

MDSCO-2023-10

Maryland Climate Bulletin

October 2023

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This publication is available from:
<https://www.atmos.umd.edu/~climate/Bulletin/>



Summary

Statewide averages show that October 2023 was warmer and drier than normal (i.e., 1991-2020 averages). Monthly mean temperatures were between 52 and 63°F; maximum temperatures were in the 61 to 74°F range, and minimum temperatures were between 41 and 53°F. Monthly total precipitation was in the 0.9 to 3.9 inches range.

Maryland Regional Features (Figures 1-5, C1, and D1)

- Mean temperature was warmer than normal everywhere, especially over portions of Howard, Anne Arundel, and Baltimore counties (above 3.2°F), Garrett County, and parts of Saint Mary's, Calvert, Talbot, and Dorchester counties (above 2.8°F).
- Maximum temperature was also warmer than normal everywhere in the state, particularly over parts of Howard, Anne Arundel, and Baltimore counties (above 4.0°F) and portions of Saint Mary's, Calvert, Talbot, Dorchester, Wicomico, Somerset, and Worcester counties (above 3.7°F).
- Minimum temperature was warmer than normal everywhere, too, especially over Garrett County (above 4.0°F).
- Precipitation was below normal everywhere except in the southwestern portion of Garrett County, which was slightly above normal. The largest precipitation anomalies were found over the northern central counties of the Piedmont, particularly over Harford and Cecil counties (3.3 in) and portions of Baltimore County (3 in).
- The extent of the surface in the state under drought conditions increased from around 35% at the start of October to around 52% at the end of it. While moderate and severe drought conditions have remained almost the same over Washington and Frederick counties, the extent of the abnormally dry conditions has expanded. Abnormally dry conditions now occupy parts of Charles, Calvert, Saint Mary's, Dorchester, Wicomico, and Cecil Counties.

Maryland Climate Divisions (Figures 6-7, B1, and B2)

- All eight climate divisions were warmer and drier than normal in October.
- The statewide temperature has been warmer than normal since August, reaching the largest magnitude in October (2.6°F). On the other hand, the statewide precipitation anomalies have been flipping signs since August; precipitation was below normal in August, then it changed to slightly wetter than normal in September and back to drier than normal in October (2.31 in).

Historical Context (Figure 8, Tables A1 and A2)

- Mean, maximum, and minimum statewide temperatures in October (59.6, 70.7, and 48.4°F) were above the long-term (1895-2022) averages and within 25% of the highest



values since 1895. October's precipitation (1.48 in) was below the long-term average and within 25% of the smallest values on record.

- Maximum temperatures in Dorchester and Wicomico counties were the fourth warmest since 1895; maximum temperatures in Somerset, Talbot, and Worcester counties were the fifth warmest.
- The minimum temperature in Garrett County was the ninth warmest on record.
- Precipitation in Cecil County was the fourth driest since 1895.

Century-Plus Trends, 1895-2023 (Figures 9, 10)

- Statewide mean temperature and heating degree days in October showed significant trends: a warming trend (1.6°F/century) and a decreasing trend (−47.87°FDD/century), respectively. Statewide precipitation had a significant wetting trend (0.76 in/century).
- Regionally, October mean temperatures showed significant warming trends to the east and south of Allegany County. Notably, the largest trend is in Baltimore City and to the west of the city in Baltimore County (2.4°F/century). Significant, century-long warming trends over this region have been identified every month since April. Trends above 2.0°F/century are also evident along the eastern shore counties in October.
- Regionally, October precipitation had significant wetting trends over large regions in the state. In particular, over Baltimore City, south-central Baltimore, Howard counties (1.2 in/century), counties along the western shore, and the Piedmont and Garrett and Allegany counties (around 0.8 in/century).



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1. Introduction

The Maryland Climate Bulletin is issued by the Maryland State Climatologist Office (MDSCO), which resides in the Department of Atmospheric and Oceanic Science at the University of Maryland, College Park. It documents the surface climate conditions observed across the state in a calendar month and is issued in the second week of the following month.

Maryland's geography is challenging, with the Allegheny and Blue Ridge mountains to the west, Piedmont Plateau in the center, the Chesapeake Bay, and the Atlantic Coastal Plain to the east. The range of physiographic features and the eastern placement of the state within the expansive North American continent contribute to a comparatively wide range of climatic conditions.

