



Weather of Fort Necessity National Battlefield and Friendship Hill National Historic Site

Eastern Rivers and Mountains Network Summary Report for 2014

Natural Resource Data Series NPS/ERMN/NRDS—2015/815



ON THE COVER

Summer sky at Fort Necessity National Battlefield, August 2008.

Photograph by: Jane Clark (NPS photos)

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Paul Knight, Kyle Imhoff, and Arthur Person

Pennsylvania State Climate Office
503 Walker Building
Pennsylvania State University
University Park, Pennsylvania

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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.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

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.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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List of Key Acronyms

ASOS	Automated Surface Observing System
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
ERMN	Eastern Rivers and Mountains Network
FAA	Federal Aviation Administration
FONE	Fort Necessity National Battlefield
FRHI	Friendship Hill National Historic Site
GOES	Geostationary Operational Environmental Satellite
IFLOWS	Integrated Flood Observing and Warning System
NADP	National Atmospheric Deposition Program
NARR	North American Regional Reanalysis
NB	National Battlefield
NCDC	National Climatic Data Center
NHS	National Historic Site
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWS	National Weather Service
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
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 (Marshall and Piekielek 2007).

The purpose of this report is to provide a concise weather and climate summary for the period from January 1 to December 31, 2014, 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 portions of the Eastern Rivers and Mountains Network (ERMN) 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 ERMN 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 the 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 to profile 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 summarized in the body of this report.

The Climate of the Southwest Plateau

Fort Necessity National Battlefield (NB) and Friendship Hill National Historic Site (NHS) are located in Pennsylvania Climate Division 9, the “Southwest Plateau.” 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. Pennsylvania is divided into 10 climate divisions (<http://www.esrl.noaa.gov/psd/data/usclimdivs/data/map.html> [NOAA 2013]). Pennsylvania is divided into 10 climate divisions.

The Southwest Plateau is generally considered to have a humid, continental type of climate, but the elevated terrain and rolling hills keep temperatures a bit lower than surrounding areas. 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 occasional influence on the climate of the area (Davey et al. 2006). Coastal storms do, at times, affect the day-to-day weather, especially in winter, though the air circulating southeastward from the Great Lakes dominates in the winter. Seldom do storms of tropical origin have a direct effect in this part of Pennsylvania, but the rough terrain has led to memorable floods in the warm half of the year (Gelber 2002).

Temperatures are moderately continental, with the tempering effects of the Great Lakes contributing to cloud production in the winter, and mountain-valley circulation-induced clouds reducing the heat during the summer. 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 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 Laurel Highlands. Annual maximum and minimum temperatures tend to be greater in Friendship Hill NHS than in Fort Necessity NB. The average annual maximum temperature in Chalk Hill, PA, is 54.4°F (12.4°C), while the annual maximum temperature in Grays Woods, PA, is 63.4°F (17.4°C). The last freeze in the region typically occurs in early May and the first frosts appear in late September or October.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 36–54 in (914–1,372 mm), while the majority of places receive 40–46 in (1,016–1,372 mm). Greatest amounts usually occur in the spring and summer months, while February is the driest month, having about 2.0 in (51 mm) less than the wettest months. Precipitation tends to be somewhat greater in the higher terrain due to uplift and additional moisture from the Great Lakes. Annual snowfall amounts are much greater for Fort Necessity NB than Friendship Hill NHS.

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 between the equinoxes and reaches a peak near the summer 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 two years. Ice storms, which can cause significant disruption, occur at irregular intervals and are primarily confined to the months between December and March (Kocin and Uccellini 2004).

Observing Stations

A total of six weather observing stations comprised of two observing networks were selected around Fort Necessity NB and Friendship Hill NHS. 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 park elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al., in review). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence data inclusion. No stations were excluded in 2014 based on this criterion; therefore, a total of six stations were used for this report (Figure 1, Table 1).

Two stations, Morgantown Lock and Dam, WV (1946-current) and Uniontown, PA (1895-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:

- Highest Annual Maximum Temperature – A measure of the individual highest maximum temperature each year
- Average Annual Mean Temperature – A measure of the composite mean temperature (averaging the maximum and minimum on a daily basis) for an entire year
- Annual Number of Hot Days (Maximum Temperature equal to or exceeding 90 °F)- A measure of warm season heat using a threshold of days with 90F maxima
- Lowest Annual Minimum Temperature – A measure of the individual lowest minimum temperature each year
- Annual Number of Cold Nights (Minimum Temperature equal to or below 32 °F) – A measure of the cold season chill using a threshold of days with 32F 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 32F in the spring and the first 32F in the fall
- Annual Precipitation – A measure of total liquid (and its equivalent melted snow) for all days
- Annual Snowfall – A measure of total solid precipitation (includes sleet and hail; does not include freezing rain)

- Annual Number of Extreme Precipitation Days (Liquid equal to or greater than 2.00”) – A measure of frequency of heavy precipitation events during each year
- Winter Precipitation (January 1 – March 31) – The three month total precipitation including rain and melted snow
- Spring Precipitation (April 1 – June 30) - The three month total precipitation
- Summer Precipitation (July 1 – September 30) - The three month total precipitation
- Autumn Precipitation (October 1 – December 31) - The three month total precipitation including rain and melted snow

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 will be 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.

The NCDC also calculates and provides climatological ranks for selected temperature and precipitation elements (<http://www.ncdc.noaa.gov/temp-and-precip/ranks.php>). Data and statistics are as of January 1895 providing a substantial period of record to place the current year in historical context.

In addition to the summary information available in this report, a near real-time data stream has been made available to the ERMN through a Web interface for the selected 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>.

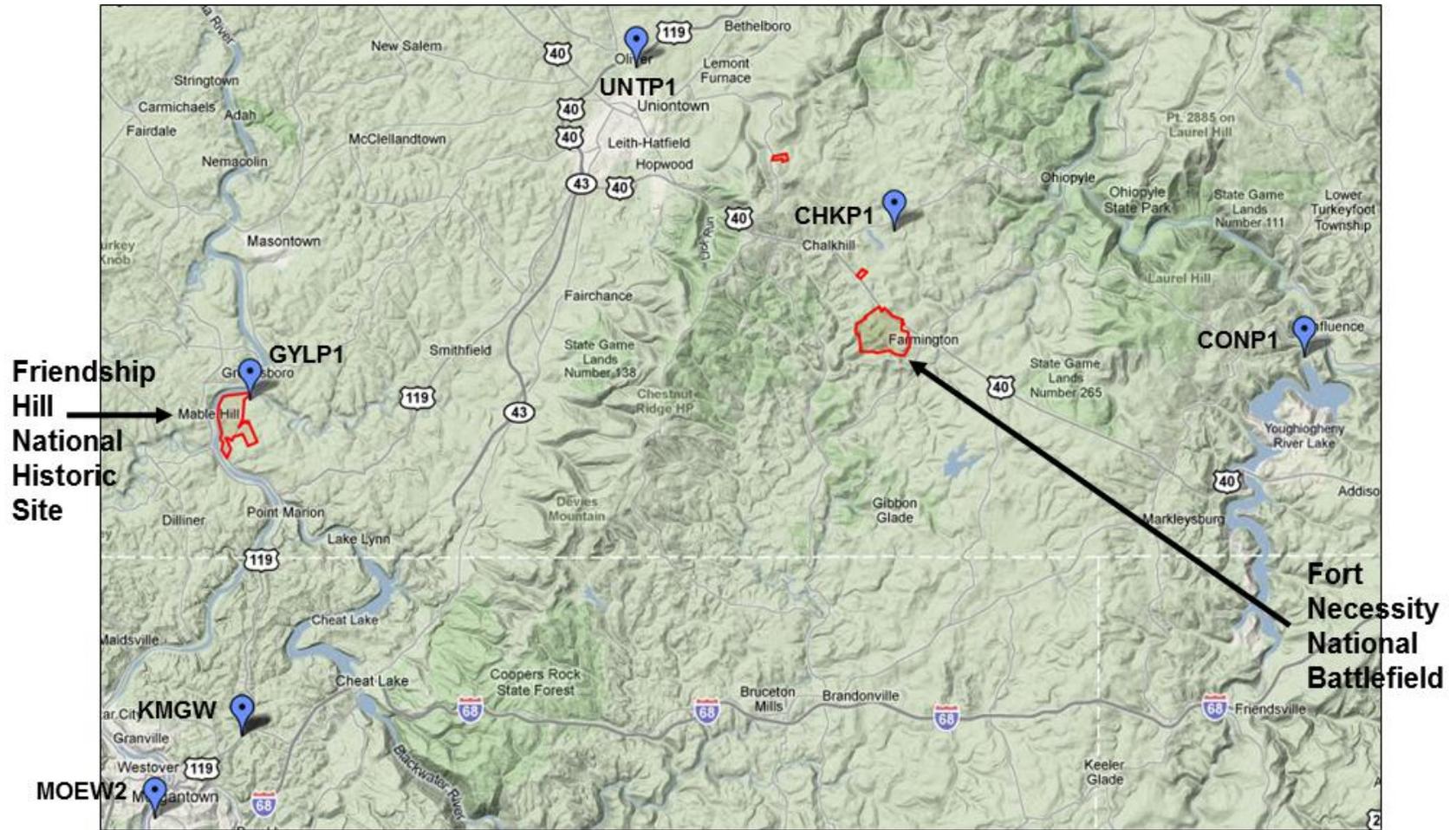


Figure 1. Location of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. See Table 1 for station names.

Table 1. List of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield selected as best representative of the parks in 2014.

Station	Observing Network	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
CHKP1	COOP	Chalk Hill 2 ENE	07/01/1977	Present	93.4	77.5	99.0	97.9
GYLP1	COOP	Grays Landing	10/01/1996	Present	99.7	100.0	97.0	99.2
UNTP1	COOP	Uniontown 1 NE	01/01/1894	Present	98.1	100.0	97.3	95.6
CONP1	COOP	Confluence 1 SW Dam	07/01/1946	Present	100.0	100.0	99.7	99.7
MOEW2	COOP	Morgantown Lock and Dam	09/01/1921	Present	65.7	79.2	94.8 ¹	95.6
∞ KMGW	ASOS	Morgantown Municipal Airport -Walter L. Bill Hart Field	12/31/1973	Present	100.0	100.0	99.0	99.0

¹ Percentage of time reporting temperature for Morgantown Lock and Dam is based upon a period of record beginning on 06/01/1944. This station did not report temperature prior to this date.

Temperature Summary

Calendar year 2014 was slightly cooler than average (Tables 2, 3 and 4), primarily due to chilly conditions that occurred in the winter, much of the summer, and November (Figures 2 and 3).

The year began very cold, as January had readings ranging from -6.2 degrees Fahrenheit (°F) (-3.4 degrees Celsius (°C)) to -7.4°F (-4.1°C) below normal (Table 4). The coldest weather of the year occurred January 29-31 when minima of -17°F (-27.2°C) were measured at Chalk Hill, PA, and a value of -8°F (-22.2°C) occurred at Morgantown Lock and Dam on the 29th (Table 2). February mean temperatures were nearly as cold (Table 4), averaging as much as 6.9°F (3.8°C) below the long-term average at Chalk Hill. Much of the same occurred in March where negative anomalies ranged from 4.0°F (2.2°C) to 5.5°F (3.1°C) (Table 4). Overall, the winter was the 5th coolest in 120 years (Table 5).

In contrast, the spring ranked the 30th warmest on record since 1895, which was +1.3°F (0.8°C) above normal (Table 5). All three spring months had near to slightly above average temperatures for all of the reporting stations (Table 4). The largest anomalies were in June across all stations, with Morgantown tallying an anomaly of +3.2°F (1.8°C), mainly due to mild nights (Figure 3 and Table 4). Daytime temperatures were near the long-term average (Figure 2). The majority of the stations saw their last freeze of the season in late April, which led to a shorter than normal length in the growing season. Many of the stations observed a string of days from near the end of June with readings in the 80's°F (> 27°C). The highest temperature of the year actually occurred during this 3-month period, with readings of 88°F (31.1°C) at Chalk Hill and 87°F (30.5°C) at Morgantown Lock and Dam on May 14th.

Summer of 2014 was chilly, ranking as the 20th coolest on record (Table 5). This negative anomaly was due in large part to a cold July and August (Figures 2 and 3). The largest negative anomalies were during July for most stations, when readings averaged as much as -3.4°F (-1.9°C) below normal at Grays Landing, PA (Table 4). Afternoon readings rose to 87°F (30.5°C) on July 2nd.

Temperatures in autumn were slightly above normal, ranking 42nd warmest since records have been kept in 1895 (Table 5). The first widespread 32°F (0°C) readings of the fall occurred on September 24 near Fort Necessity NB. November had increasingly large negative anomalies in daytime readings (Figure 2). Nighttime readings fell below 10°F (-12.2°C) for four days during November at Chalk Hill. There were an above average number of cold days and notably above average number of sub-zero days (Table 2). Overall, 2014 averaged -0.8°F (-0.5°C) below the long-term average around Fort Necessity NB and Friendship Hill NHS (Table 4) and the year ranked as the 18th coolest in 120 years.

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 1. Status of 2014 temperature indicators compared to the 30-year normal (1981–2010) and the station period of record at the Morgantown Lock and Dam (MOEW2) and Uniontown (UNTP1) stations.

Temperature Indicator	Morgantown Lock and Dam, WV MOEW2 2014*	Morgantown Lock and Dam, WV MOEW2 1981–2010	Morgantown Lock and Dam, WV 1946-2013 Mean (1 SD)	Uniontown, PA UNTP1 2014	Uniontown, PA UNTP1 1981–2010	Uniontown, PA 1895-2013 Mean (1 SD)
Average Annual Temperature	50.5°F 10.3°C	52.3°F 11.3°C	52.7 (51.1 – 54.4) °F 11.5 (10.6 – 12.4) °C	50.1°F 10.1°C	51.2°F 10.7°C	52.5(51.0 – 54.0) °F 11.4 (10.6 – 12.2) °C
Average Annual Maximum Temperature	62.3°F 16.8°C	62.6°F 17.0°C	NA	61.5°F 16.4°C	62.9°F 17.2°C	NA
Maximum Temperature	87°F 30.5°C	93.0°F 33.9°C	94.0 (90.6 – 97.4) °F 34.4 (32.6 – 36.3) °C	90.0°F 32.2°C	94.0°F 34.4°C	94.3 (97.3 – 91.4) °F 34.6 (36.3 – 33.0) °C
Hot Days (days with Tmax≥90°F/32°C)	0	5	14 (26 – 2)	5	13	13 (5 –22)
Average Annual Minimum Temperature	38.6°F 3.6°C	41.9°F 5.5°C	NA	38.8°F 3.8°C	39.5°F 4.2°C	NA
Minimum Temperature	-8°F -22.2°C	-1.1°F -18.4°C	-2.4 (-9.9 - 5.1) °F -19.1 (-23.3 – -14.9) °C	-9.0°F -22.8°C	-4.0°F -20.0°C	-3.9(-10.9 - 3.1) °F -19.9 (-23.8 – -16.1) °C
Cold Days (days with Tmax≤32°F/0°F)	21	22	NA	33	26	NA
Sub-freezing Days (days with Tmin≤32°F/0°C)	99	117	116 (101 – 131)	136	128	115 (101 – 130)
Sub-zero Days (days with Tmin≤0°F/-17.8°C)	8	2	NA	16	3	NA
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	170	181	170 (150 – 190)	184	156	165 (147 – 183)

*Morgantown Lock and Dam was missing temperature data for about ¼ of the year – the annual numbers may be skewed as a result

