



Weather of Petersburg National Battlefield and Richmond National Battlefield Park

Mid-Atlantic Network Summary Report for 2017

Natural Resource Data Series NPS/MIDN/NRDS—2018/1168



ON THE COVER

“[Fort Stedman – Petersburg, VA](#)” — Petersburg National Battlefield

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Natural Resource Data Series NPS/MIDN/NRDS—2018/1168

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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Abstract

The Mid-Atlantic Network (MIDN) weather and climate monitoring protocol documents the current status and long-term trends in air temperature and precipitation at multiple temporal and spatial scales in MIDN parks. The purpose of this report is to provide a concise weather and climate summary for Petersburg National Battlefield (PETE) and Richmond National Battlefield Park (RICH) for the time period of January 1 to December 31, 2017. PETE and RICH are located in the Tidewater and Eastern Piedmont climate divisions of Virginia. In 2017, a total of four weather stations were selected to report park weather and climate conditions, and a large suite of precipitation and temperature metrics were summarized. Ultimately, 2017 was a very warm year and ranked as the 3rd and 5th warmest on record for the Tidewater and the Eastern Piedmont, respectively. All of the seasons were warmer than normal, particularly the winter and spring. The year was also drier than normal, being the 28th (Eastern Piedmont) and 54th (Tidewater) driest out of 123 years of records. Moderate drought conditions were reported in the Eastern Piedmont during the late winter and late fall of 2017. No drought conditions occurred in the Tidewater during 2017.

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, 2017, and to place current patterns and trends in an appropriate historical and regional 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 2017's climate summary.

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 are summarized in this report.

Methods

Observing Stations

A total of four weather observing stations, comprising three weather networks, were selected as the most representative weather stations around Petersburg National Battlefield (PETE) and Richmond National Battlefield Park (RICH) in 2017 (Figure 1, Table 1). Representative stations within a 100-km range of each park were chosen based on several criteria, which include proximity to the park, representativeness of the station to the park elevation profile, 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.

Petersburg National Battlefield and Richmond National Battlefield Park lie in VA Climate Division 1 (Tidewater) and 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>).

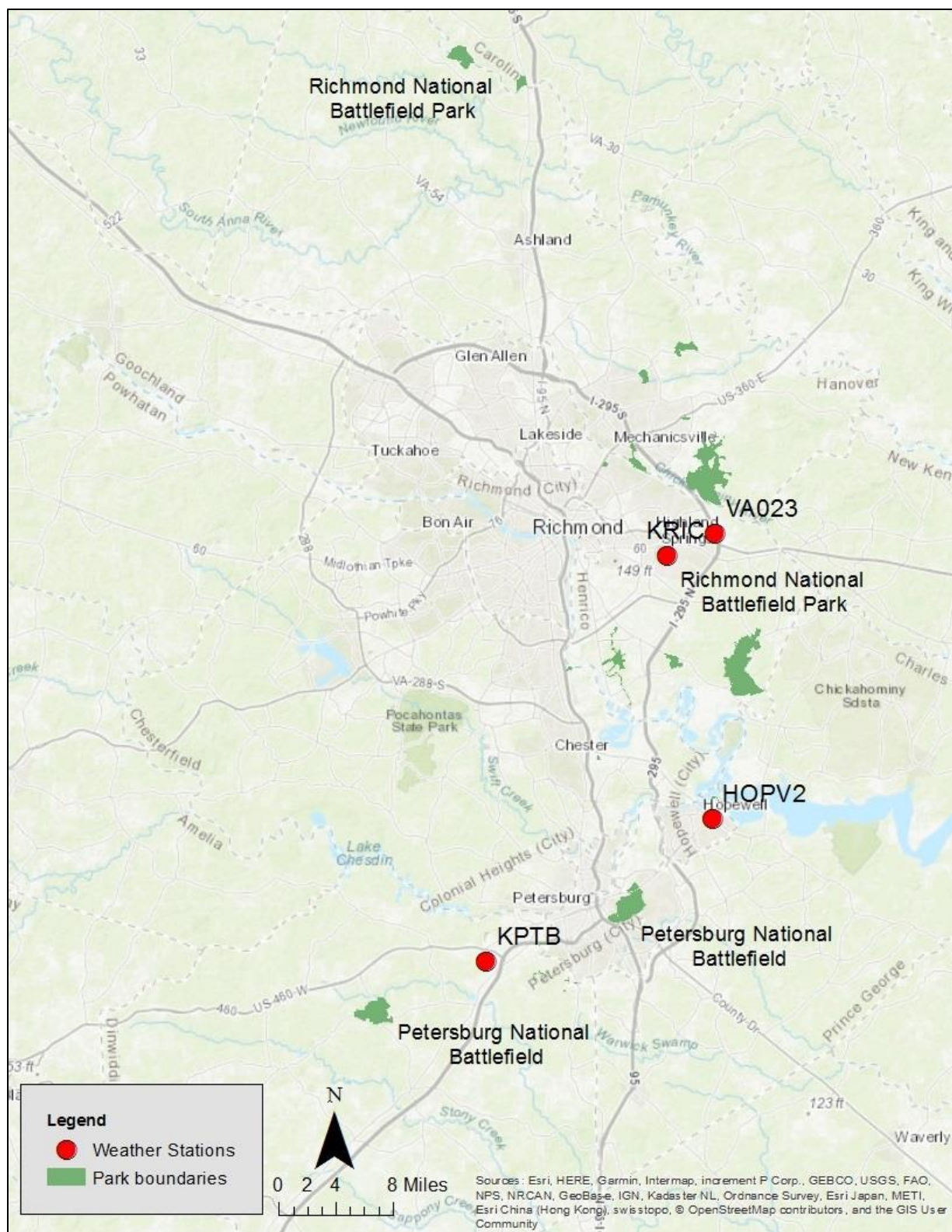


Figure 1. Location of weather observing stations around Petersburg National Battlefield and Richmond National Battlefield Park selected as most representative of the parks in 2017. See Table 1 for station names.