The bulletin seeks to document and characterize monthly surface climate conditions statewide, and climate division and county-wise, placing them in the context of regional and continental climate variability and change to help Marylanders interpret and understand recent climate conditions.

The monthly surface climate conditions for October 2023 are presented via maps of key variables, such as average surface air temperature, maximum surface air temperature, minimum surface air temperature, total precipitation, and their anomalies (i.e., departures from normal); they are complemented by drought conditions for the state, as given by the U.S. Drought Monitor (Section 3). Statewide and climate division averages for the month are compared against each other via scatter plots (Section 4). The monthly statewide averages are placed in the context of the historical record via box and whisker plots in Section 5. Century-plus trends in statewide air temperature, heating degree-days, precipitation, and state maps of air temperature and precipitation are presented in Section 6. Ancillary statewide, climate division, and county-level information is provided via tables and plots in Appendices A-B; climatology and variability maps are in Appendices C-D.

2. Data

Surface air temperatures, total precipitation, and heating degree-days data in this report are from the following sources:

- NOAA Monthly U.S. Climate *Gridded* Dataset at 5-km horizontal resolution (NClimGrid – Vose et al. 2014), which is available in a preliminary status at <https://www.ncei.noaa.gov/data/nclimgrid-monthly/access/>
Data was downloaded on 11/12/2023.
- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20231106) at: <https://www.ncei.noaa.gov/pub/data/cirs/climdiv/>
Data was downloaded on 11/12/2023.



The drought conditions are from the U.S. Drought Monitor website:

<https://droughtmonitor.unl.edu/Maps/MapArchive.aspx>

Some definitions:

About the anomalies: Anomalies for a given month (e.g., October 2023) are the departures of the monthly value from the corresponding month's 30-year average (i.e., from the average of 30 Octobers) during 1991-2020; the 30-year average (or mean) is the climate normal, or just the climatology. When the observed monthly value exceeds its climatological value, it is referred to as above-normal (e.g., warmer than normal or wetter than normal) or a positive anomaly. In contrast, when this value is smaller than its climatological value, it is referred to as below-normal (e.g., colder than normal or drier than normal) or negative anomaly.

About NOAA's Climate Divisions. The term "climate division" refers to one of the eight divisions in the state that represent climatically homogeneous regions, as determined by NOAA: <https://www.ncei.noaa.gov/access/monitoring/dyk/us-climate-divisions>

The eight climate divisions in Maryland are:

- Climate Division 1: Southeastern Shore. It includes the counties of Somerset, Wicomico, and Worcester.
- Climate Division 2: Central Eastern Shore. It includes the counties of Caroline, Dorchester, and Talbot.
- Climate Division 3: Lower Southern. It includes the counties of Calvert, Charles, and St. Mary's.
- Climate Division 4: Upper Southern. It includes the counties of Anne Arundel and Prince George's.
- Climate Division 5: Northeastern Shore. It includes the counties of Kent and Queen Anne's.
- Climate Division 6: North Central. It includes the counties of Baltimore, Carroll, Cecil, Frederick, Harford, Howard, Montgomery, and the city of Baltimore.
- Climate Division 7: Appalachian Mountains. It includes the counties of Allegany and Washington.
- Climate Division 8: Allegheny Plateau. It includes Garrett County.

Note that these Climate Divisions do not correspond with the *Physiographic Provinces* in the state, as the former follow county lines. Climate Division 8 follows the *Appalachian Plateau Province*, Climate Division 7 follows the *Ridge and Valley Province*; however, Climate Division 6 includes the *Blue Ridge and the Piedmont Plateau provinces*, Climate Divisions 3, 4, and a



portion of 6 include the *Upper Coastal Plain Province*, and Climate Divisions 1, 2, 5, and a portion of 6 include the *Lower Coastal Plain (or Atlantic Continental Shelf) Province*.