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	24.9 °F	28.8 °F	36.9 °F	55.4 °F	63.9 °F	72.6 °F	72.3 °F	72.5 °F	67.2 °F	56.6 °F	41.7 °F	38.1 °F	52.6 °F
		-3.9 °C	-1.7 °C	2.7 °C	13.0 °C	17.7 °C	22.5 °C	22.4 °C	22.5 °C	19.5 °C	13.6 °C	5.4 °C	3.4 °C	11.4 °C
Chalk Hill 2 ENE	CHKP1	17.5°F	20.7°F	M	M	57.2 °F	66.1°F	65.9°F	64.8°F	58.4°F	49.1°F	34.2°F	M	M
		-8.0 °C	-6.3 °C	M	M	14.0 °C	18.9 °C	18.8 °C	18.2 °C	14.6 °C	9.5 °C	1.3 °C	M	M
Uniontown 1 NE	UNTP1	23.4°F	25.8°F	34.4°F	51.4°F	60.8 °F	70.0°F	70.4°F	69.6°F	64.3°F	54.6°F	38.6°F	38.1°F	50.1°F
		-4.7°C	-3.4 °C	1.3 °C	10.7 °C	16.0 °C	21.1 °C	21.3 °C	20.9 °C	17.9 °C	12.5 °C	3.6 °C	3.4 °C	10.0 °C
Confluence 1 SW Dam	CONP1	20.2°F	23.8°F	32.0°F	47.7°F	58.2 °F	67.2°F	68.8°F	66.7°F	62.9°F	52°F	35.6°F	34.8°F	47.5°F
		-6.6°C	-4.6°C	0.0°C	8.7°C	14.6 °C	19.6°C	20.4°C	19.3°C	17.2°C	11.1°C	2.0°C	1.6°C	8.6°C
Morgantown Lock and Dam*	MOEW2	M	M	38.3°F	56.6°F	M	71.2°F	71.4°F	71.2°F	66.4°F	55.7°F	41.4°F	38.7°F	M
		M	M	3.5°C	13.7°C	M	21.8°C	21.9°C	21.8°C	19.1°C	13.2°C	5.2°C	3.7°C	M
Grays Landing	GYLP1	22.5°F	25.5°F	33.6°F	49.9°F	60.3 °F	69.5°F	70.0°F	69.5°F	64.2°F	54.0°F	37.8°F	36.1°F	49.4°F
		-5.3 °C	-3.6 °C	0.8 °C	9.9 °C	15.7 °C	20.7 °C	22.8 °C	20.8 °C	17.8 °C	12.2 °C	3.2 °C	2.3 °C	9.6 °C

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

*Indicates that Morgantown Lock and Dam had sparse temperature data in 2014 - Fairmont, WV (FRTW2) was used as a proxy location for this data.

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown	KMGW	-6.4 °F	-5.4 °F	-5.2 °F	2.7 °F	2.8°F	3.2 °F	-0.9 °F	0.5°F	2.0 °F	4.4 °F	-3.2 °F	3.3 °F	-0.1 °F
		-3.6 °C	-3.0 °C	-2.9 °C	1.5 °C	1.6 °C	1.8 °C	-0.5 °C	0.3 °C	1.1 °C	2.4 °C	-1.8 °C	1.8 °C	-0.1 °C
Chalk Hill 2 ENE	CHKP1	-7.4 °F	-6.9 °F	M	M	1.8°F	2.9 °F	-0.7 °F	-0.5 °F	-0.2 °F	0.9 °F	-4.5 °F	M	M
		-4.1 °C	-3.8 °C	M	M	1.0 °C	1.6 °C	-0.4 °C	-0.3 °C	-0.1 °C	0.5°C	-2.5 °C	M	M
Uniontown 1 NE	UNTP1	-6.2 °F	-6.3 °F	-5.0 °F	1.4 °F	1.4 °F	1.9 °F	-1.6 °F	0.6 °F	2.2 °F	-4.2 °F	4.8 °F	3.5 °F	0.5 °F
		-3.4 °C	-3.5 °C	-2.8 °C	0.8 °C	0.8 °C	1.1 °C	-0.9 °C	-0.7 °C	0.3 °C	1.2 °C	-2.3 °C	2.7 °C	0.3 °C
Confluence 1 SW Dam	CONP1	-6.3 °F	-5.5 °F	-4.9 °F	-0.4 °F	0.6 °F	0.8 °F	-1.5 °F	-2.8 °F	0.5 °F	1.1 °F	-5.2 °F	4.4 °F	-1.6 °F
		-3.5 °C	-3.1 °C	-2.7 °C	-0.2 °C	0.3 °C	0.4 °C	-0.8 °C	-1.6 °C	0.3 °C	0.6 °C	-2.9 °C	2.4 °C	-0.9 °C
Morgantown Lock and Dam*	MOEW2	M	M	-4.0 °F	3.2 °F	M	1.0 °F	-2.3 °F	-1.5 °F	0.6 °F	1.1 °F	-3.7 °F	3.8 °F	M
		M	M	-2.2 °C	1.8 °C	M	0.6 °C	-1.3 °C	-0.8 °C	0.3 °C	0.6 °C	-2.1 °C	2.1 °C	M
Grays Landing ¹	GYLP1	-6.5 °F	-6.1 °F	-5.5 °F	-0.4 °F	0.5 °F	0.7 °F	-3.4 °F	-2.5 °F	-0.2 °F	1.4 °F	-4.5 °F	3.7 °F	-1.9 °F
		-3.6 °C	-3.4 °C	-3.1 °C	-0.2 °C	0.3 °C	0.4 °C	-1.9 °C	-1.4 °C	-0.1 °C	0.8 °C	-2.4 °C	2.1 °C	-1.1 °C

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

¹Indicates a station's Period of Record is ten or more years but less than 30 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.

*Indicates that Morgantown Lock and Dam had no data in 2014 - Fairmont, WV (FRTW2) was used as a proxy location for this data.

**Friendship Hill National Historic Site and Fort Necessity National Battlefield
Departure from Average Monthly Maximum Temperature
2014 vs. 1981–2010**

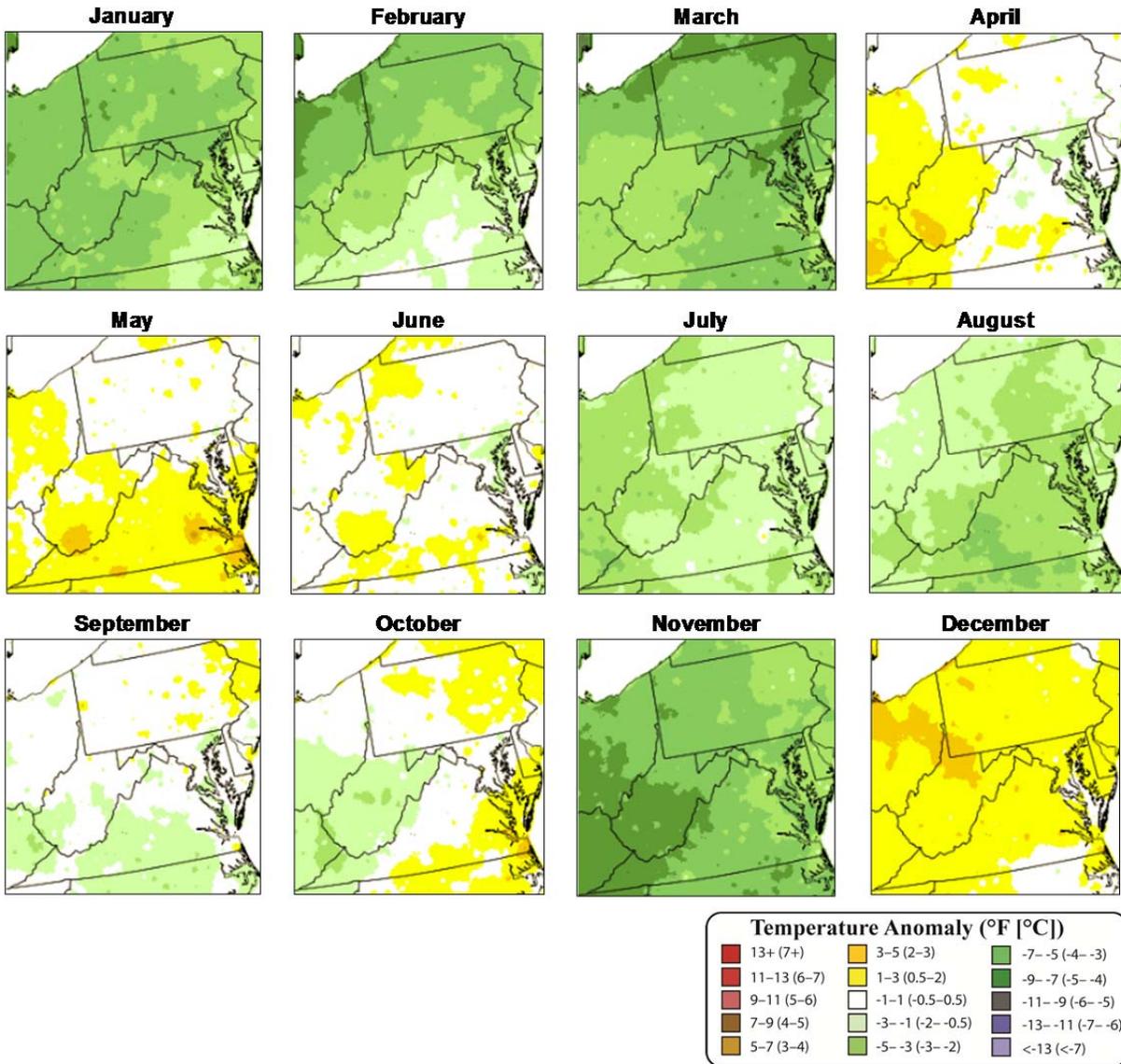


Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).

**Friendship Hill National Historic Site and Fort Necessity National Battlefield
Departure from Average Monthly Minimum Temperature
2014 vs. 1981–2010**

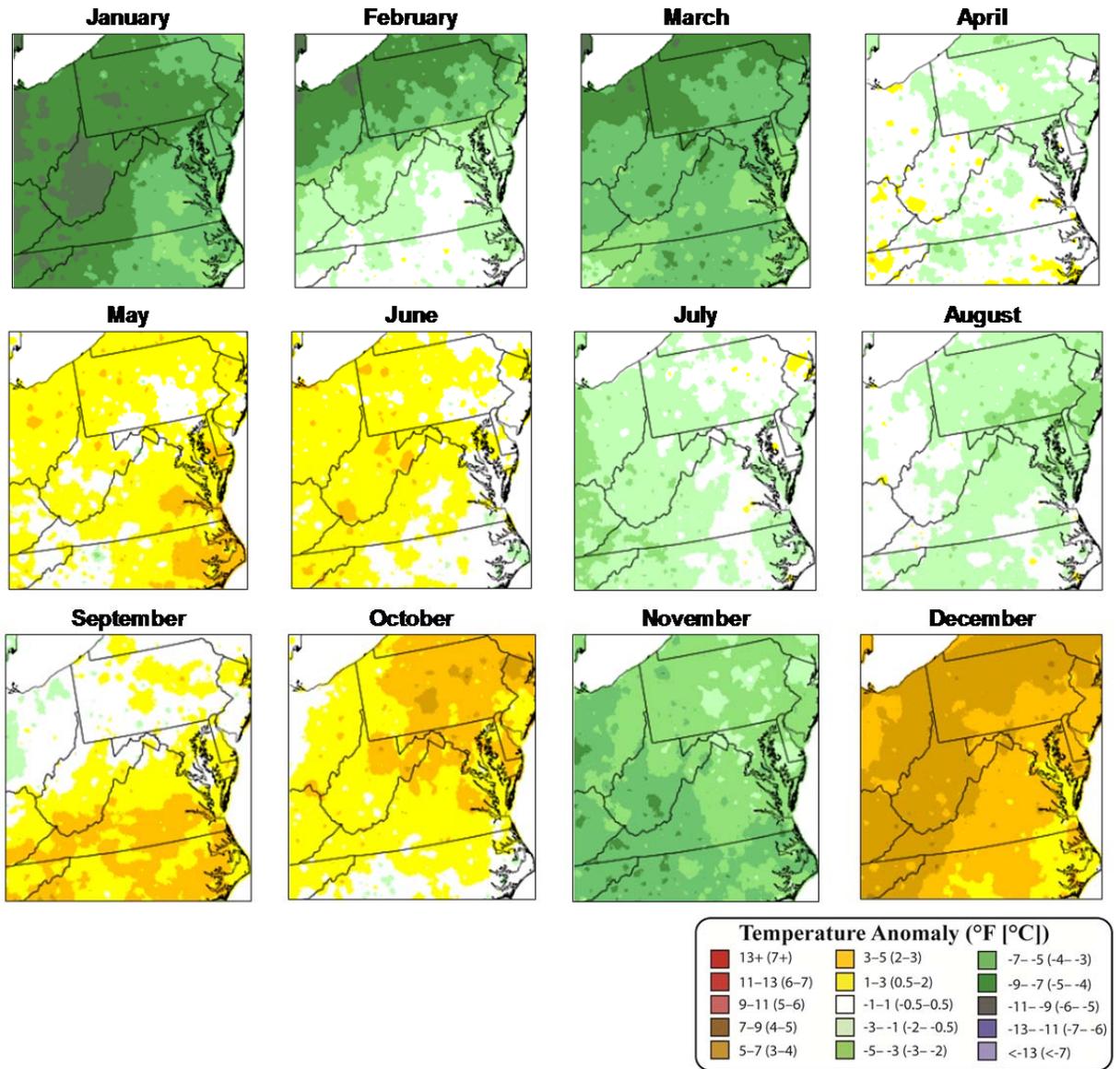


Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).

Table 5. Seasonal and annual temperature and precipitation rankings for 2014 over 120 years (1 = warmest/wettest year and 120 = coldest/driest year) for Pennsylvania Climate Division 9.

PA Climate Division 9 Rankings "Southwest"	Jan-Feb-Mar WINTER	Apr-May-Jun SPRING	Jul-Aug-Sep SUMMER	Oct-Nov-Dec AUTUMN	Jan - Dec ANNUAL
Temperature-2014	116	30	101	42	103
Precipitation-2014	96	17	71	69	68

Precipitation Summary

Overall, 36.7 in (932 mm) of liquid precipitation (rain plus melted snow, ice, sleet, etc.; hereafter precipitation) fell in Uniontown, PA (near Fort Necessity NB), and 41.9 in (1064 mm) fell in Morgantown Airport, WV (near Friendship Hill NHS), during the year making 2014 the 53rd driest year on record (60 is the mid-point; Tables 5 and 6). Precipitation totals ranged from 83 to 100 percent of normal (Table 9). The longest dry spell of the year occurred from Sept 17-21, when no measurable rain fell at Chalk Hill (Table 7). Conversely, the wettest day in 2014 occurred on August 23, when 3.73 in (95 mm) fell in Chalk Hill, nearly a month's worth of rain in one day (Table 7). Precipitation oscillated between wet and dry periods during 2014 at Fort Necessity NB and Friendship Hill NHS, with all of the reporting stations averaging less than 80 percent of normal in 4 of the 12 months (Tables 8 and 9).

The winter season began with a very dry January, with only 1.4 in (36 mm [40 percent of average]) precipitation falling at Confluence SW Dam (Tables 8 and 9). February was notably wetter, with precipitation ranging from 2.8 in (71 mm) at Grays Landing, which was 113 percent of normal, to 4.4 in (112 mm) at Chalk Hill, 116 percent of its monthly normal sum (Table 8). March was another dry month, with stations averaging about 65 percent of normal precipitation (Table 9). Overall, the winter (January, February, and March) ranked as the 25th driest since 1895 (Table 5). Below average seasonal snowfall was recorded near Fort Necessity NB, as Chalk Hill tallied 77.1 in (195.8 cm) that was approximately 12 in (30 cm) below the long-term average though moderate and heavy snow days were slightly above average (Table 6).