Table 1. List of weather observing stations around Petersburg National Battlefield and Richmond National Battlefield Park selected as most representative of the parks in 2017.

Station Name	Station	Observing Network ^A	Period of Record (POR)		Percentage of Time Reporting Temperature for 2017	Percentage of Time Reporting Precipitation for 2017	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
Hopewell	HOPV2	COOP	01/01/1960	Present	88.2	92.3	97.1	97.5
I-295 Over Meadow Road	VA023	RWIS	08/24/2005	Present	96.2	-	67.5	35.4
(Petersburg) Dinwiddie County Airport	KPTB	ASOS	01/01/1996	Present	98.4	99.7 ^B	83.2	68.5
Richmond International Airport	KRIC	ASOS	02/01/1949	Present	100	100	96.4	89.5

^A Observing networks are: ASOS — Automated Surface Observation System, COOP — National Weather Service Cooperative Observer Program, RWIS — Road Weather Information System.

^B KPTB precipitation data for 2017 is not included in this report due to major inconsistencies with surrounding stations.

Climate Indicators and Climatological Normals

A suite of indicators were identified to provide a summary of weather and climate conditions (Marshall et al. 2012). 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 2018) 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.

Of the four stations, only Richmond and Hopewell have a Period of Record (POR) sufficiently long for a 30-year normal (normal calculated from years 1981–2010). Complete temperature and precipitation metrics are only calculated for Richmond, as Hopewell was missing significant amounts of data in 2017. Precipitation data from Petersburg (Dinwiddie County airport) was excluded in 2017 due to major inconsistencies between this station’s reported precipitation versus surrounding stations. Monthly averages are calculated for all four stations (with the exclusion of precipitation from Petersburg) and deviations from monthly normals are presented for Hopewell, Petersburg, and Richmond. Because the Petersburg station does not have a full 30 yr. period of record, the Petersburg normal was calculated using data from 1996-2010. The I-295 over Meadow Road station is excluded

from a normal calculation because of its very short period of record and generally low reporting percentages.

Maps of multi-state departures of temperature and precipitation from long-term averages were derived 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. 2008). More information can be found at <http://www.prism.oregonstate.edu/>.

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). Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3 : very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3 : severe to extreme drought) (NOAA 2018a).

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 2018). 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).

Data Processing and Quality Assurance

Data from selected stations are downloaded from relevant data streams (ASOS – Automated Surface Observation System, COOP – National Weather Service Cooperative Observer Program, RWIS – Road Weather Information System, etc.). Variables are calculated using simple statistics (e.g. mean, minimum, maximum, etc.).

Each data stream has varying levels of associated quality assurance (from none to extensive). ASOS, has rigorous and extensive quality assurance beginning at the point of gather (data-logger on site) and at additional levels as described in the respective user's manuals and specification documents. The COOP data quality control is now much more extensive in real-time as the electronically submitted data passes through several levels of quality assurance and is in a final format within a few days of submission. See NOAA (2017) for a summary of ASOS and COOP quality control programs. Quality assurance of RWIS data is performed manually by comparing values with nearby stations.

Data management procedures are fully outlined in Marshall, et al (2012)

Results

Temperature Summary

Most temperature metrics calculated from stations around PETE and RICH indicate that 2017 was a warm year. Across the year, several months had average temperatures that were much higher than normal (Figures 2 and 3, Tables 2 and 3). Average annual temperatures, average annual maximum, and average annual minimum temperatures were also above normal at Richmond (Tables 3 and 4). The warm weather resulted in a growing season length was almost two weeks longer than normal. Ultimately, all of the seasons ranked warmer than average in both the Tidewater and Eastern Piedmont climate divisions. In all, 2017 was the 3rd (Tidewater) and 5th (Eastern Piedmont) warmest year since 1895 (Tables 5 and 6).