3. October 2023 Maps

A. Mean Temperatures

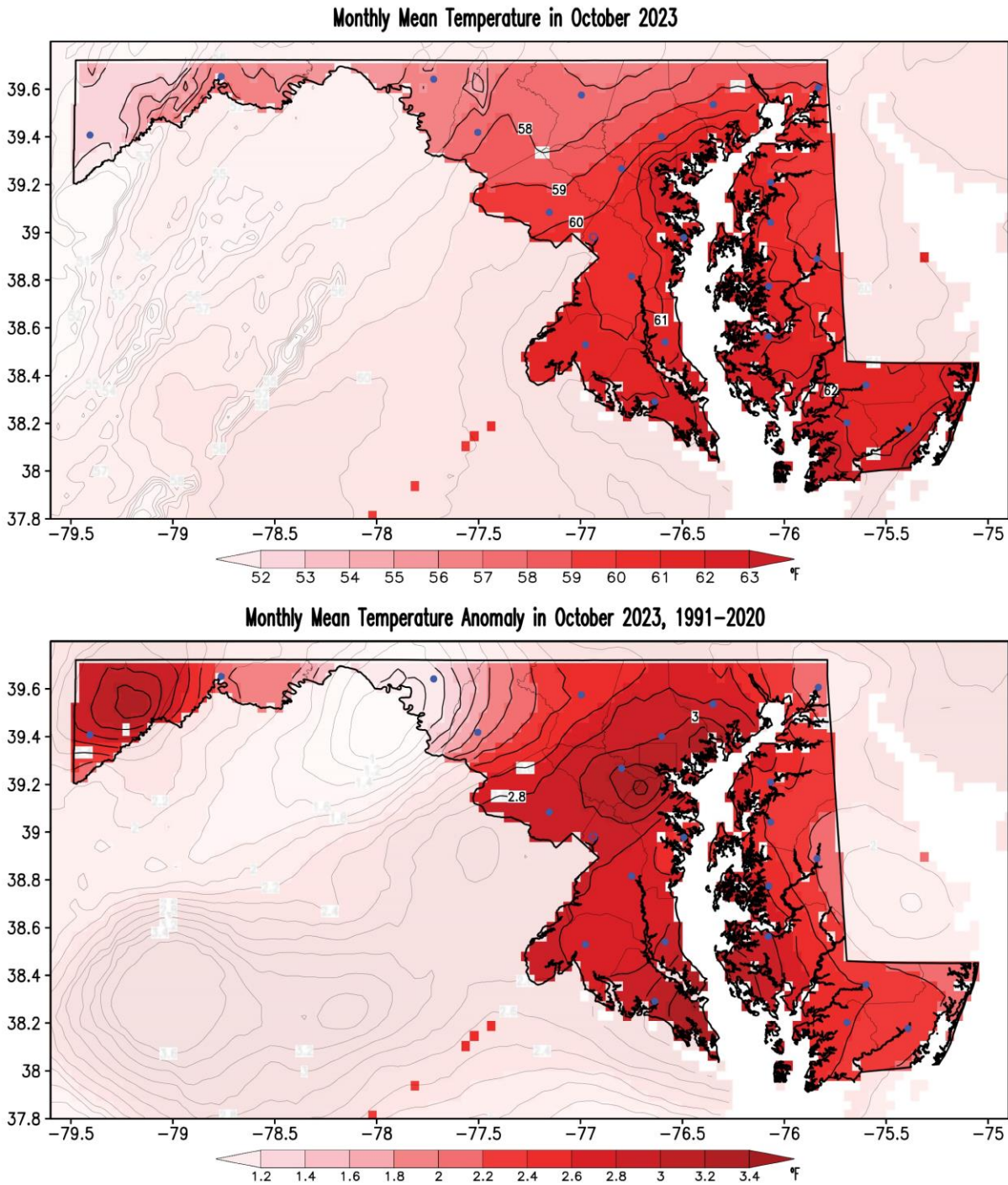


Figure 1. Monthly mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for October 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.