April precipitation was well below normal, ranging from 41 to 60 percent of normal (Table 9). May rainfall ranged from 2.77 in (71 mm) at Grays Landing to 3.87 in (100 mm) at Morgantown (Table 8). June brought more showers, with the region averaging more than 120 percent of long-term normal (Table 9). Overall, spring of 2014 ranked as the 55th wettest in this climate division (Table 5).

Summer of 2014 precipitation started close to average (Figure 4); but it turned markedly drier in September. Overall, this season ranked as the 50th driest (60 is the mid-point; Table 5). The deficit was caused by the aforementioned dry September which was 10th driest since 1895. September had as little as 1.9 in (48 mm) of rain falling in Grays Landing (66 percent of normal) (Tables 8 and 9). Two of the year's wettest days occurred in August (Table 7).

The autumn of 2014 was another dry season and its ranking was the 52nd wettest in 120 years in the Southwest Plateau Pennsylvania Climate Division (Table 5). Autumn precipitation started off above normal but deficits began and quickly grew in November and December (Figure 4). The number of heavy precipitation days was near to slightly below normal in 2014.

Table 2. Status of 2014 precipitation indicators compared to the 30-year normal (1981–2010) and the station period of record at the Morgantown Lock and Dam (MOEW2) and Uniontown (UNTP1) stations.

Precipitation Indicator	Morgantown Lock and Dam, WV MOEW2 2014*	Morgantown Lock and Dam, WV MOEW2 1981–2010	Morgantown Lock and Dam, WV 1946-2013 Mean (min – max)	Uniontown, PA UNTP1 2014	Uniontown, PA UNTP1 1981–2010	Uniontown, PA 1895-2013 Mean (min – max)
Annual Precipitation	46.2 in 1,173 mm	47.7 in 1,212 mm	42.1 (29.4 – 57.9) in 1,069 (747 – 1,471) mm	36.7 in 932 mm	42.4 in 1,077 mm	42.6 (26.3 – 60.9) in 1,082 (668 – 1,547) mm
Autumn (Oct, Nov, Dec) Precipitation	11.7 in 297 mm	11.2 in 284 mm	9.0 (3.4 – 14.9) in 229 (86 – 378) mm	9.1 in 231 mm	9.5 in 241 mm	9.2 (3.9 – 18.1) in 234 (99 – 460) mm
Heavy Precipitation Days (days with ≥1.0 in [25 mm] rain)	9	9	NA	5	7	NA
Extreme Precipitation Days (days with ≥2.0 in [51 mm] rain)	0	1	1 (0 – 5)	0	1	1 (0 – 3)
Micro-drought (strings of 7+ days without rain)	5	5	NA	3	6	NA
Annual Snowfall ²	84.4 in 214.4 cm	87.5 in 222 cm	15.2 (0 – 41.8) in 386 (0 – 1,062) mm	49.1 in 124.7 cm	22.5 in 57.2 cm	30.6 (2.0 – 77.3) in 777 (51 – 1,963) mm
Measurable Snow Days (days with ≥0.1 in [0.3 cm] snow)	57	40	NA	21	12	NA
Moderate Snow Days (days with ≥3.0 in [7.6 cm] snow)	9	11	NA	8	3	NA
Heavy Snow Days (days with ≥5.0 in [12.7 cm] snow)	0	4	NA	3	1	NA

²MOEW2 1981-2010 normal snowfall data is approximated using Fairmont, WV snowfall data.

*Uniontown data used for these values **Morgantown Airport data used for these values

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2014 from stations at Chalk Hill (CHKP1) and Morgantown Lock and Dam (MOEW2).

Wettest Days in 2014	Dry Spells in 2014
Aug 23: 3.73 in(95mm)	Sept 24-30
May 16: 1.62 in (41mm)	Sept 17-21
Aug 12: 1.58 in (40mm)	Aug 24-27
Jun 5: 1.42 in (36mm)	Aug 8-11
Oct 15: 1.33 in (34mm)	Mar 4-7

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
Morgantown Airport	KMGW	2.0 in	3.4 in	2.8 in	3.0 in	4.5 in	4.5 in	5.4 in	5.0 in	2.3 in	4.1 in	1.9 in	2.9 in	41.9 in
		51 mm	86 mm	71 mm	76 mm	114 mm	114 mm	137 mm	127 mm	58 mm	104 mm	48 mm	74 mm	1064 mm
Chalk Hill 2 ENE	CHKP1	2.9 in	4.4 in	3.0 in	M	5.0 in	5.8 in	5.9 in	8.0 in	2.5 in	M	M	M	M
		74 mm	112 mm	76 mm	M	127 mm	147 mm	150 mm	203 mm	64 mm	M	M	M	M
Uniontown 1 NE	UNTP1	2.0 in	3.1 in	2.4 in	2.8 in	4.8 in	2.5 in	4.5 in	3.4 in	2.0 in	3.3 in	2.5 in	3.3 in	36.7 in
		51 mm	79 mm	61 mm	71 mm	122 mm	64 mm	114 mm	86 mm	51 mm	84 mm	64 mm	84 mm	932 mm
Confluence 1 SW Dam	CONP1	1.4 in	3.6 in	1.9 in	1.9 in	6.6 in	6.7 in	4.1 in	2.8 in	2.9 in	3.8 in	1.4 in	0.8 in	37.8 in
		36 mm	91 mm	48 mm	48 mm	168 mm	170 mm	104 mm	71 mm	74 mm	97 mm	36 mm	20 mm	960 mm
Morgantown Lock and Dam	MOEW2	M	4.0 in	2.5 in	2.4 in	M	6.3 in	5.5 in	M	M	4.2 in	M	M	M
		M	102 mm	64 mm	61 mm	M	160 mm	140 mm	M	M	107 mm	M	M	M
Grays Landing	GYLP1	1.7 in	2.8 in	2.5 in	2.9 in	3.7 in	4.0 in	3.8 in	3.5 in	1.9 in	3.2 in	2.2 in	2.8 in	35.2 in
		43 mm	71 mm	64 mm	74 mm	94 mm	102 mm	97 mm	89 mm	48 mm	81 mm	56 mm	71 mm	894 mm

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

Station Name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	71	131	77	85	98	109	117	141	72	147	55	100	100
Chalk Hill 2 ENE	CHKP1	68	116	64	M	93	115	111	198	57	M	M	M	M
Uniontown 1 NE	UNTP1	65	111	65	76	108	59	98	97	60	111	68	107	85
Confluence 1 SW Dam	CONP1	40	116	49	49	136	160	92	80	76	128	38	22	83
Morgantown Lock and Dam	MOEW2	M	136	63	67	M	152	126	M	M	149	M	M	M
Grays Landing ¹	GYLP1	60	113	69	90	86	101	102	107	66	126	58	94	89

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

¹Indicates a station's Period of Record is ten or more years but less than 30 years. In these cases, the departure from normal values was calculated with normals derived from data spanning the length of the station's period of record.

**Friendship Hill National Historic Site and Fort Necessity National Battlefield
Percent of Average Monthly Precipitation
2014 vs. 1981–2010**

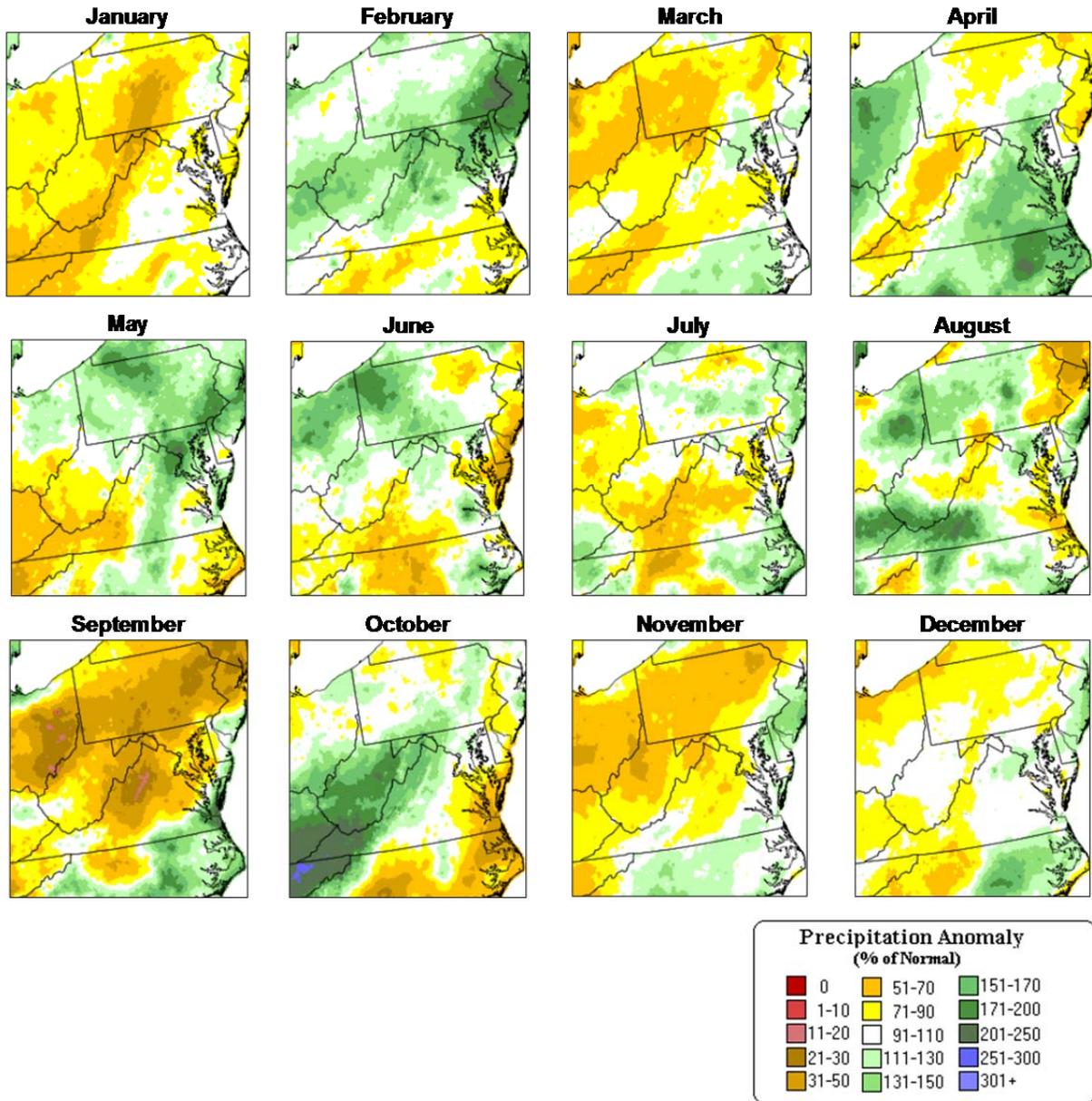


Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).

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 . Monthly PDSI values for Pennsylvania Climate Division 9 in 2014 are shown in Figure 5.

The DM – Drought Intensity Index is a synthesis of multiple indices (including the PDSI) and impacts, and represents a consensus of federal and academic scientists (NIDIS 2013). 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 Pennsylvania are shown in Figure 6 and the Northeast are shown in Figure 7 for 2014.

According to the PDSI in Climate Division 9, a persistently moist spring and early summer was followed by a moist early winter (January) and a wet late summer and autumn. The moist conditions led the drought severity index to improve for 2014, in comparison to 2013 (Figure 5). Heavy rainfall during November and December raised the PDSI values above $+2.5$, moderately moist, by the latter half of December. The calendar year 2013 was most similar to 2012 and most dissimilar to the latter winter months of 2014.

The DM – Drought Severity Index for Pennsylvania (Figure 6) and the Northeast (Figure 7) shows a similar pattern for the growing season (April through September); abnormally to moderately dry (D0) developed during May and June, but dissipated by July in southwestern Pennsylvania.

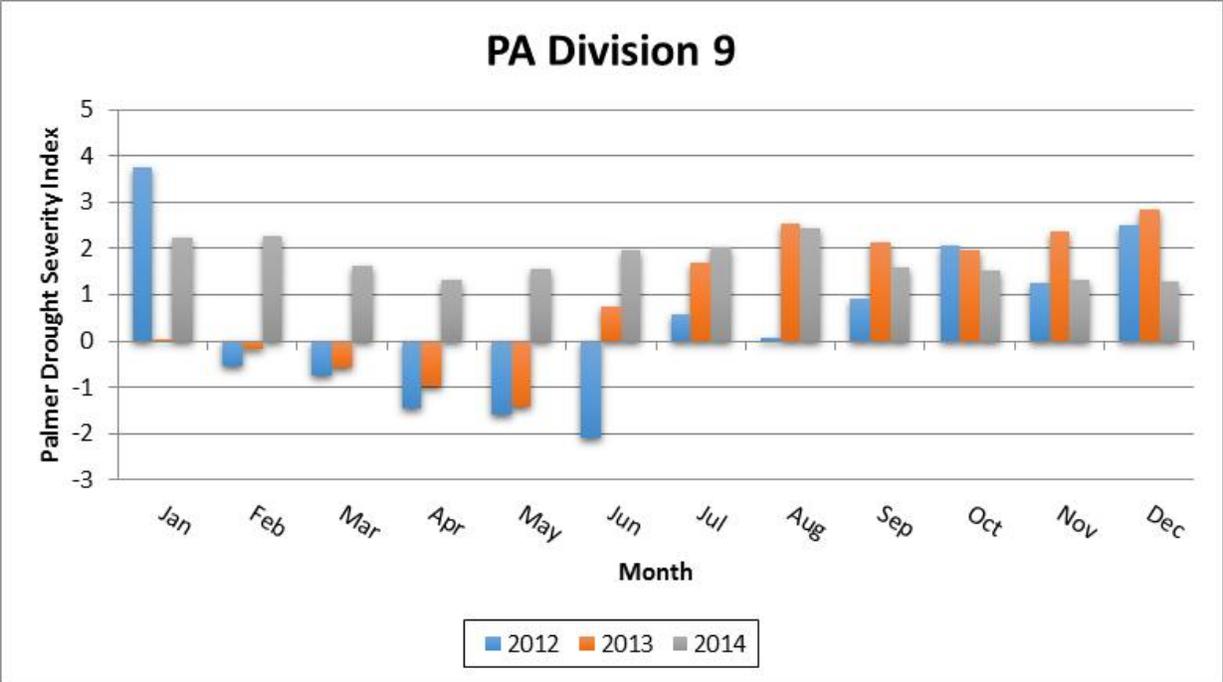


Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 9, 2012–2014.