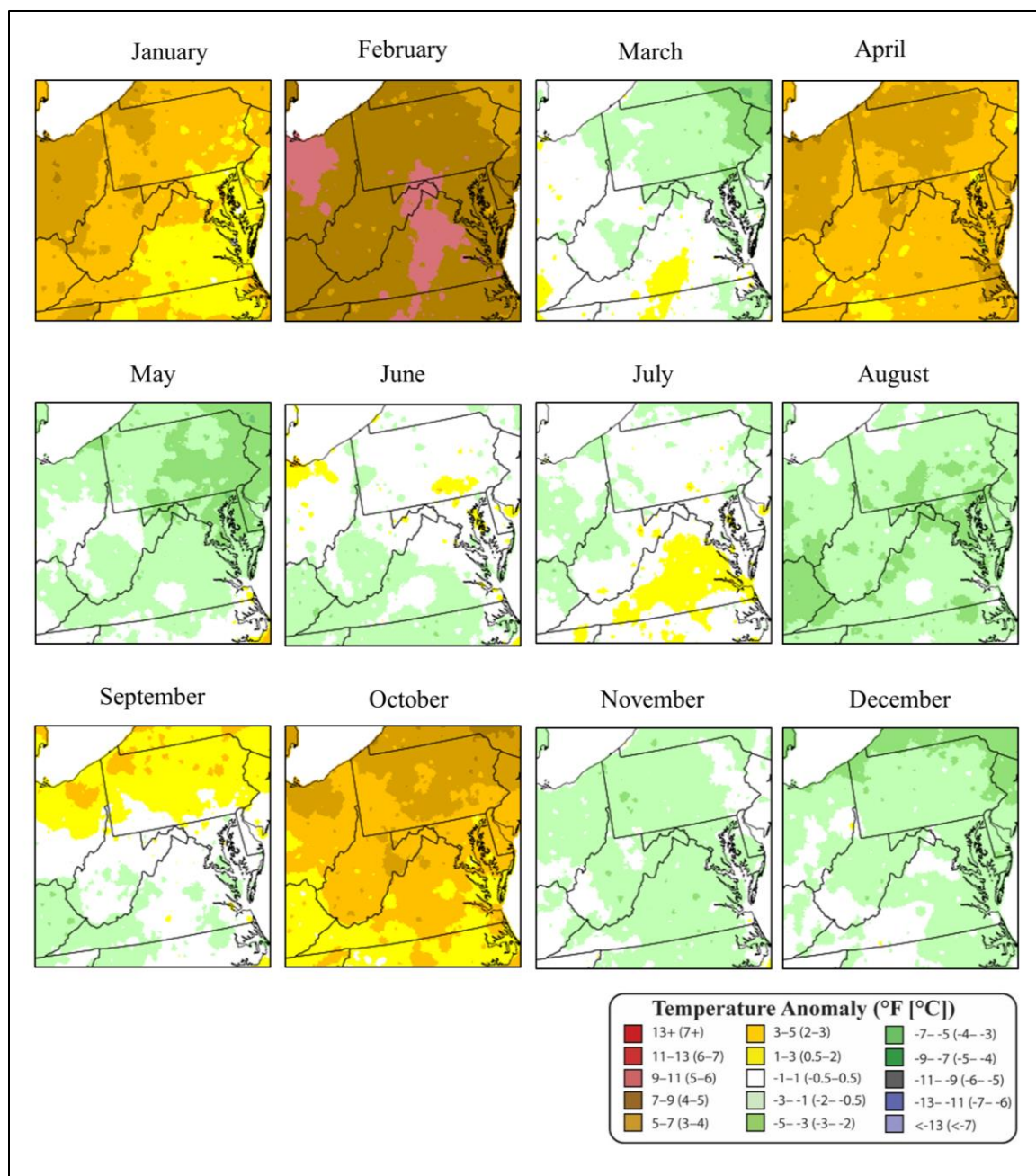


Figure 2. Maps showing departure from average monthly maximum temperature in 2017 compared to the 30-year normal (1981–2010).

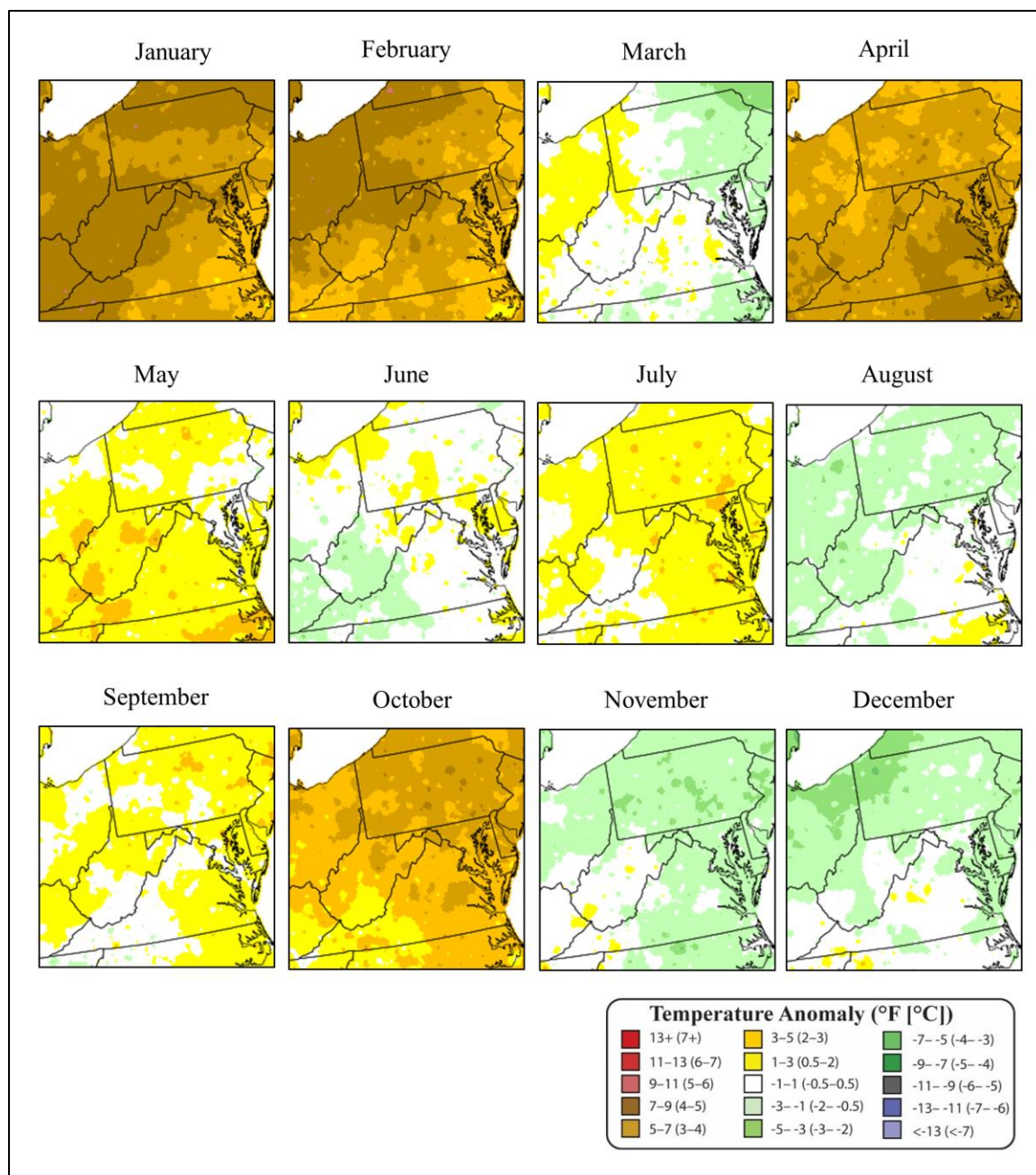


Figure 3. Maps showing departure from average monthly minimum temperature in 2017 compared to the 30-year normal (1981–2010).