B. Maximum Temperatures

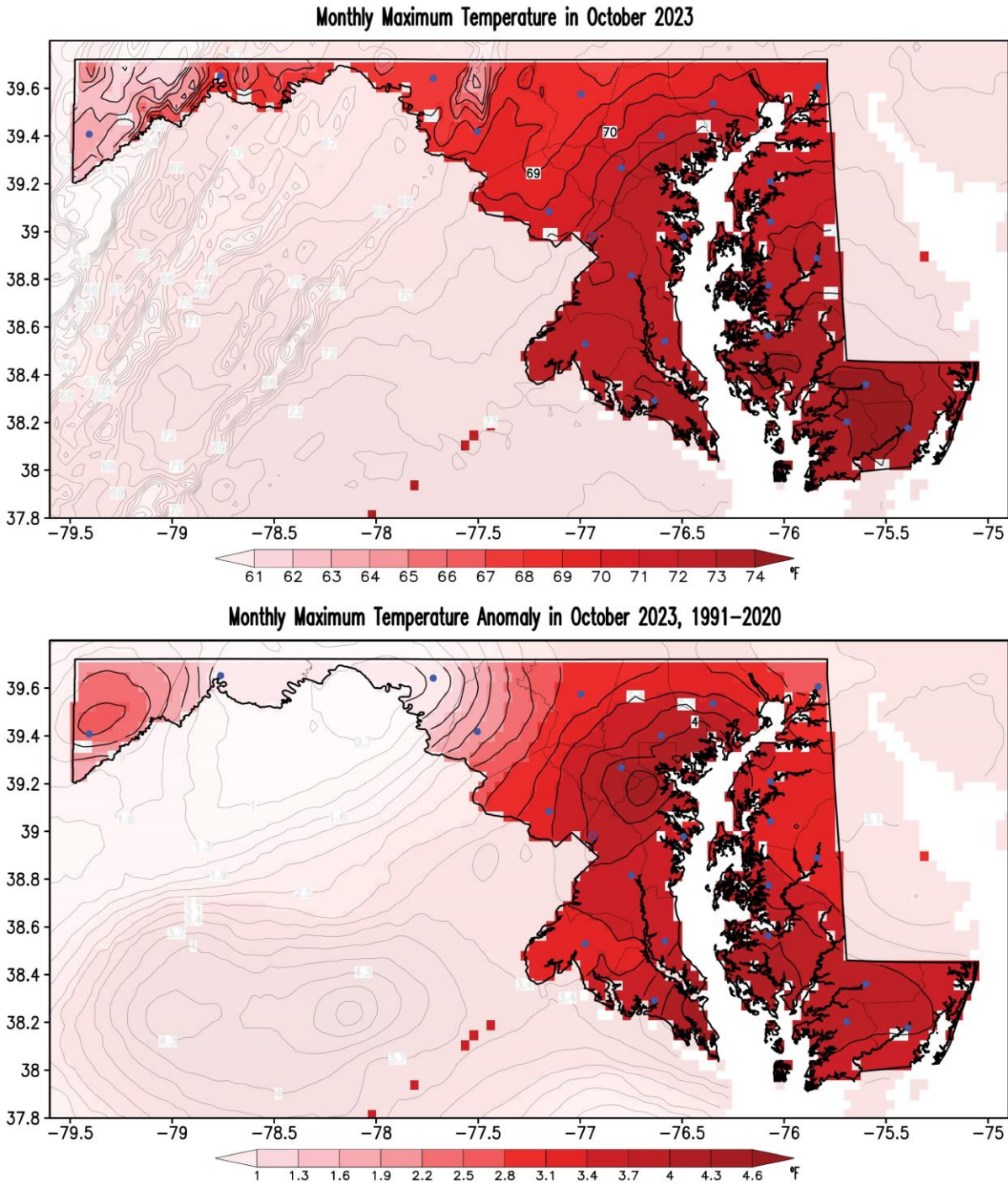


Figure 2. Monthly maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for October 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