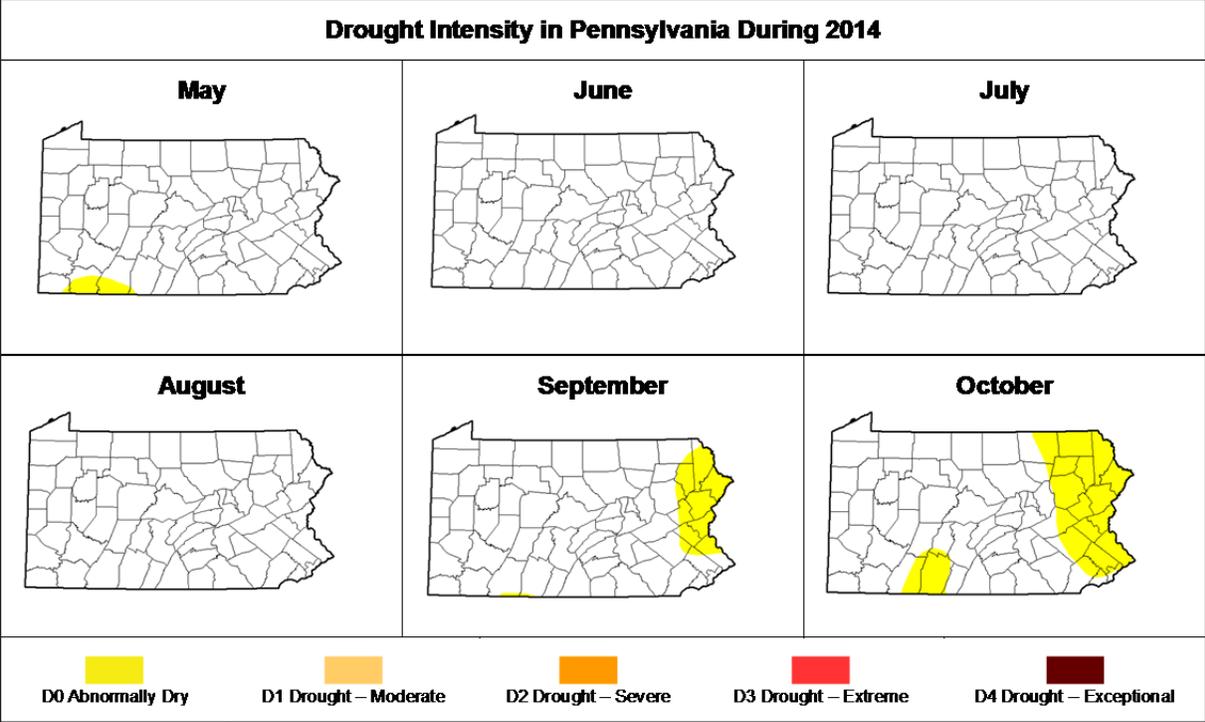


Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Pennsylvania in 2014.

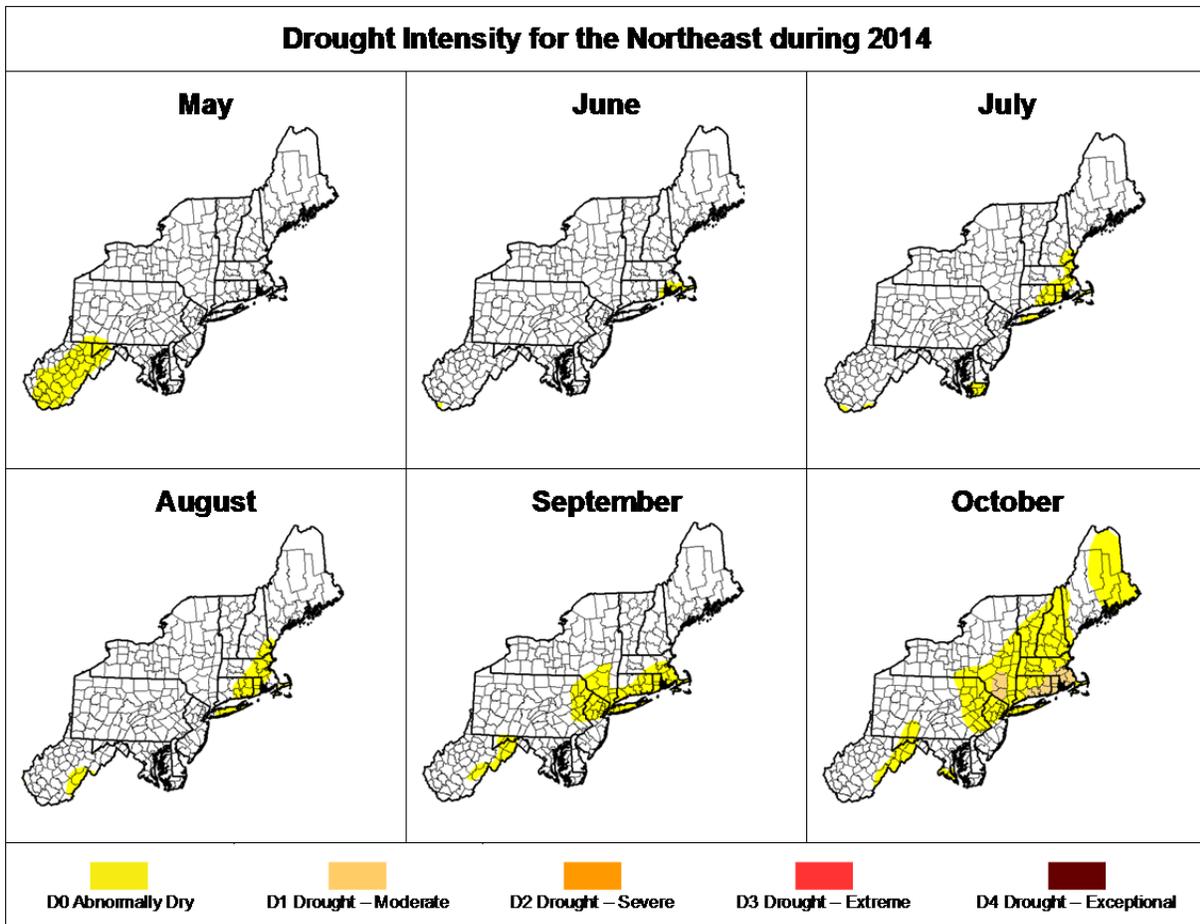


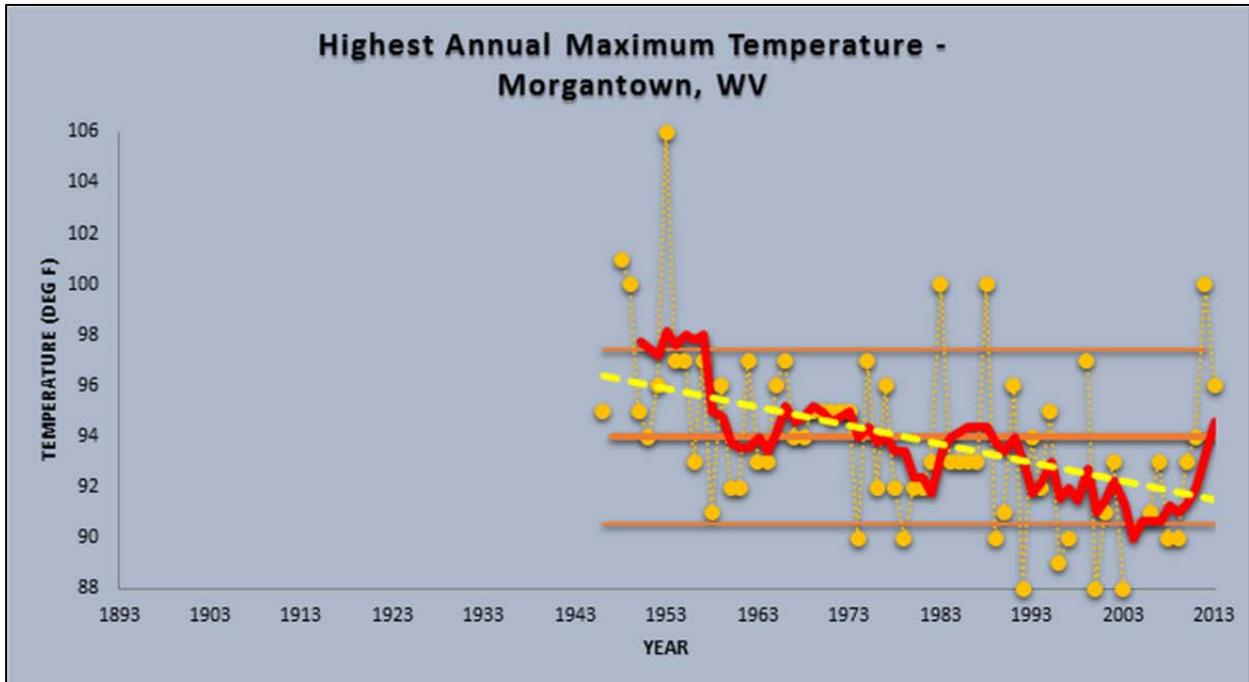
Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Northeast in 2014.

References

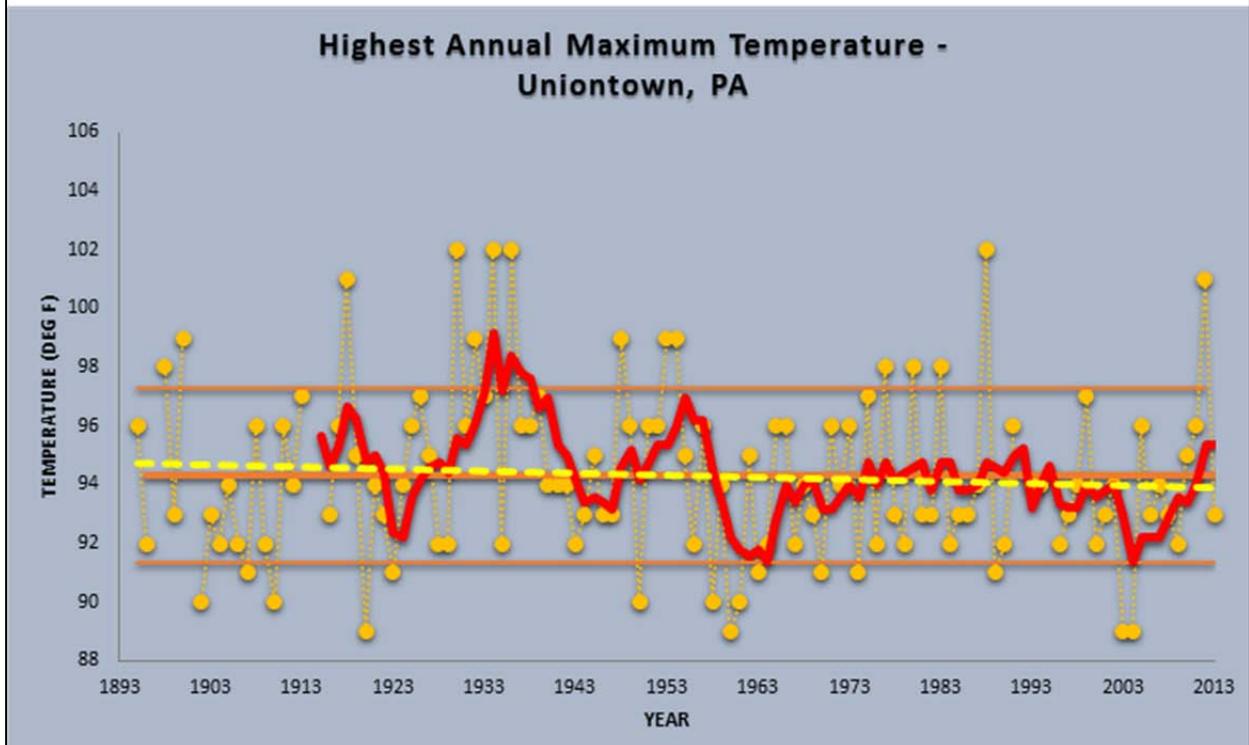
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Appendix

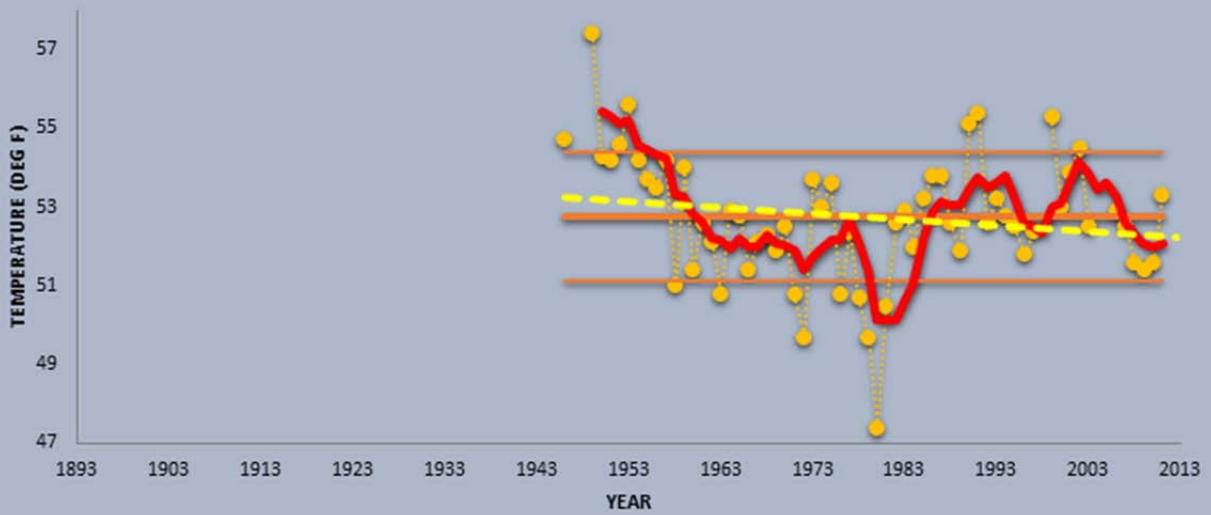
Below are graphs illustrating long-term trend analysis for multiple climate indicators. For temperature indicators, yearly values are marked by the dotted orange line, the 5-year moving average is indicated by the thick red line, the long-term linear trend is shown by the dotted yellow line, the long-term 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: Though the stations are relatively close to each other (only 46.3km apart), the trends are down (more than 4°F per 50 years at Morgantown) and about 1°F at Uniontown. The average annual maximum temperature is 94.0°F (1SD ranges from 90.6-97.4°F) at Morgantown and 94.3°F (1SD ranges from 91.4-97.3°F) at Uniontown (Table 2).