Table 2. Summary of 2017 monthly average temperatures for selected stations.

Station	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
HPOV2	Hopewell	M	51.8°F 11.0°C	51.0°F 10.6°C	M	67.9°F 19.9°C	NA NA	82.2°F 27.9°C	77.7°F 25.4°C	72.4°F 22.4°C	M	51.2°F 10.7°C	41.2°F 5.1°C	M
VA023	I-295	42.4°F 5.8°C	49.3°F 9.6°C	48.6°F 9.2°C	M	65.1°F 18.4°C	74.5°F 23.6°C	80.3°F 26.8°C	75.4°F 24.1°C	70.1°F 21.2°C	62.2°F 16.8°C	48.4°F 9.1°C	39.5°F 4.2°C	M
KPTB	Petersburg	41.1°F 5.1°C	47.2°F 8.4°C	46.8°F 8.2°C	62.7°F 17.1°C	64.4°F 18.0°C	72.4°F 22.4°C	78.3°F 25.7°C	74.1°F 23.4°C	68.4°F 20.2°C	64.6°F 18.1°C	M	39.7°F 4.3°C	59.3°F 15.2°C
KRIC	Richmond Airport	42.0°F 5.6°C	48.8°F 9.3°C	48.9°F 9.4°C	64.0°F 17.8°C	66.0°F 18.9°C	75.1°F 23.9°C	80.7°F 27.1°C	75.7°F 24.3°C	70.6°F 21.4°C	63.0°F 17.2°C	48.9°F 9.4°C	40.4°F 4.7°C	60.4°F 15.8°C

M = missing data (monthly and annual statistics are reported as "M" if more than 4 or 12 days of data are missing, respectively)

Table 3. Summary of 2017 departure from normal temperature based on the 30-year normal (1981-2010) for selected stations.

Station	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
HPOV2	Hopewell	M	7.6°F 4.2°C	-0.6°F -0.3°C	NA NA	-1.1°F -0.7°C	M	1.4°F 0.8°C	-1.5°F -0.8°C	-0.4°F -0.3°C	M	-2.1°F -1.1°C	-2.8°F -1.6°C	M
KPTB*	Petersburg	1.6°F 0.9°C	6.2°F 3.4°C	-2.8°F -1.6°C	3.2°F 1.8°C	-3.0°F -1.7°C	-3.4°F -1.9°C	-0.5°F -0.3°C	-2.0°F -1.1°C	-2.0°F -1.1°C	5.2°F 2.9°C	M	-1.1°F -0.6°C	M
KRIC	Richmond Airport	4.1°F 2.3°C	7.9°F 4.4°C	0.3°F 0.2°C	5.8°F 3.2°C	-0.4°F -0.2°C	-0.2°F -0.2°C	1.4°F 0.8°C	-1.8°F -1.0°C	0.0°F 0.0°C	3.3°F 1.8°C	-1.5°F -0.8°C	-0.6°F -0.3°C	1.5°F 0.9°C

M = missing data (monthly and annual statistics are reported as "M" if more than 4 or 12 days of data are missing, respectively)

*KPTB normal was calculated using data from 1996-2010

Table 4. Status of 2017 temperature indicators compared to the 30-year normal (1981-2010) for selected stations.

Temperature Indicator	Richmond Airport 2017	Richmond Airport 1981–2010
Average Annual Temperature	60.4°F 15.8°C	58.9°F 14.9°C
Average Annual Maximum Temperature	71.0°F 21.7°C	69.6°F 20.9°C
Maximum Temperature	101.0°F 38.3°C	99.8°F 37.7°C
Hot Days (days with Tmax≥90°F/32°C)	42	42
Average Annual Minimum Temperature	50.2°F 10.1°C	48.1°F 8.9°C
Minimum Temperature	0.0°F -17.8°C	9.6°F -12.4°C
Cold Days (days with Tmax≤32°F/0°C)	5	5
Sub-freezing Days (days with Tmin≤32°F/0°C)	61	74
Sub-zero Days (days with Tmin≤0°F/-18°C)	1	0
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	231	218

Table 5. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for the Eastern Piedmont (NOAA 2018b).

Parameter	VA 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-2017	5	10-T	37-T	31-T	5
Precipitation-2017	102	14	89	103	96

1 = warmest/wettest year and 123 = coldest/driest year. T = Tie between multiple years

Table 6. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for the Tidewater (NOAA 2018b).

Parameter	VA Climate Division 1 Rankings —Tidewater				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2017	7	3-T	30-T	33-T	3
Precipitation-2017	83	27	50	99	70

1 = warmest/wettest year and 123 = coldest/driest year. T = Tie between multiple years

Precipitation Summary

Monthly precipitation totals in 2017 were highly variable but annual totals were below normal (Figure 4, Tables 7 and 8). Most months had less than normal precipitation, with February being particularly dry (Tables 7 and 8). Monthly totals ranged from a low of 0.5 inches (13 mm) at Hopewell in February to a high of 10.4 inches (264 mm) at Hopewell in August. At Richmond, annual precipitation was 5.8 inches (146 mm) below average (Table 9). The wettest day occurred on August 29th when 3.0 inches (75 mm) of rain was observed (Table 10). In all, 2017 was a dry year, ranking as the 28th driest (96th wettest) year on record for the Eastern Piedmont and the 54th driest (70th wettest) for the Tidewater (Tables 5 and 6).