C. Minimum Temperatures

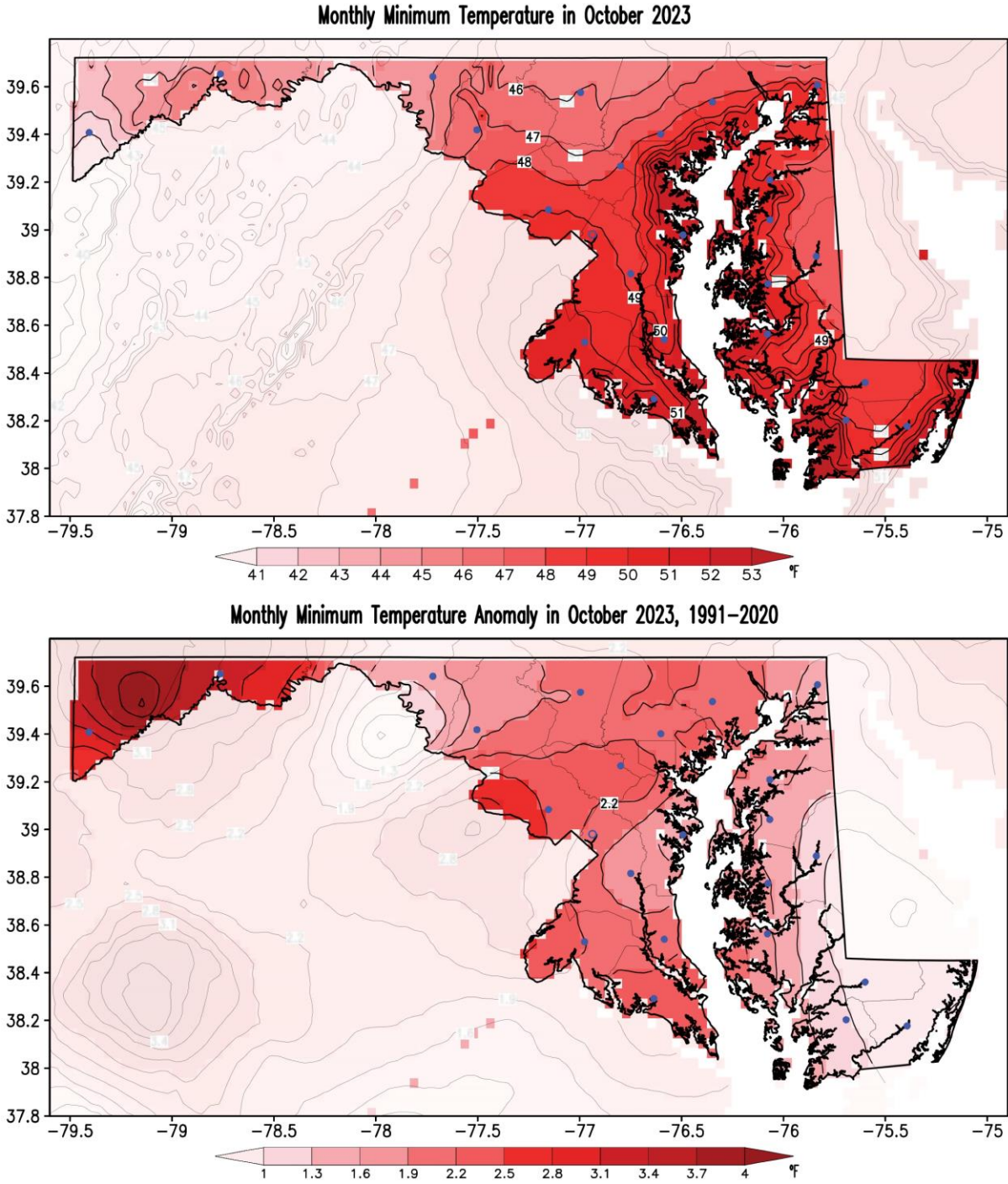


Figure 3. Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for October 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