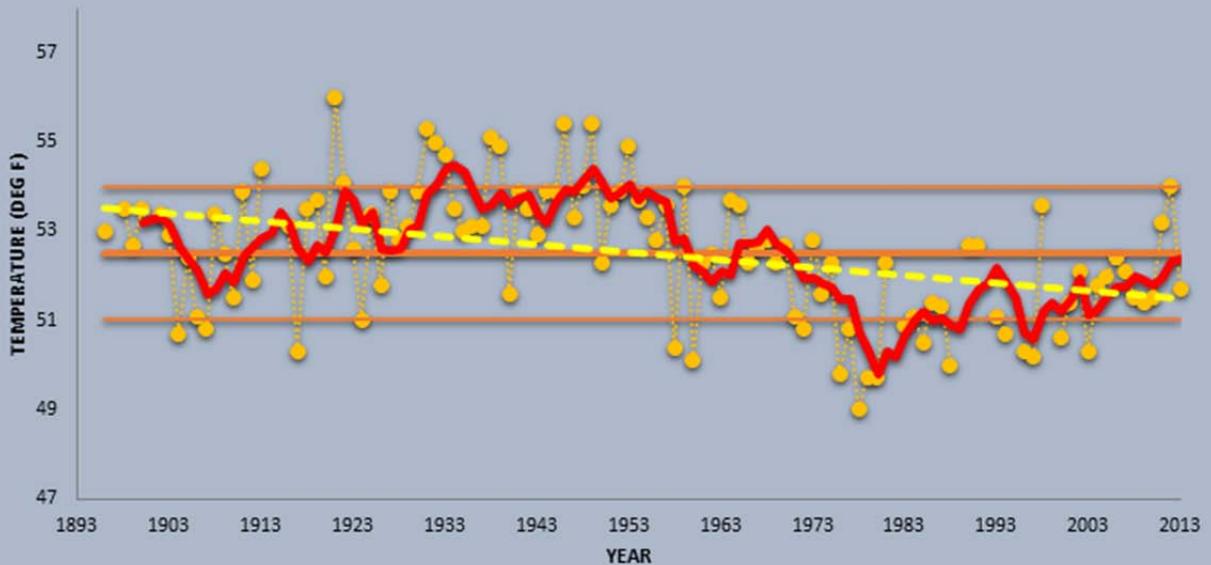


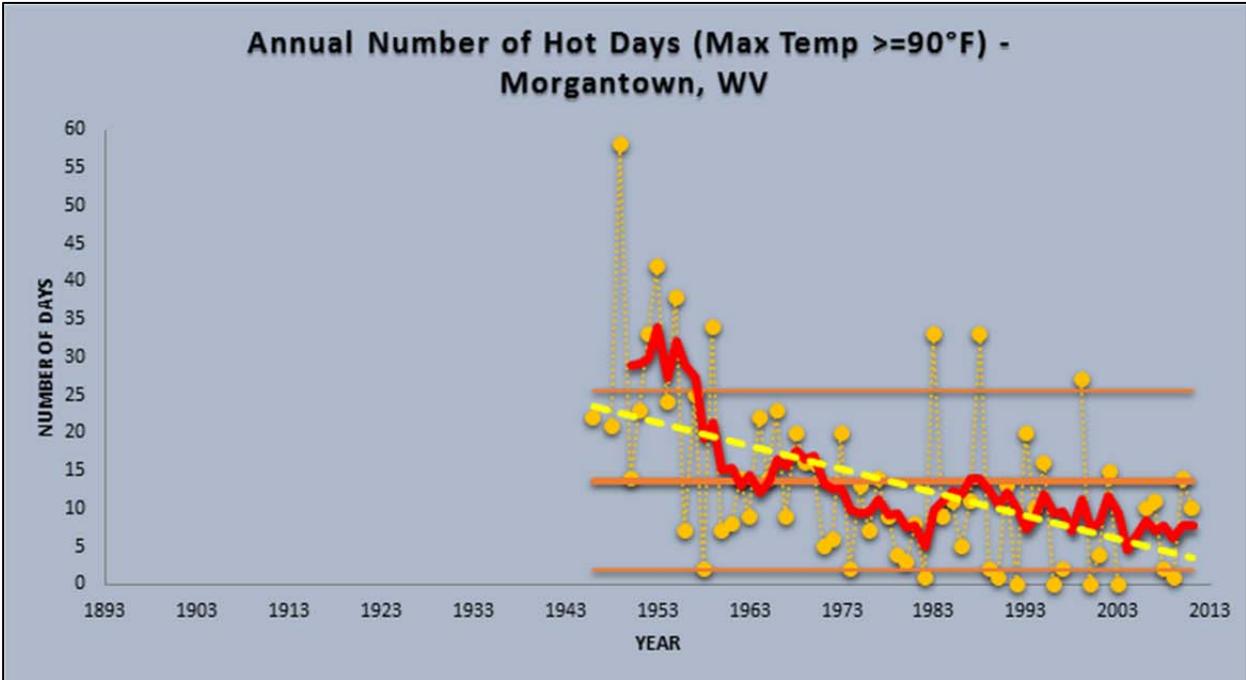
Average Annual Mean Temperature - Morgantown, WV



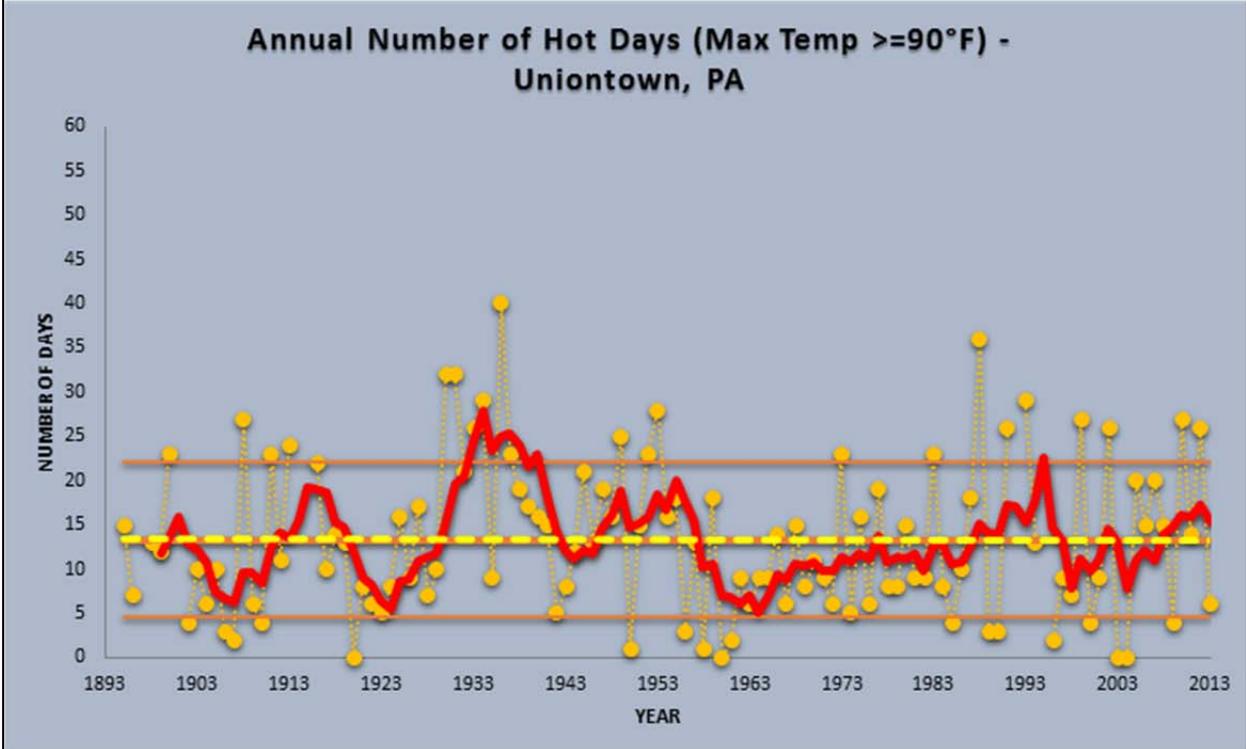
Annual Mean Trends: The annual temperature (average of maximum and minimum) show a slight decline (between 1-2°F over each station's POR), contrary to the long-term warming. The average annual mean temperature at Morgantown is 52.7°F (1SD ranges from 51.1-54.4°F) and 52.5°F (1SD ranges from 51.0-54.0°F) at Uniontown (Table 2).

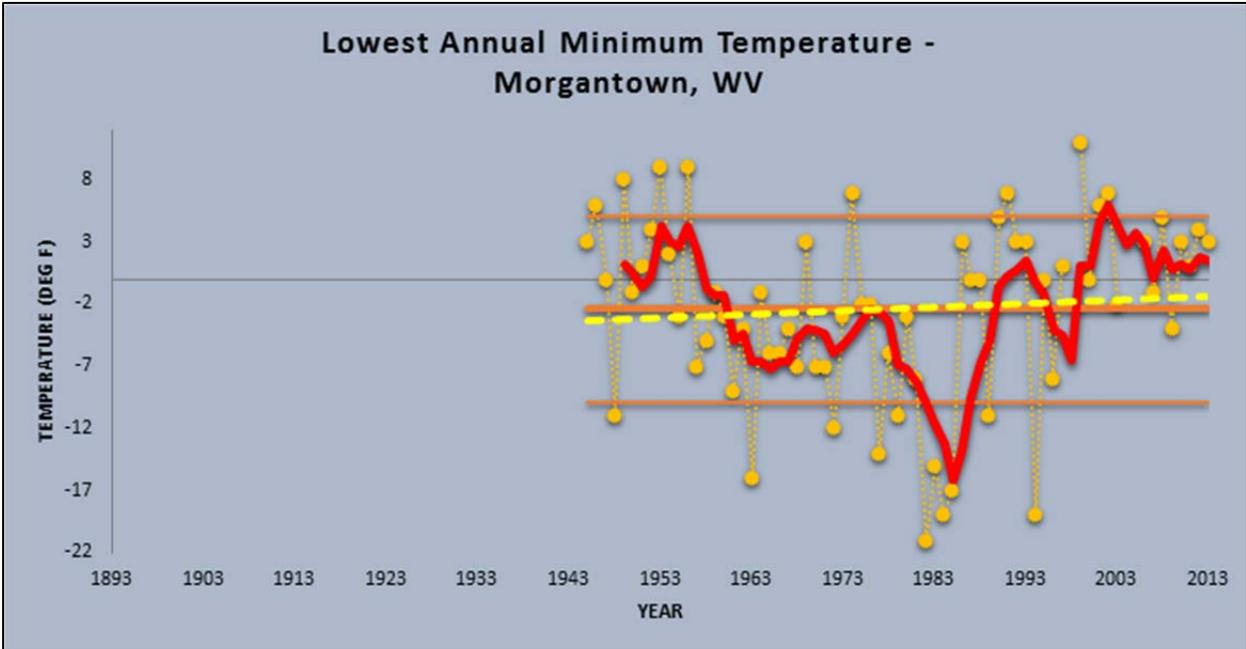
Average Annual Mean Temperature - Uniontown, PA



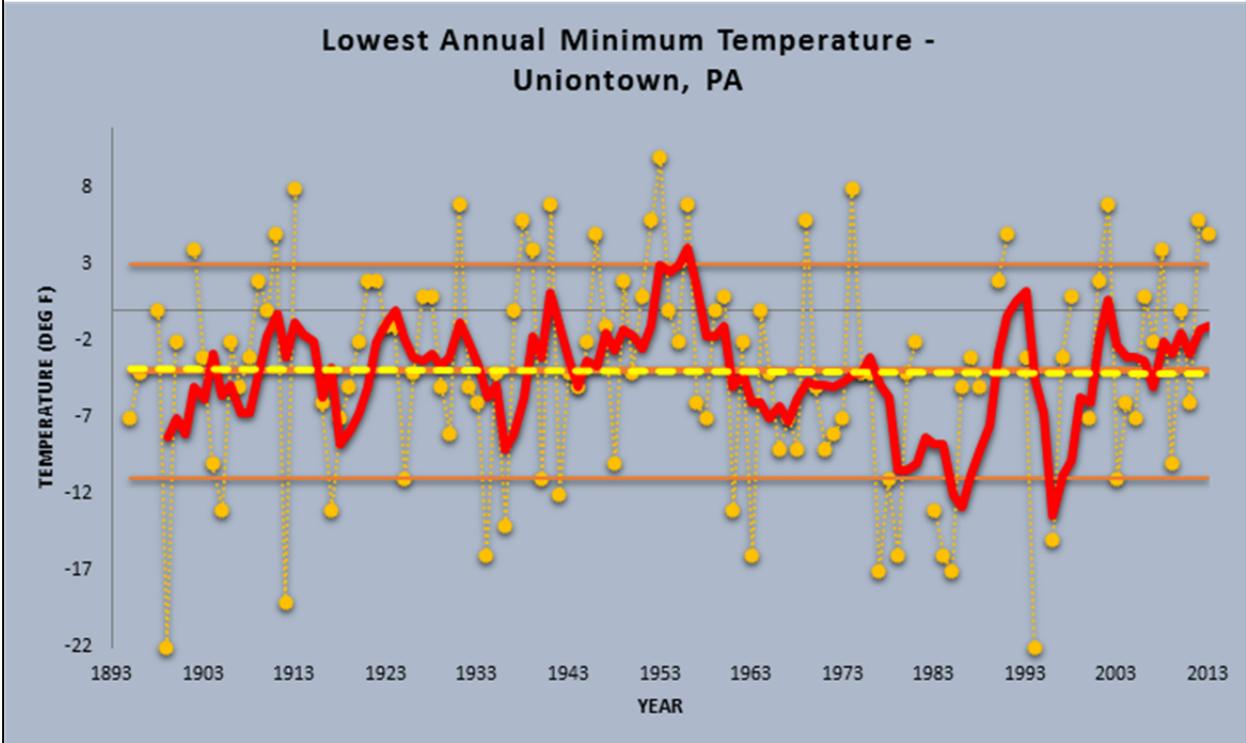


Annual Number of Hot Days: While Morgantown shows a decrease (about 15 days over the past ~70 years), Uniontown has shown no change in hot summer days. The average number of annual hot days is 14 (1SD ranges from 2-26) at Morgantown and 13 (1SD ranges from 5-22) at Uniontown (Table 2).

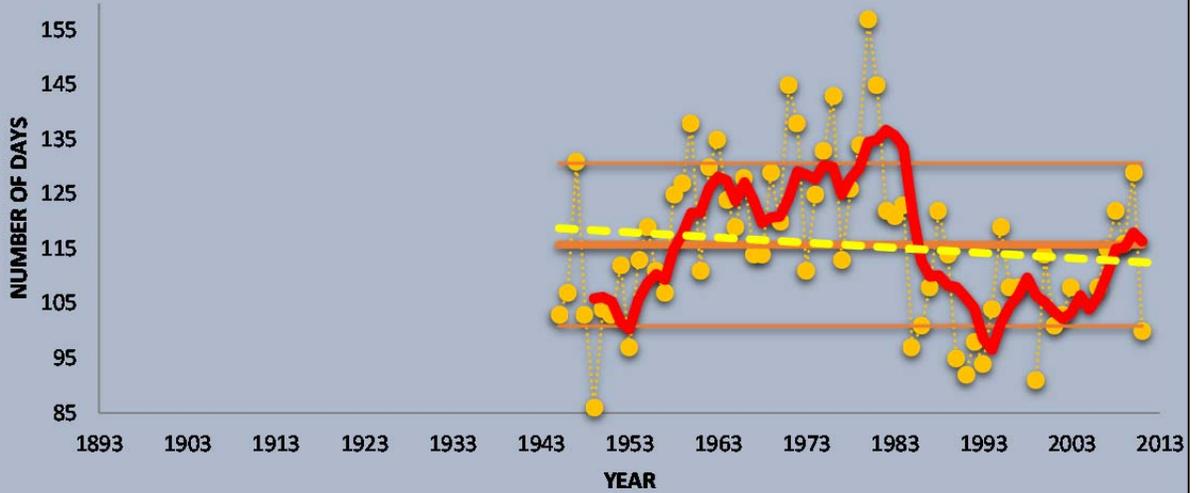




Annual Lowest Minimum Temperature: The slight upward trend (around 3°F over the course of the POR) at Morgantown, but no change at Uniontown may explain part of the annual mean temperature rise. The average annual minimum temperature is -2.4°F (1SD ranges from -9.9-(+5.1) °F) at Morgantown and -3.9°F (1SD ranges from -10.9-(+3.1)°F) at Uniontown (Table 2).