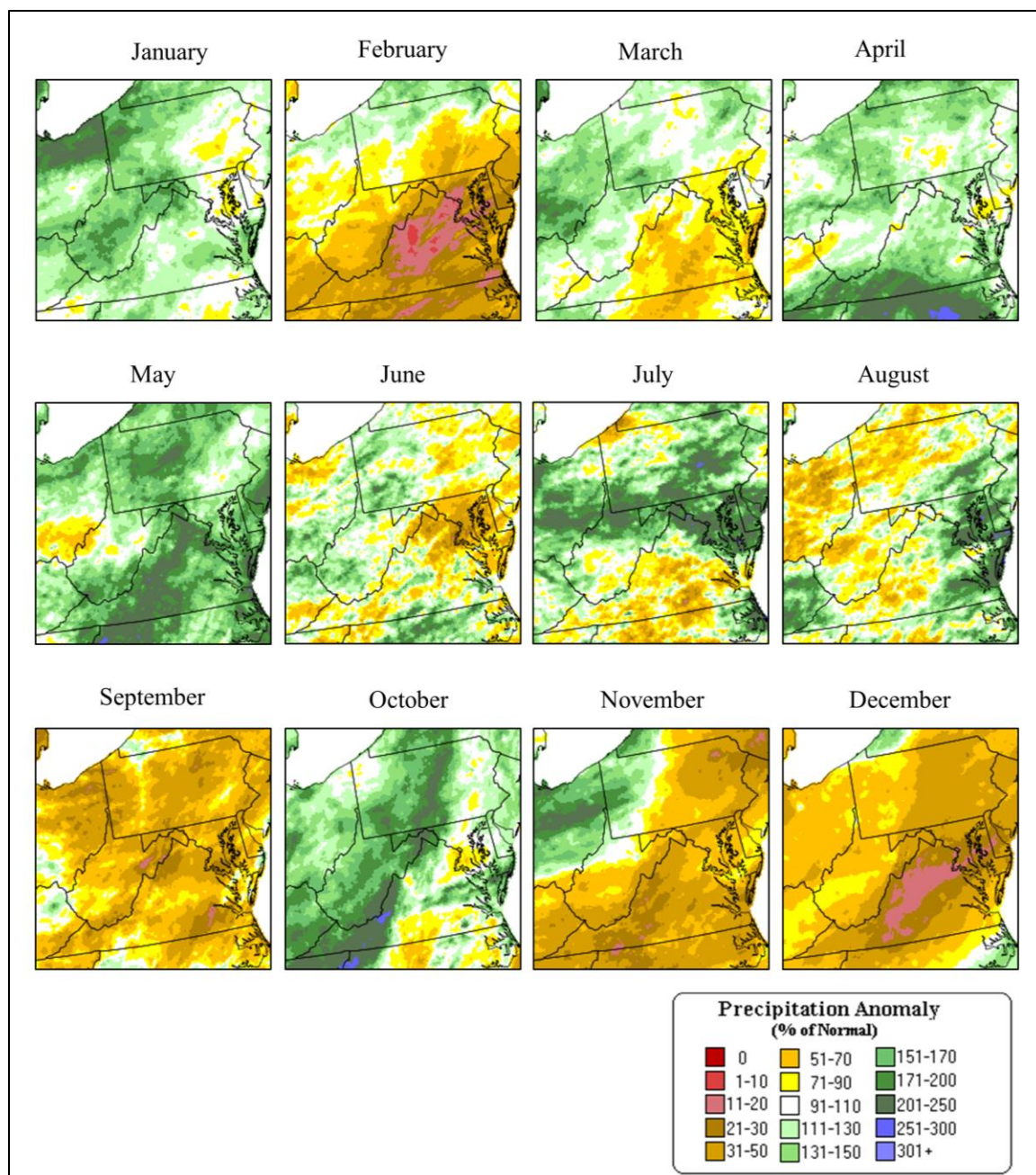


Figure 4. Maps showing percent of average monthly precipitation in 2017 compared to the 30-year normal (1981–2010).

Table 7. Summary of 2017 monthly precipitation for selected stations

Station	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
HPOV2	Hopewell	M	0.5 in 13 mm	4.2 in 107 mm	1.9 in 48 mm	7.2 in 183 mm	M	3.9 in 99 mm	10.4 in 264 mm	1.6 in 41 mm	M	1.5 in 38 mm	1.8 in 46 mm	M
KRIC	Richmond Airport	4.3 in 109 mm	0.7 in 18 mm	3.7 in 94 mm	2.3 in 58 mm	7.6 in 193 mm	2.3 in 58 mm	2.2 in 56 mm	5.9 in 150 mm	1.5 in 38 mm	5.0 in 127 mm	1.4 in 36 mm	1.1 in 28 mm	38.0 in 965 mm

M = missing data (monthly and annual statistics are reported as “M” if more than 4 or 12 days of data are missing, respectively)

Table 8. Summary of 2017 percent of normal precipitation based on the 30-year normal (1981-2010) for selected stations.

Station	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
HPOV2	Hopewell	M	16	102	50	189	M	83	204	35	M	43	51	M
KRIC	Richmond Airport	143	25	92	70	200	59	49	126	37	167	44	33	87

M = missing data (monthly and annual statistics are reported as “M” if more than 4 or 12 days of data are missing, respectively)

Table 9. Status of 2017 precipitation indicators compared to the 30-year normal (1981-2010) for selected stations.