D. Precipitation

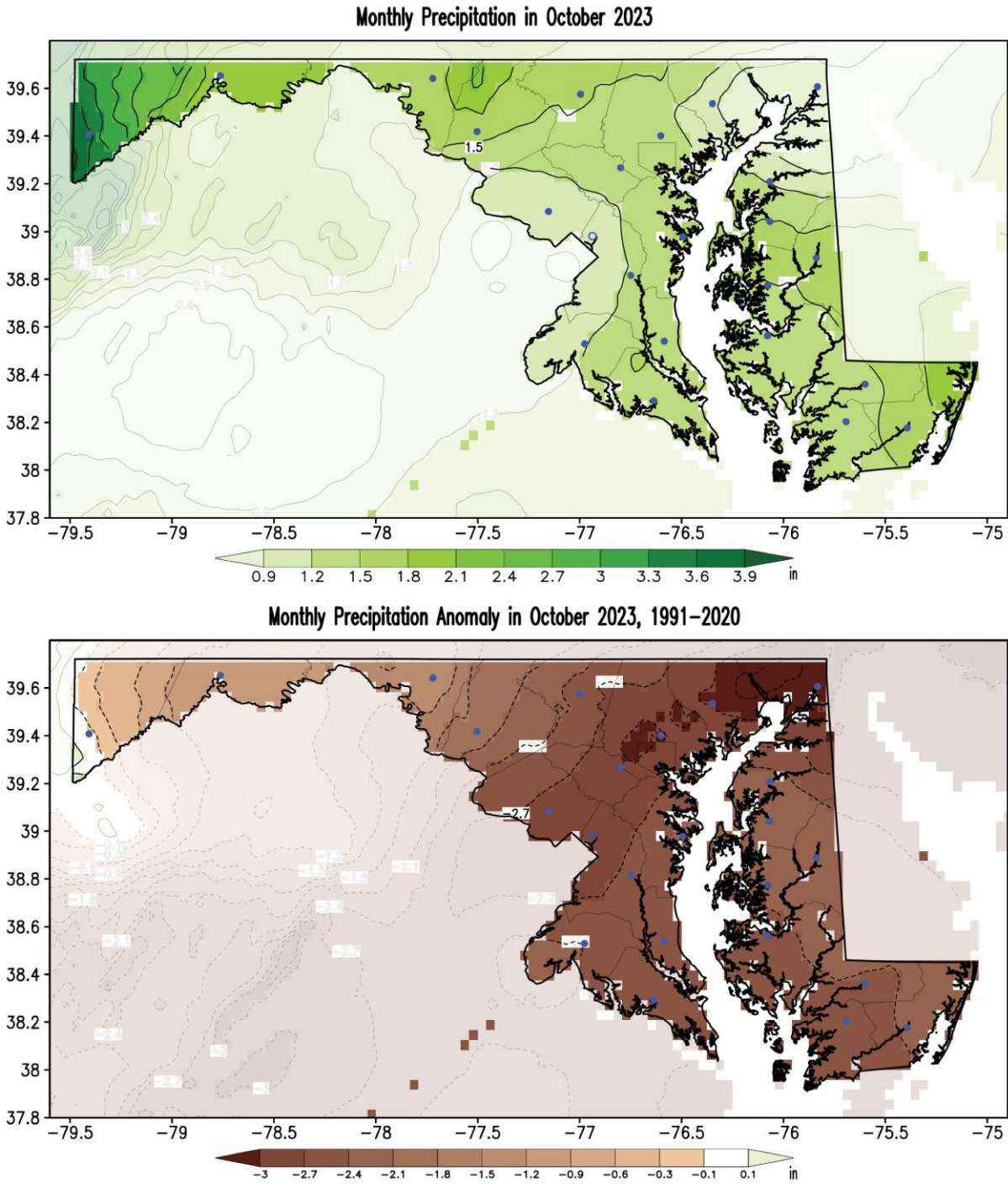
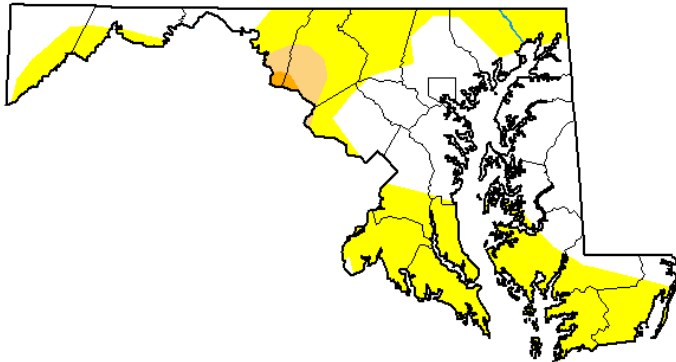


Figure 4. Monthly total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for October 2023. Precipitation is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

E. Drought

**U.S. Drought Monitor
Maryland**

October 31, 2023
(Released Thursday, Nov. 2, 2023)
Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0	D1	D2	D3	D4
Current	48.31	48.35	2.86	0.47	0.00	0.00
Last Week 10-24-2023	67.32	29.37	2.83	0.47	0.00	0.00
3 Months Ago 08-01-2023	57.39	15.11	15.24	12.26	0.00	0.00
Start of Calendar Year 01-03-2023	100.00	0.00	0.00	0.00	0.00	0.00
Start of Water Year 09-26-2023	63.11	33.59	2.83	0.47	0.00	0.00
One Year Ago 11-01-2022	97.16	2.84	0.00	0.00	0.00	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Brian Fuchs
National Drought Mitigation Center



droughtmonitor.unl.edu

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on October 31, 2023. Yellow shading indicates *abnormally dry* regions, light orange shading shows regions under *moderate drought*, and darker orange shows areas under *severe drought*. Numbers in the table indicate the percentage of the state covered under the particular drought condition at the cited time in the left column. At this time, 51.68% of the state was under some drought category, which was an increase of around 16% with respect to the beginning of the month. This increase in the extent of drought conditions is largely due to the increase in abnormally dry conditions.