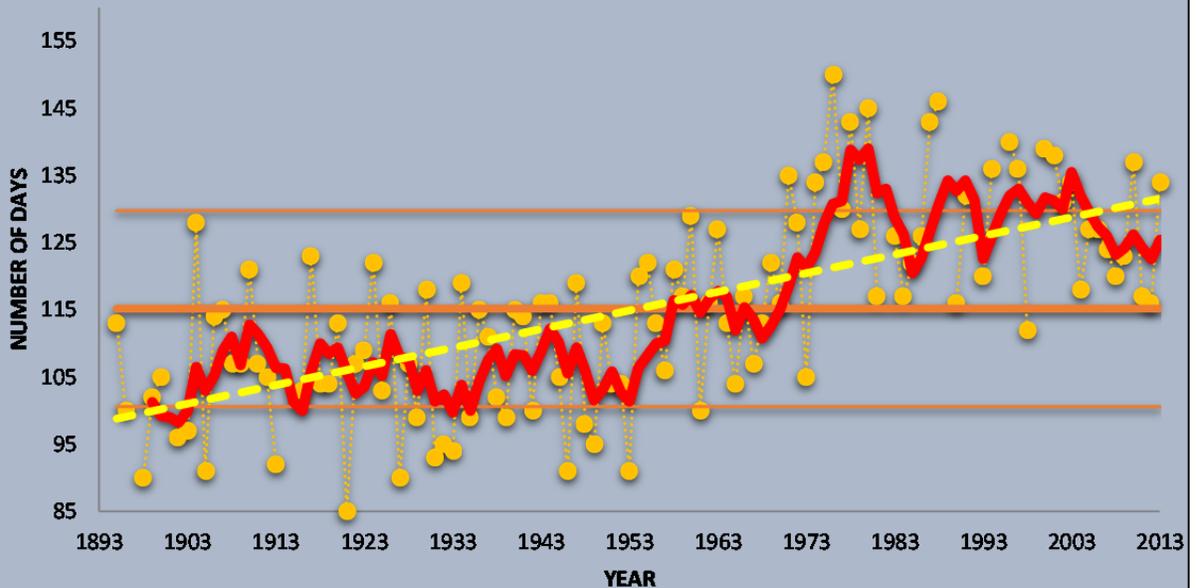


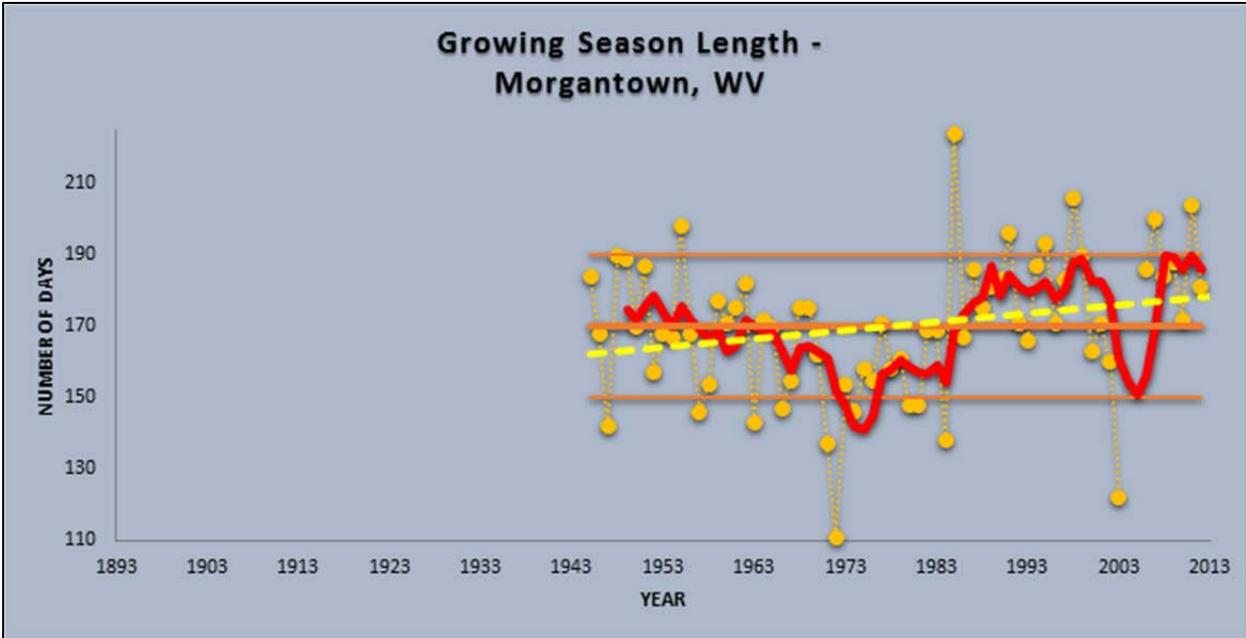
Number of Days with Minimum Temperature $\leq 32^{\circ}\text{F}$ - Morgantown, WV



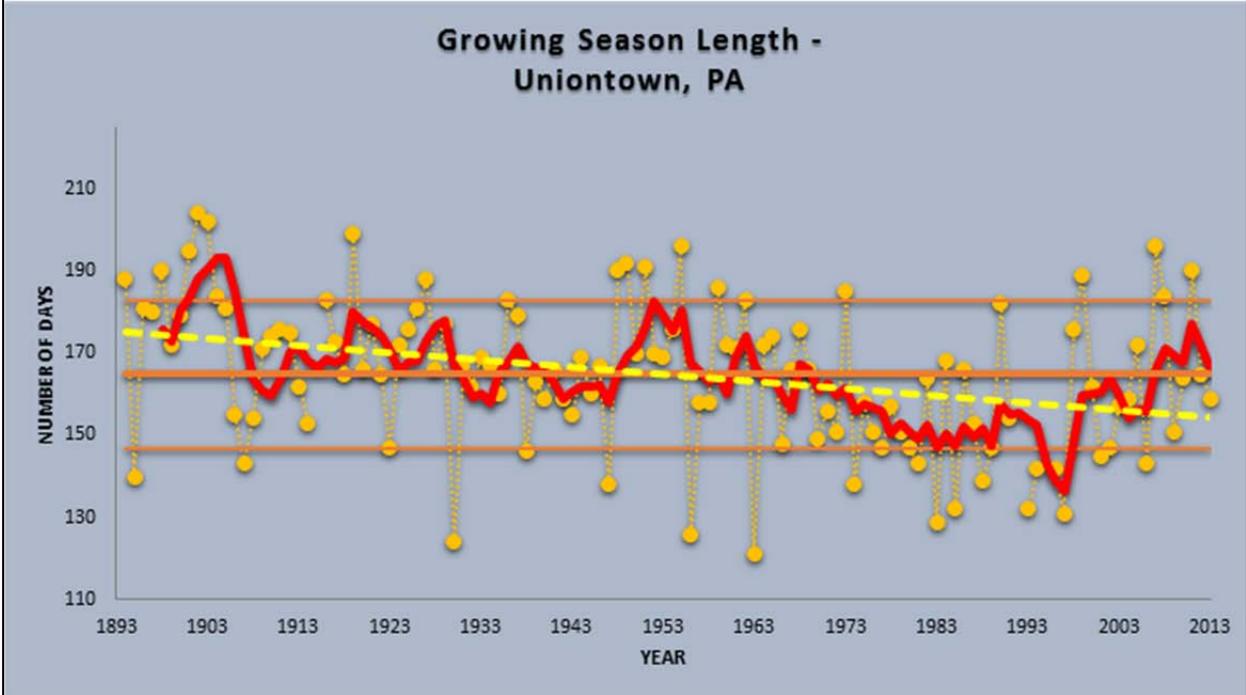
Annual Number of Days with Minimums at or below Freezing: The trend does show a slight decrease with about 10 fewer nights below freezing now compared to 70 years ago at Morgantown, however, Uniontown has shown a marked increase indicating local environment changes. The average number of nights is 116 (1SD ranges from 101-131) at Morgantown and 115 (1SD ranges from 101-130) at Uniontown (Table 2).

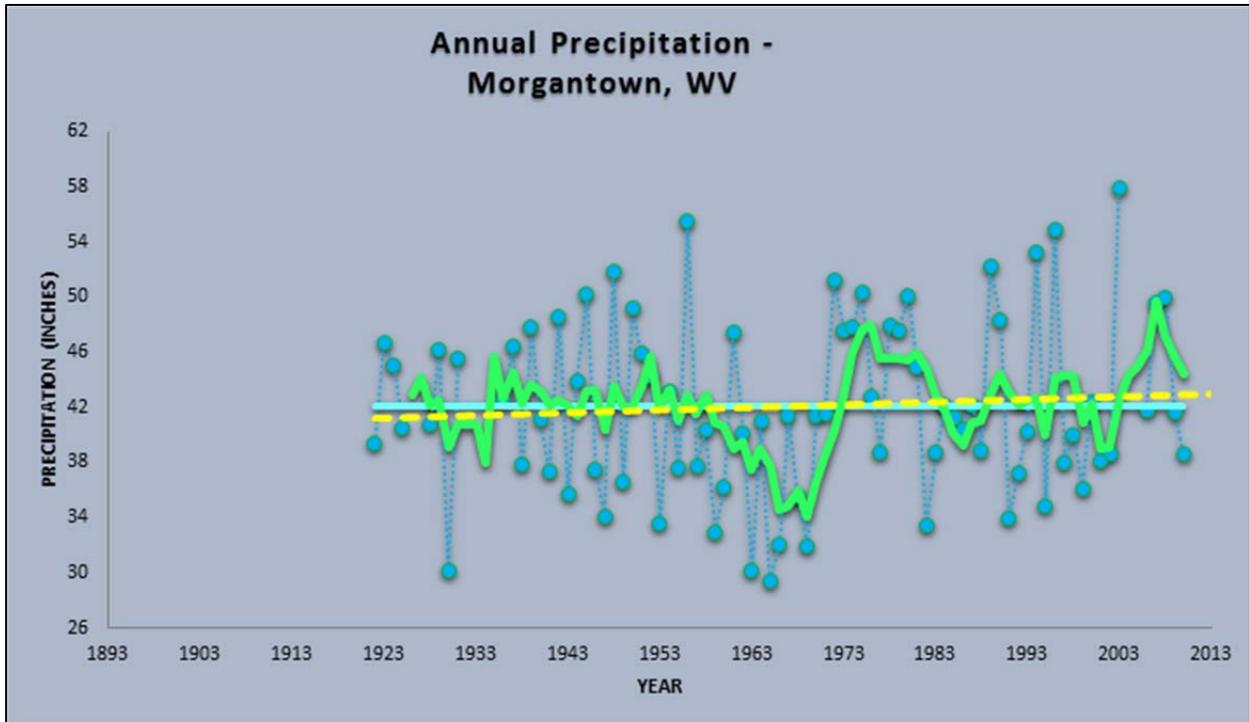
Number of Days with Minimum Temperature $\leq 32^{\circ}\text{F}$ - Uniontown, PA



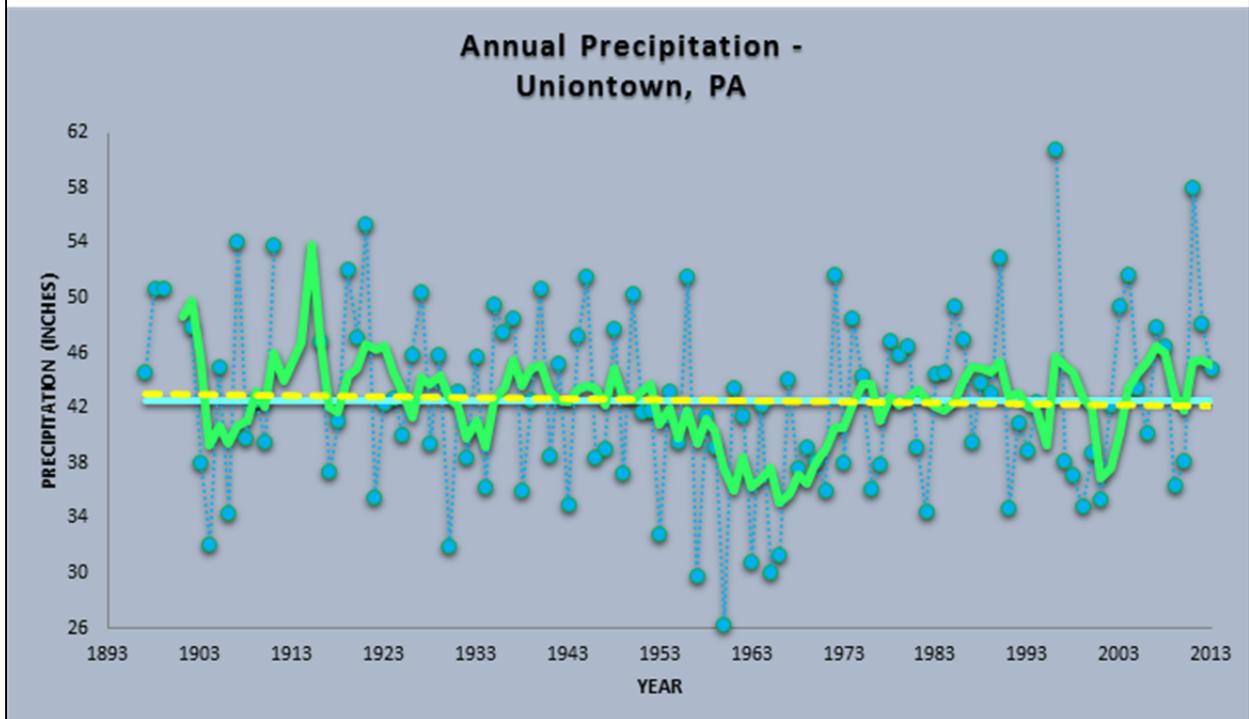


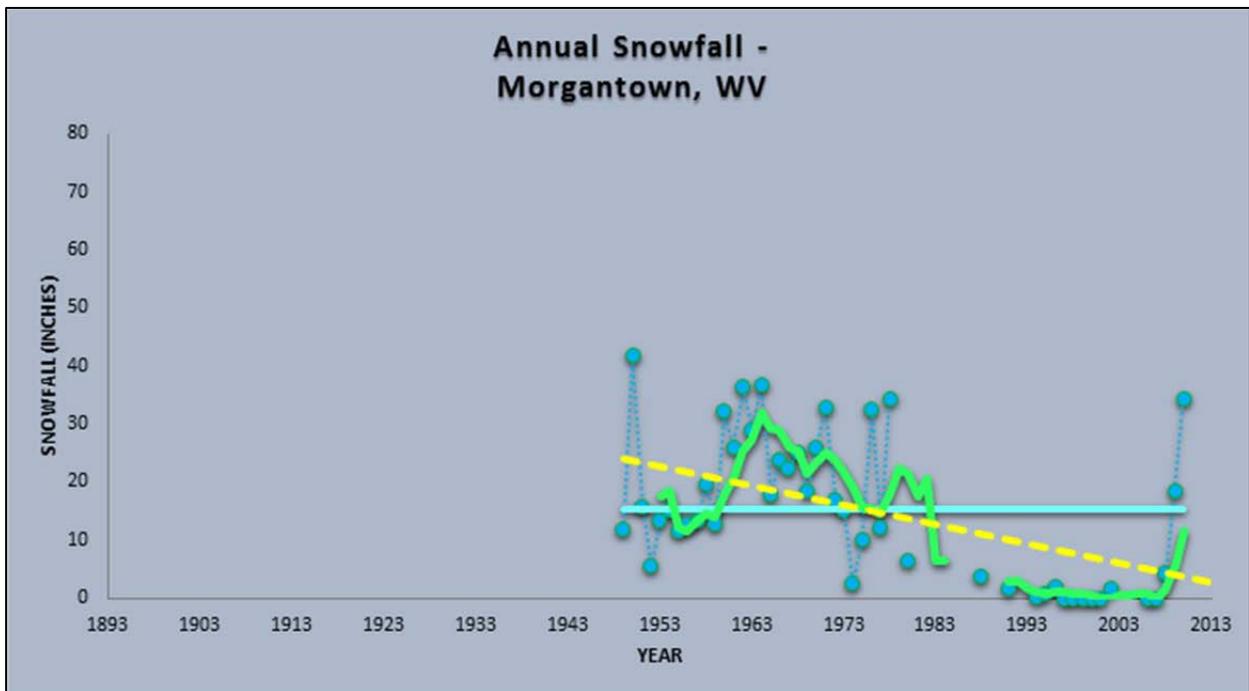
Growing Season Length Trends: Each station shows a different trend in the length of the growing season with about a two to three week increase in the past 70 years at Morgantown and a three week decrease at Uniontown during the last century. The average annual number of days in the growing season is 170 (1SD ranges from 150-190) at Morgantown and 165 (1SD ranges from 147-183) at Uniontown (Table 2).