Precipitation Indicator	Richmond Airport 2017	Richmond Airport 1981–2010
Annual Precipitation	38.0 in 965 mm	43.8 in 1,111 mm
Autumn (Oct, Nov, Dec) Precipitation	7.4 in 188 mm	9.5 in 241 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	9	11
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	1	2
Micro-drought (periods of 7+ days without rain)	12	4
Annual Snowfall	10.2 in 25.9 cm	10.3 in 26.2 cm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	4	6
Moderate Snow Days (days with ≥ 3.0 in (7.6 cm) snow)	1	1
Heavy Snow Days (days with ≥ 5.0 in (12.7 cm) snow)	1	1

Table 10. Top five wettest days and top five dry spells (consecutive days with a trace of less of liquid precipitation) during 2017 from Hopewell and Richmond Airport.

Wettest Days in 2017	Dry Spells in 2017
Aug 29: 3.0 in (75 mm)	Sep 13 – Oct 07
Aug 8: 2.7 in (69 mm)	Jul 06 – Jul 22
Aug 19: 2.5 in (64 mm)	Feb 09 – Feb 22
Aug 18: 2.1 in (55 mm)	Nov 22 – Dec 05
Jul 06: 2.0 in (51 mm)	Apr 06 – Apr 17

The Eastern Piedmont entered “moderate drought” conditions briefly in February and March and again in December, as measured by the Palmer Drought Severity Index (PDSI; Figure 5). In contrast, the Tidewater never entered drought conditions, according to the PDSI (Figure 6). The Drought Intensity Index notes that “abnormally dry” periods were encountered in 2017 near PETE and RICH and in surrounding states, particularly as summer transitioned into fall (Figures 7 and 8).

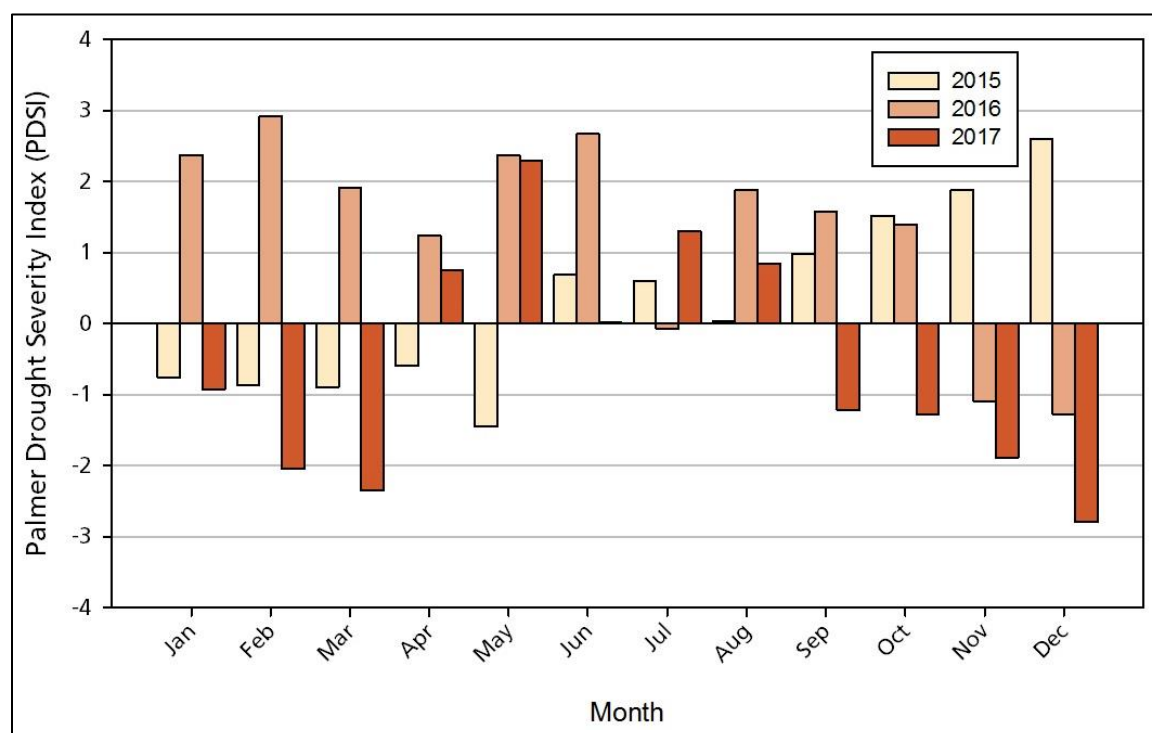


Figure 5. Palmer Drought Severity Index (PDSI) for the Eastern Piedmont, 2015–2017. Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3: very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3: severe to extreme drought).

