Figure 7).

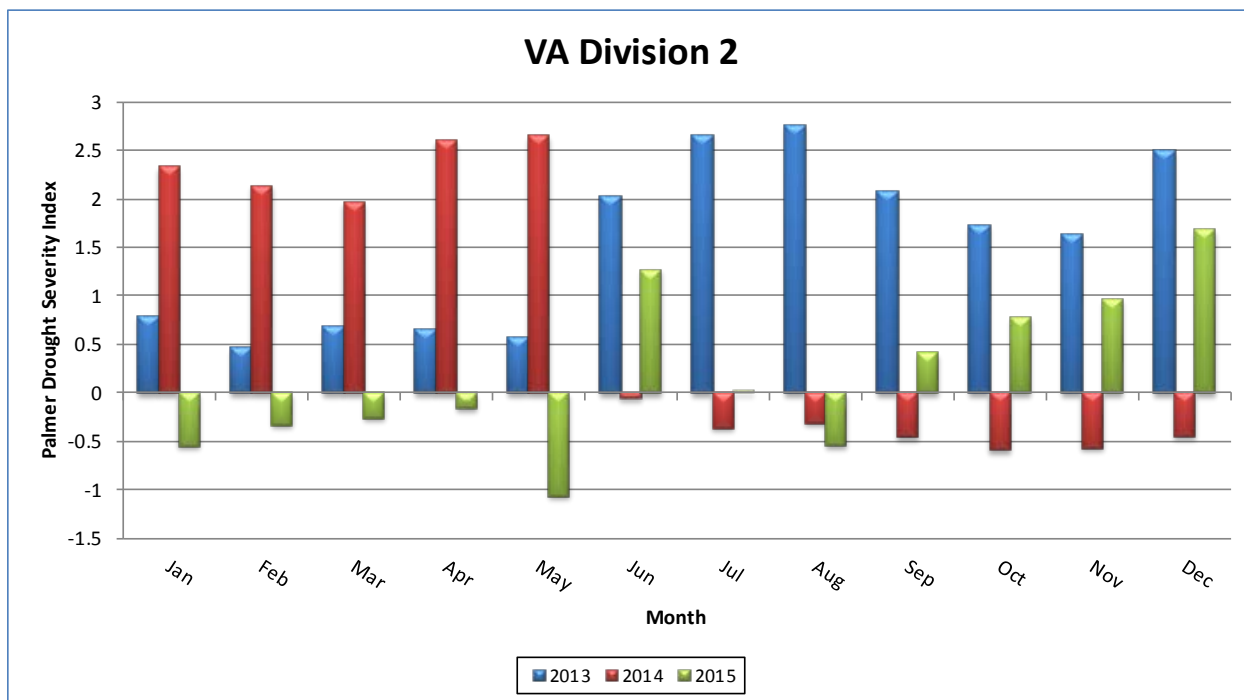


Figure 5. Monthly Palmer Drought Severity Index (PDSI) for the Eastern Piedmont, 2013–2015.