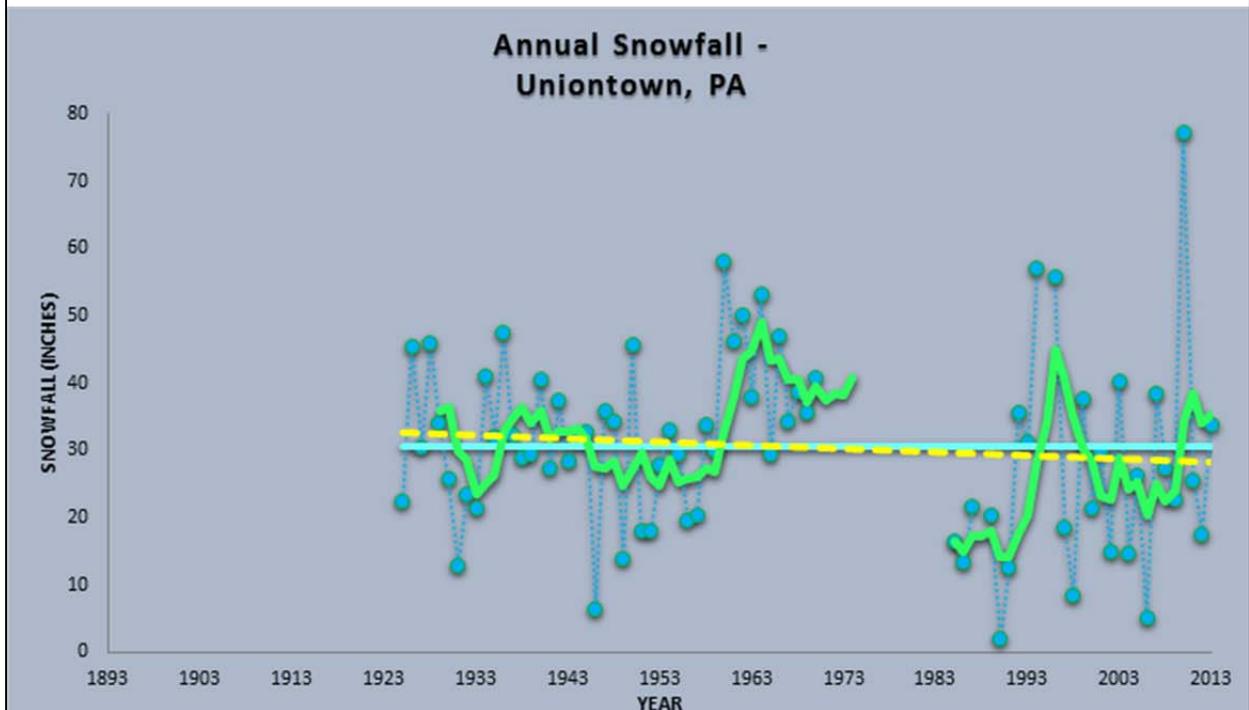


Annual Precipitation Trends: Morgantown shows a slight rise (approx. 2 in. over the past ~90 years) in annual precipitation, whereas Uniontown displays virtually no change. The average annual precipitation at Morgantown is 42.1 in. (min of 29.4 in and max of 57.9 in) and 42.6 in (min of 26.3 in and max of 60.9 in) at Uniontown (Table 6).

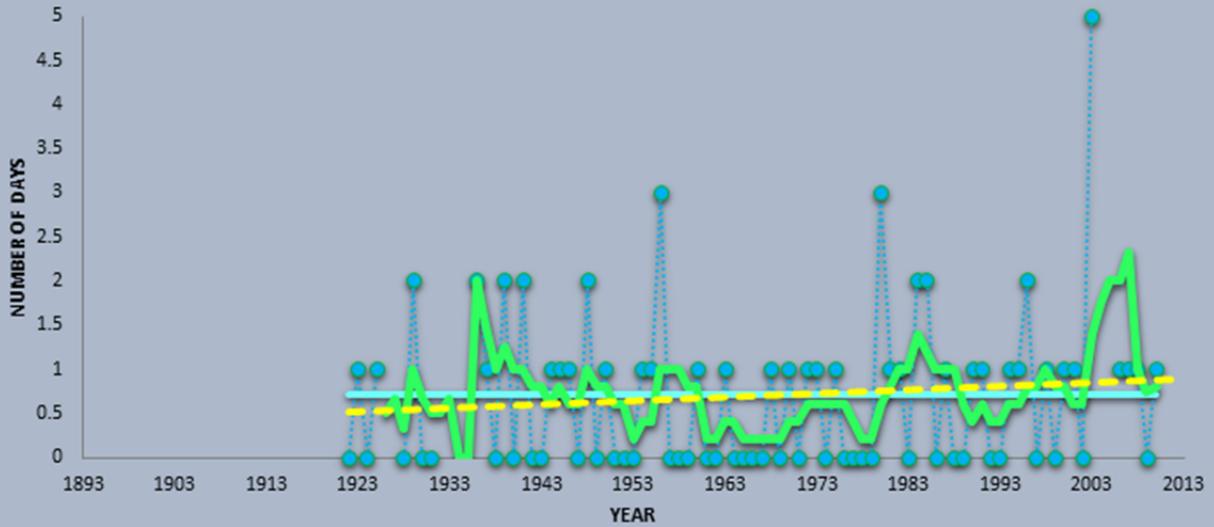




Annual Snowfall Trends: Uniontown shows a slight decrease, whereas Morgantown displays a marked decrease in annual snowfall, approximately a 70% decline. The average annual snowfall amount at Uniontown is 30.6 in. (min of 2.0 in and max of 77.3 in) and 15.2 in (min of 0 in and max of 41.8 in) at Morgantown (Table 6).

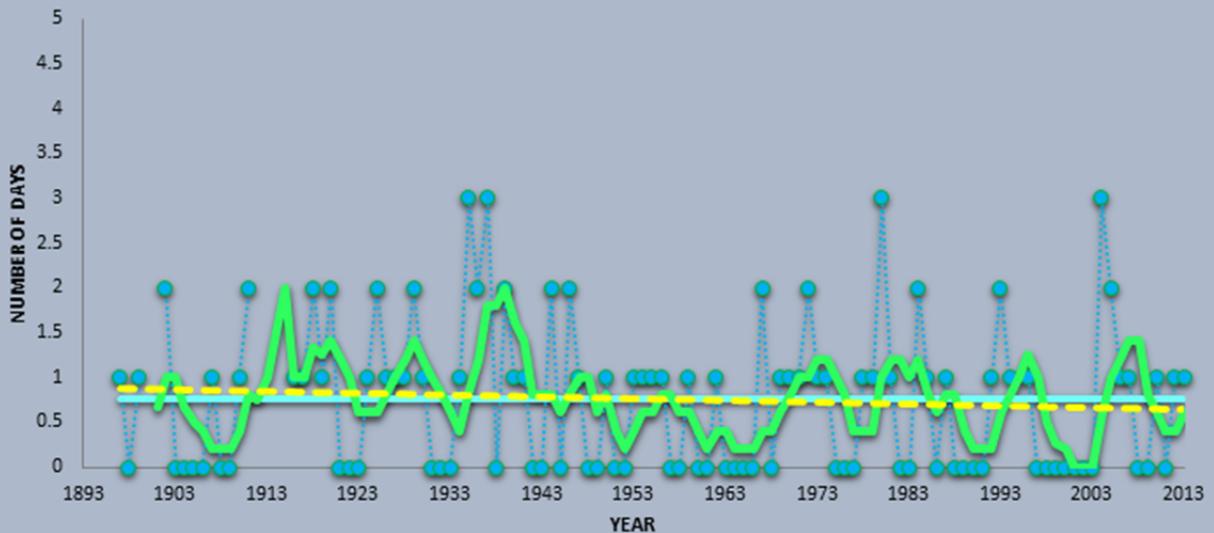


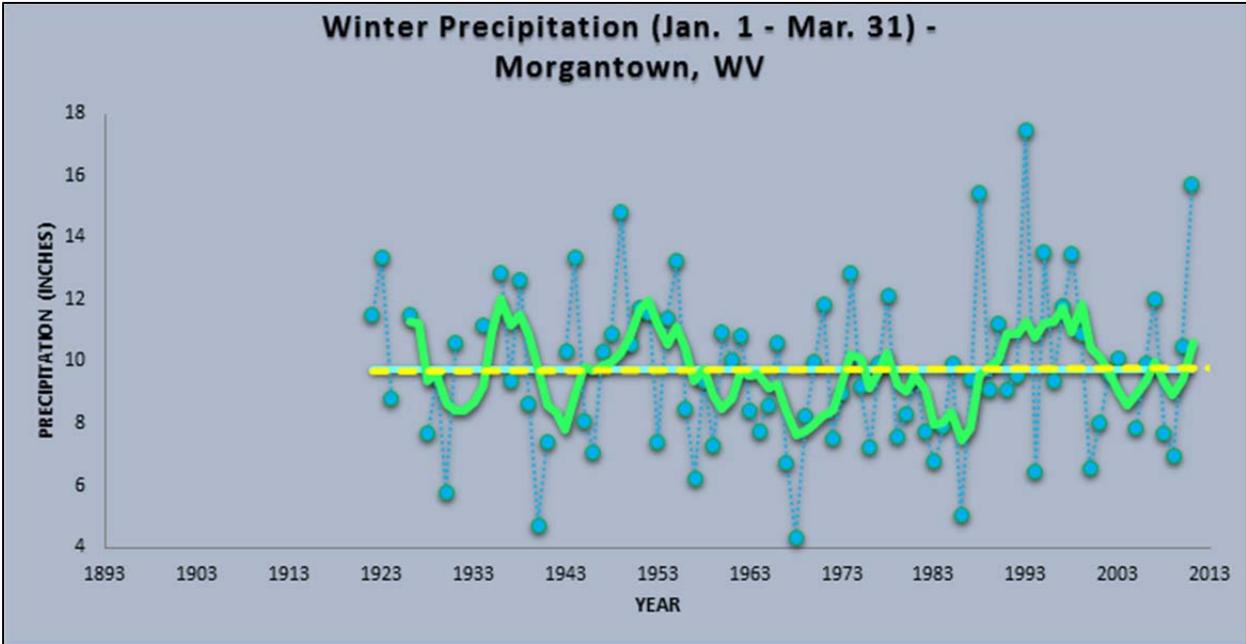
Number of Extreme Precipitation (≥ 2.00 ") Days - Morgantown, WV



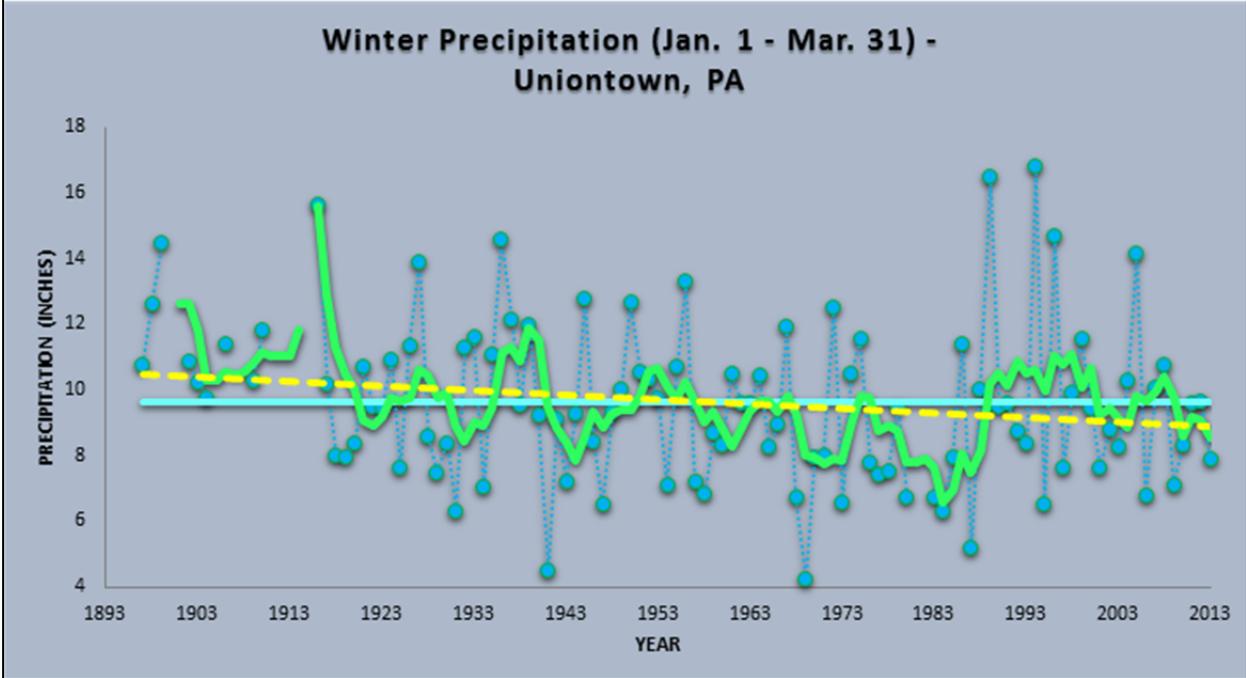
Annual Number of Extreme Precipitation Events: Morgantown shows a slight increase, whereas Uniontown displays a very small downward trend (less than a day over the past ~1000 years) in extreme precipitation days. The average number of days at Morgantown is 1 (min of 0 and max of 5) and 1 (min of 0 and max of 3) at Uniontown (Table 6).