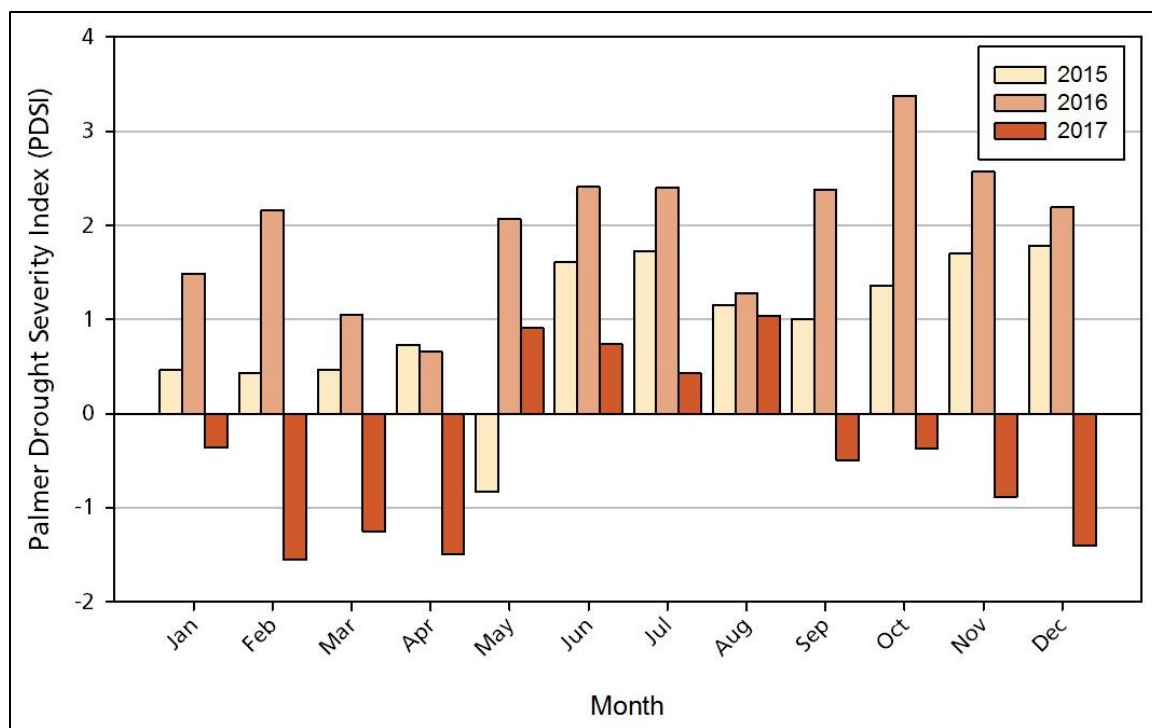


Figure 6. Palmer Drought Severity Index (PDSI) for the Tidewater, 2015–2017. Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3: very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3: severe to extreme drought).

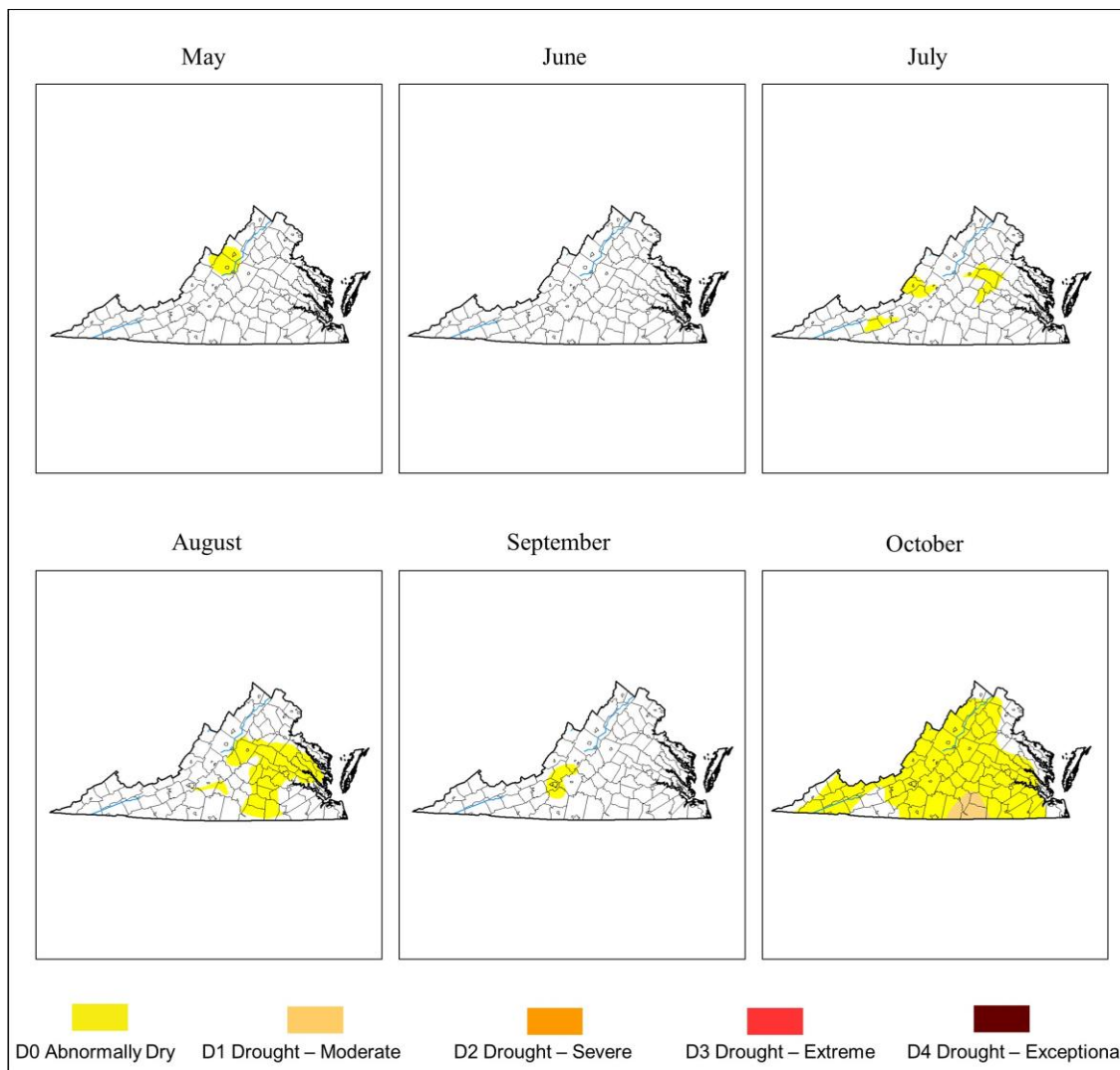


Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Virginia in 2017.