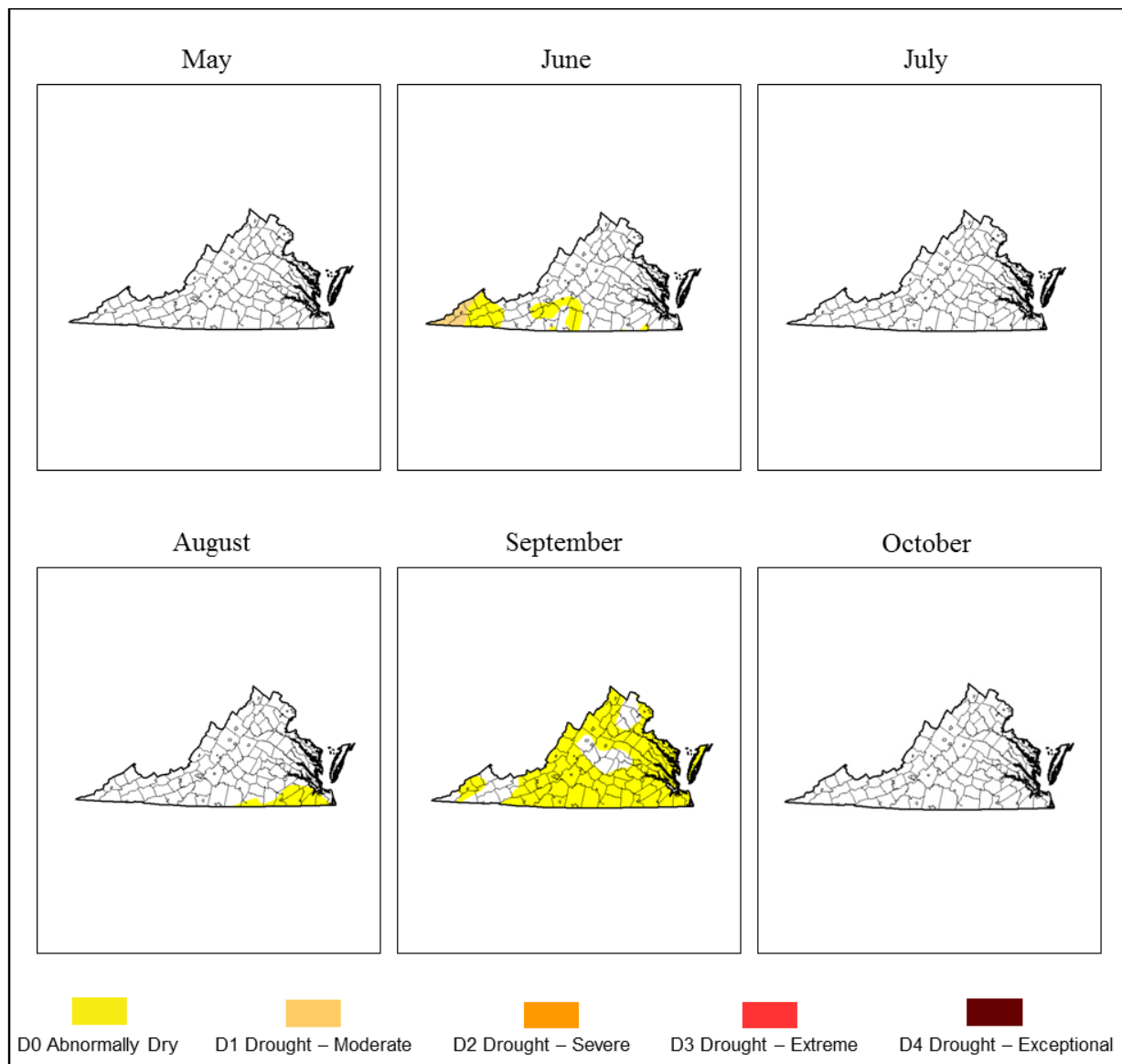


Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Virginia in 2015.

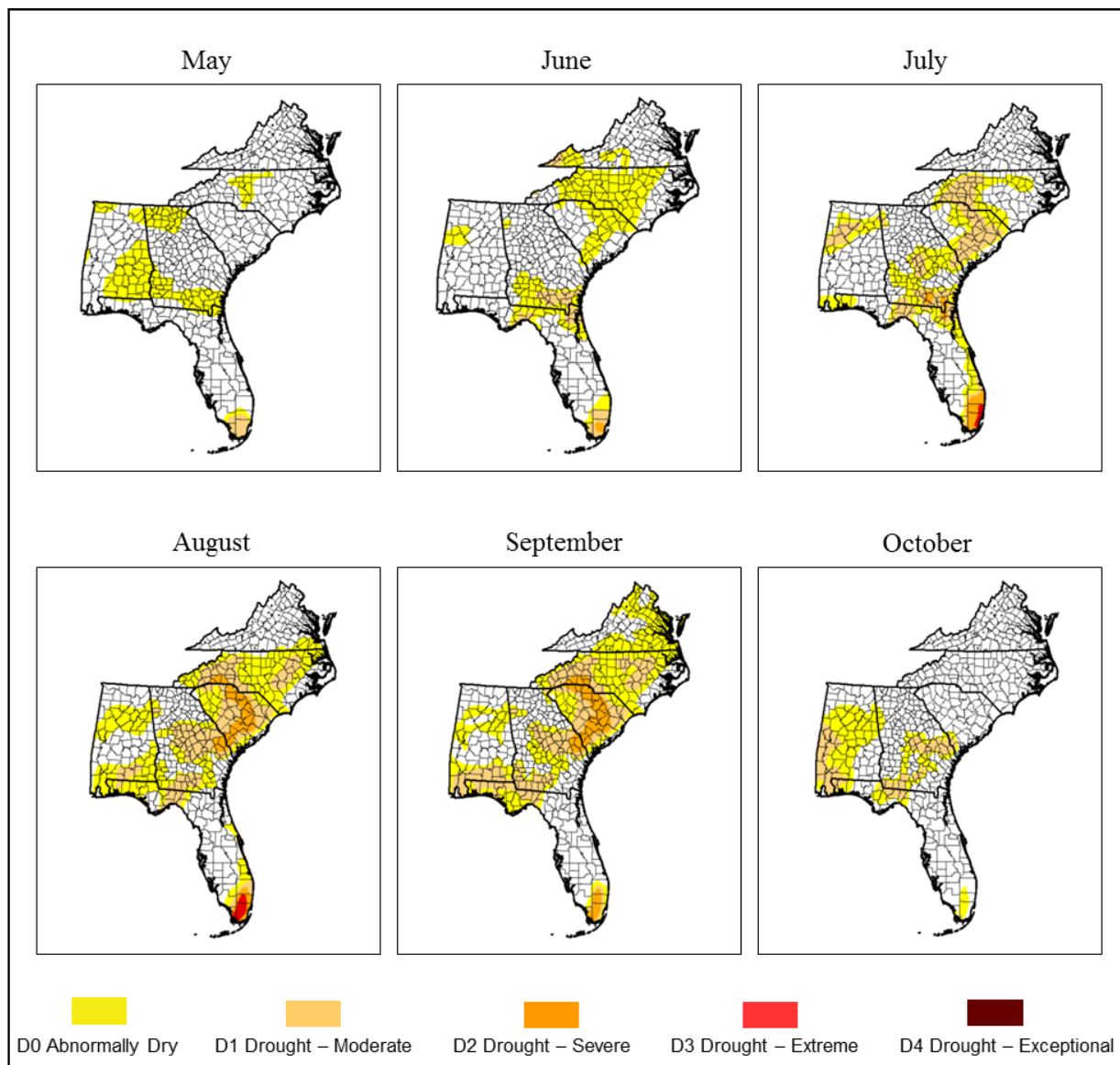


Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Southeast in 2015.

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