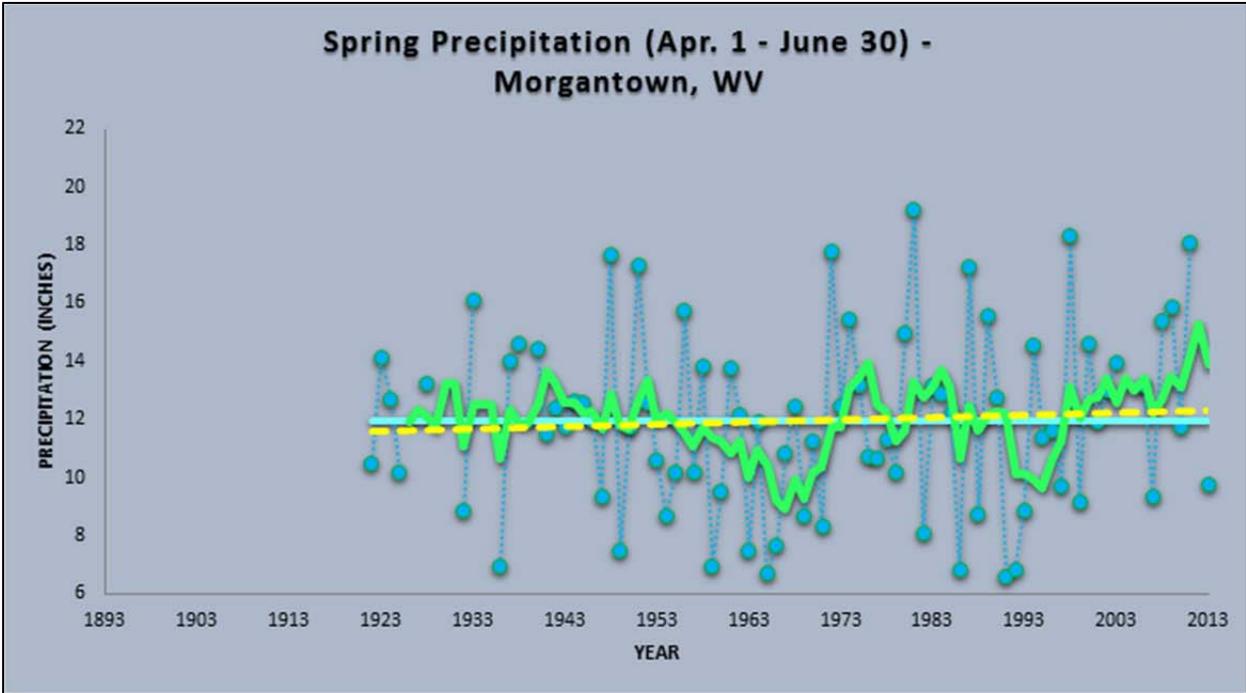
Number of Extreme Precipitation (≥ 2.00 ") Days - Uniontown, PA



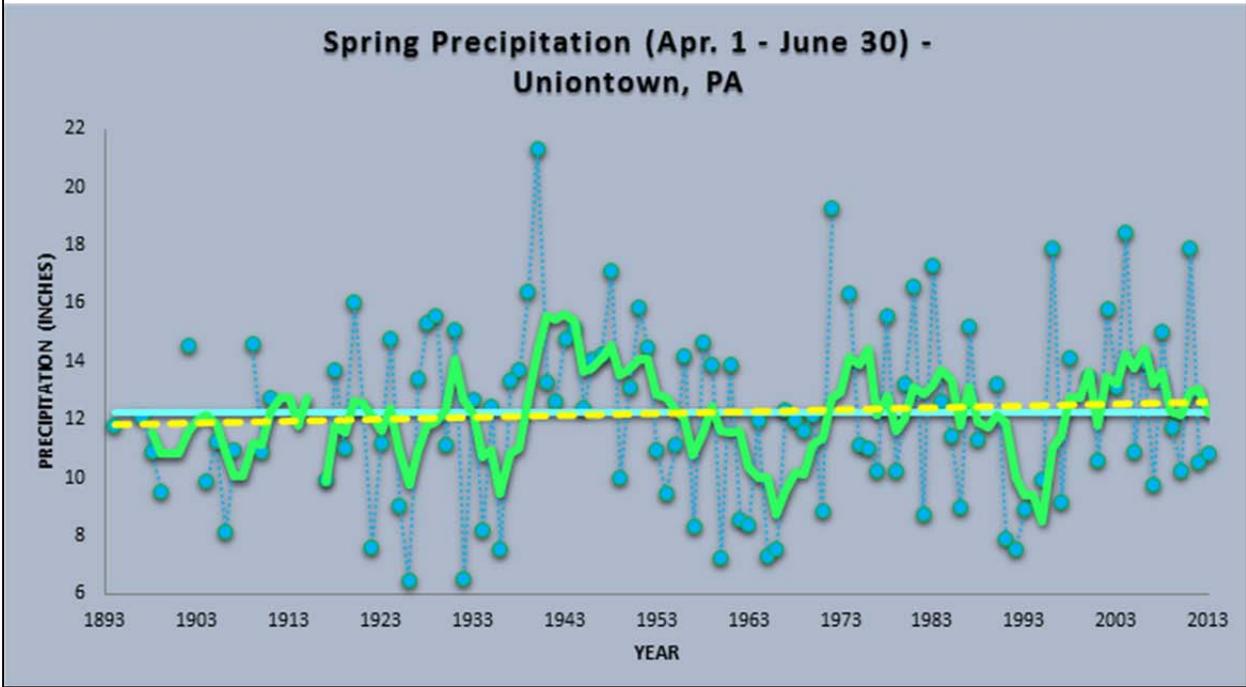


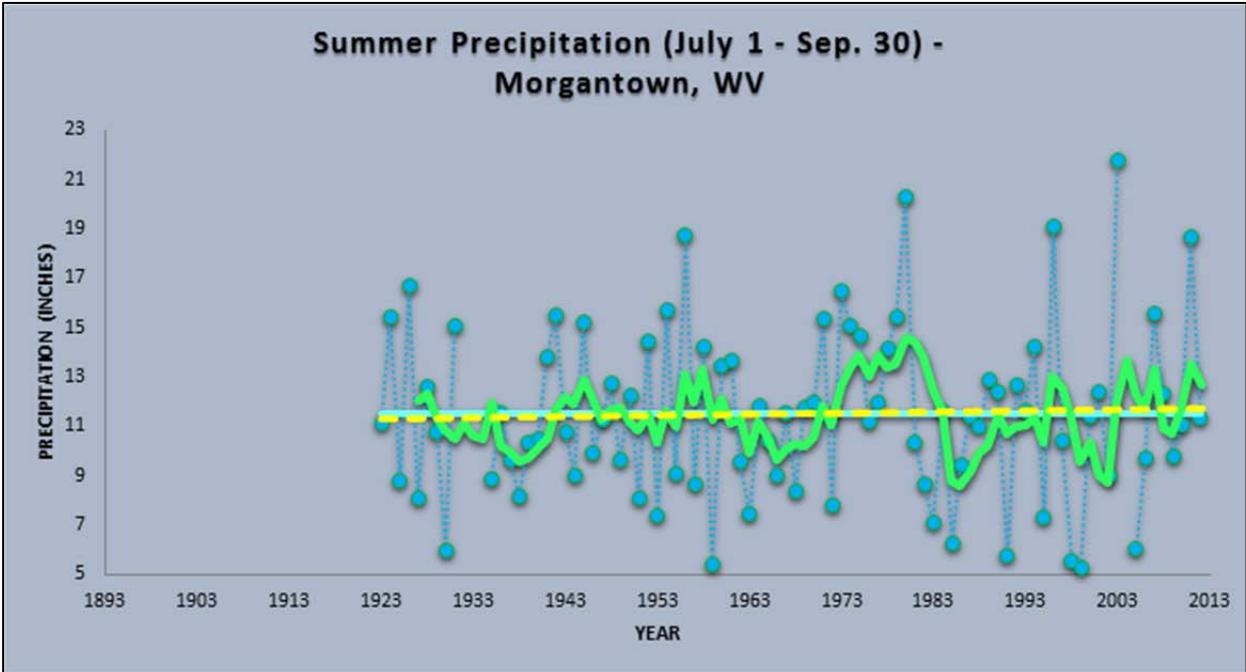
Winter Precipitation Trends: Morgantown shows no trend, whereas Uniontown displays a small downward trend (about 2 in over the past 120 years) in winter precipitation. Morgantown's winter precipitation has ranged between 4.3 in to as much as 17.5 in over its period of record while Uniontown has ranged from 4.2 in to 16.8 in.



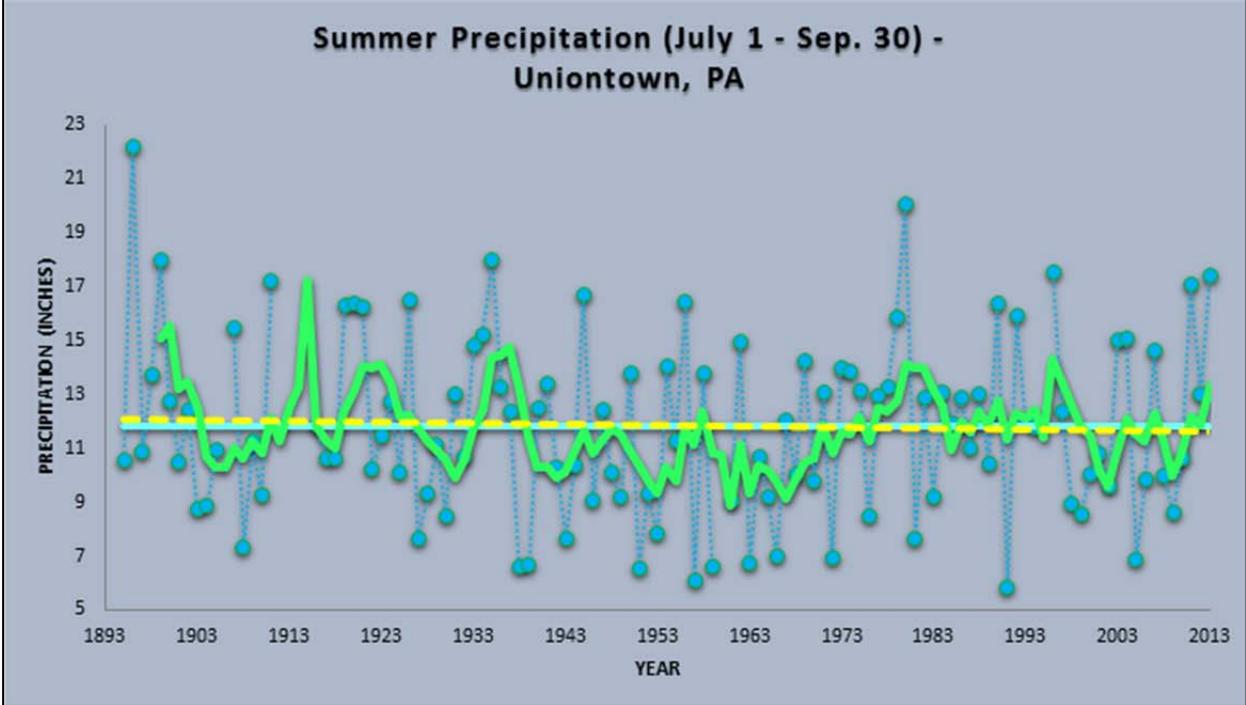


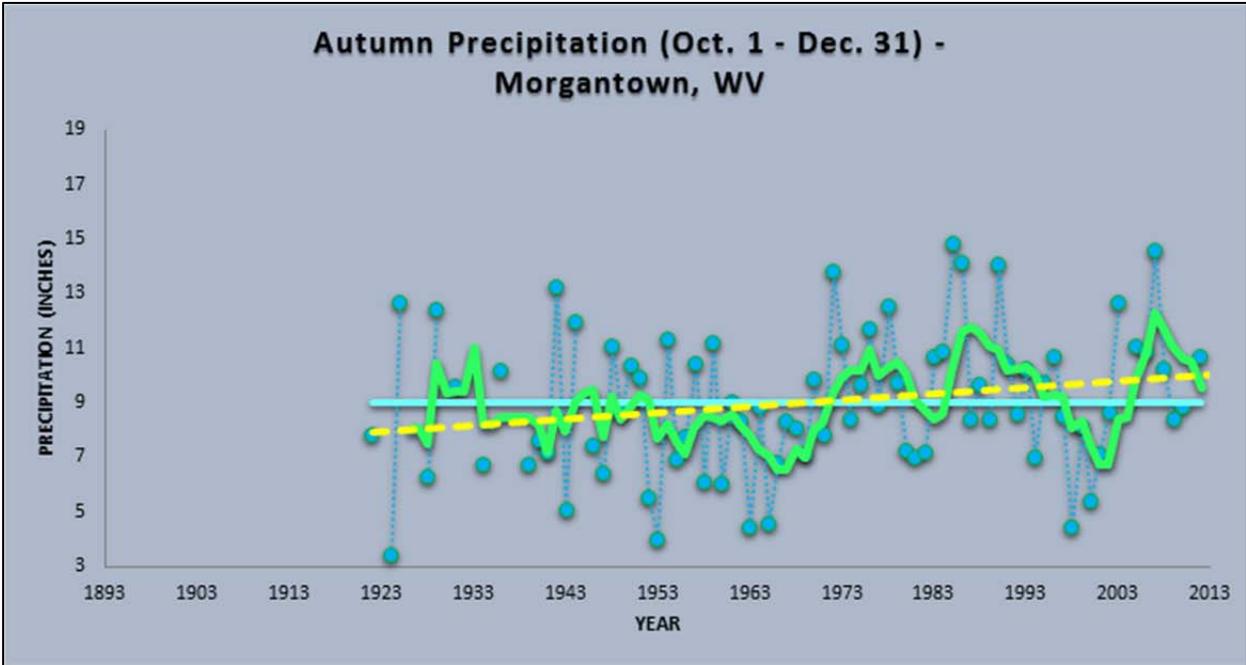
Spring Precipitation Trends: Both stations shows a slight increase (approx. 1 in over the past ~100 years) in spring precipitation. Morgantown has seen as much as 19.2 in and as little as 6.7 in during the spring while Uniontown has seen between 6.5 and 21.3 in.



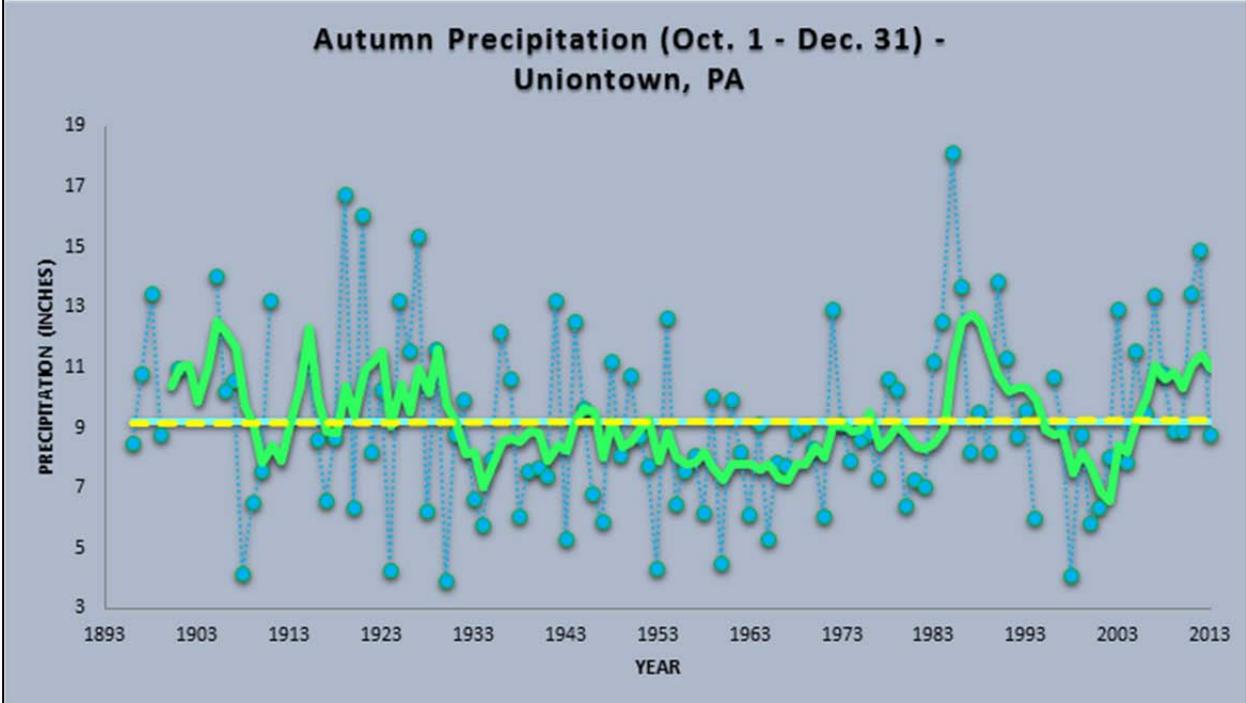


Summer Precipitation Trends: No significant trend exists in summer precipitation at both locations. Morgantown's summer precipitation has ranged between 5.3 to 21.8 in. while Uniontown has seen a minimum of 5.8 in to a maximum of 22.2 in.





Autumn Precipitation Trends: Morgantown show a steady increase in autumn precipitation with Uniontown demonstrating virtually no shift. The average sum of precipitation during the autumn is 9.0 in (min of 3.4 and max of 14.9 in) at Morgantown compared to an average of 9.2 in (min of 3.9 and max of 18.1 in) at Uniontown.



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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National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

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