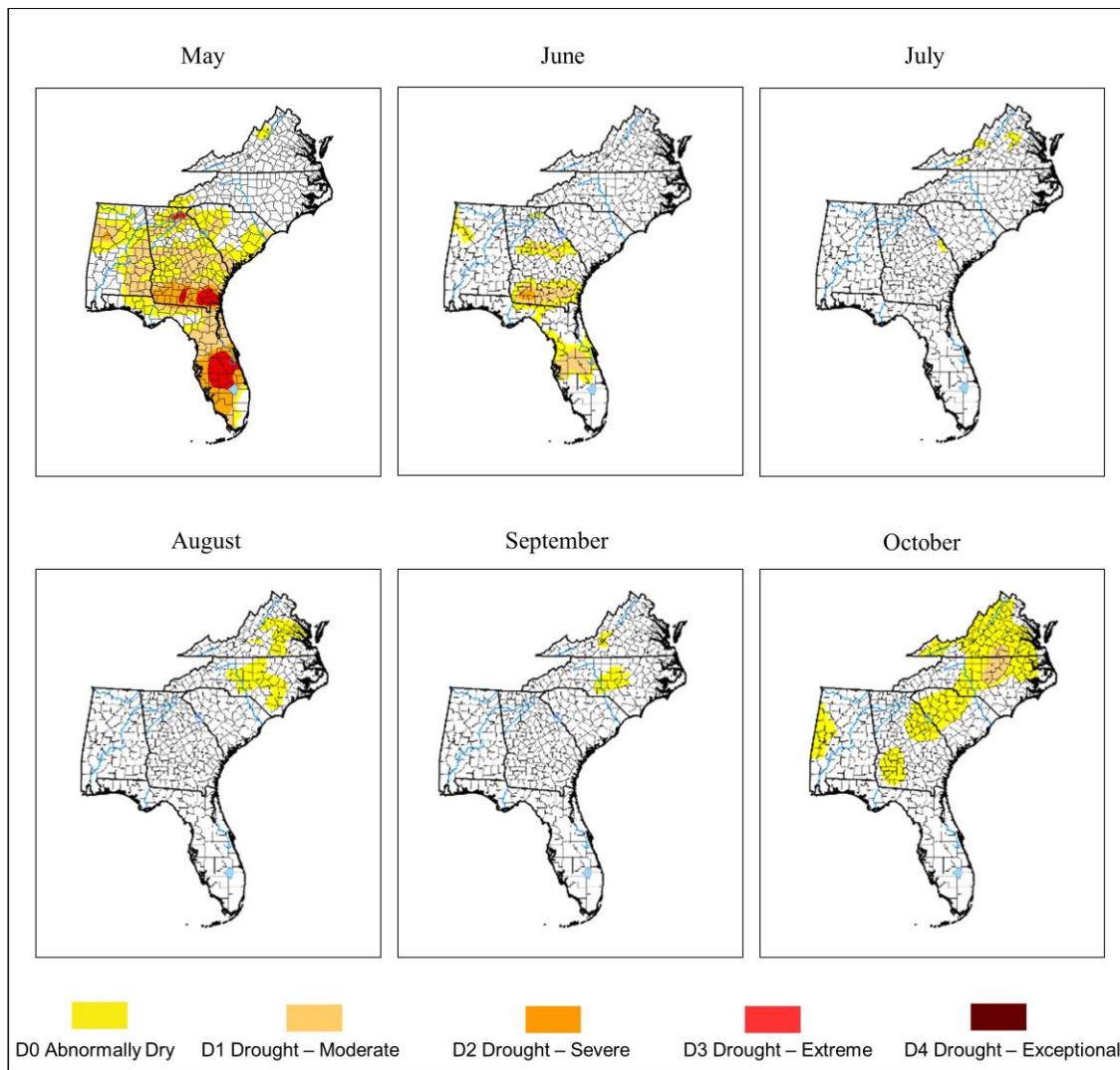


Figure 8. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Southeast in 2017.

Literature Cited

- Comiskey, J. A., and K. K. Callahan. 2008. Mid-Atlantic Network vital signs monitoring plan. Natural Resource Report NPS/MIDN/NRR—2008/071. National Park Service, Fort Collins, CO.
- Daly, C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis, and P.P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. *International Journal of Climatology*, 28: 2031-2064.
- Knight, P., K. Imhoff, and A. Person. 2016. Weather of Petersburg National Battlefield and Richmond National Battlefield Park: Mid-Atlantic Network summary report for 2014. Natural Resource Data Series. NPS/MIDN/NRR—2016/1114. National Park Service. Fort Collins, Colorado
- Marshall, M., P. Knight, and J. Comiskey. 2012. Weather and climate monitoring protocol: Eastern Rivers and Mountains Network and Mid-Atlantic Network. Natural Resource Report NPS/ERMN-MIDN/NRR—2012/498. National Park Service, Fort Collins, Colorado.
- National Assessment Synthesis Team. 2001. Climate Change Impacts on United States: The Potential Consequences of Climate Variability and Change. Report for the U.S. Global Change Research Program. Cambridge University Press, Cambridge, UK.
- National Integrated Drought Information System (NIDIS). 2018. National Climate Data Center and United States Department of Agriculture. Available at: <http://droughtmonitor.unl.edu/Maps/MapArchive.aspx> (accessed 16 February 2018).
- National Oceanic and Atmospheric Administration (NOAA). 2017. National Weather Service Instruction 10-1305. Available at <http://www.nws.noaa.gov/directives> (accessed 23 April 2018).
- National Oceanic and Atmospheric Administration (NOAA). 2018a. National Centers for Environmental Information Historical Palmer Drought Indices. Available at: <https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/> (accessed 5 April 2018).
- National Oceanic and Atmospheric Administration (NOAA). 2018b. National Centers for Environmental Information Climatological Rankings. Available at: <http://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/> (accessed 5 April 2018).

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