4. October and ASO 2023 Climate Divisions Averages

A. October 2023 Scatter Plots

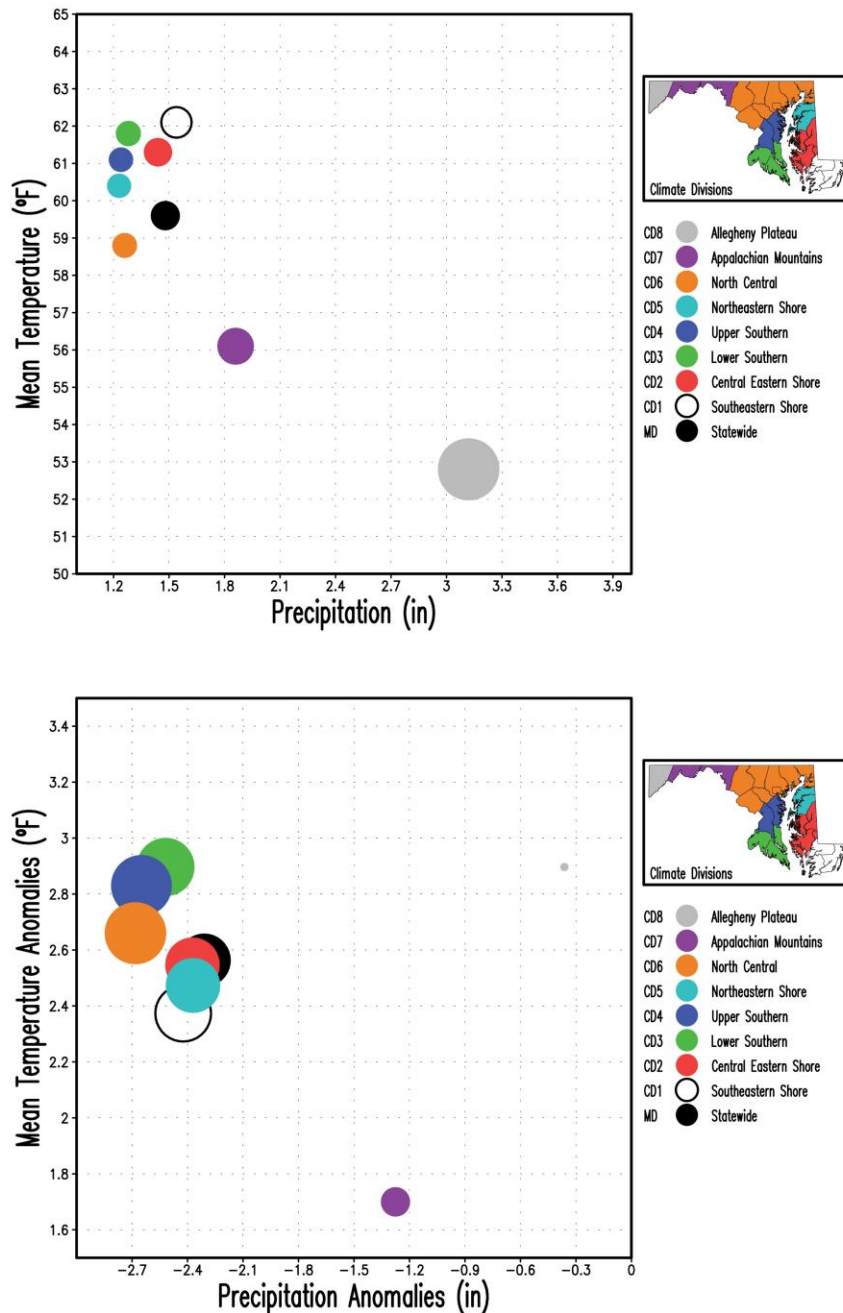


Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for October 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. Temperatures are in °F and precipitation is in inches. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (3.12 inches in CD8, top panel) and by the maximum precipitation anomaly (|-2.68| inches in CD6, bottom panel) among the nine regions. Note that the color of the filled circles corresponds to the color in the Climate Divisions according to the inset map.



B. August-October 2023 Scatter Plots

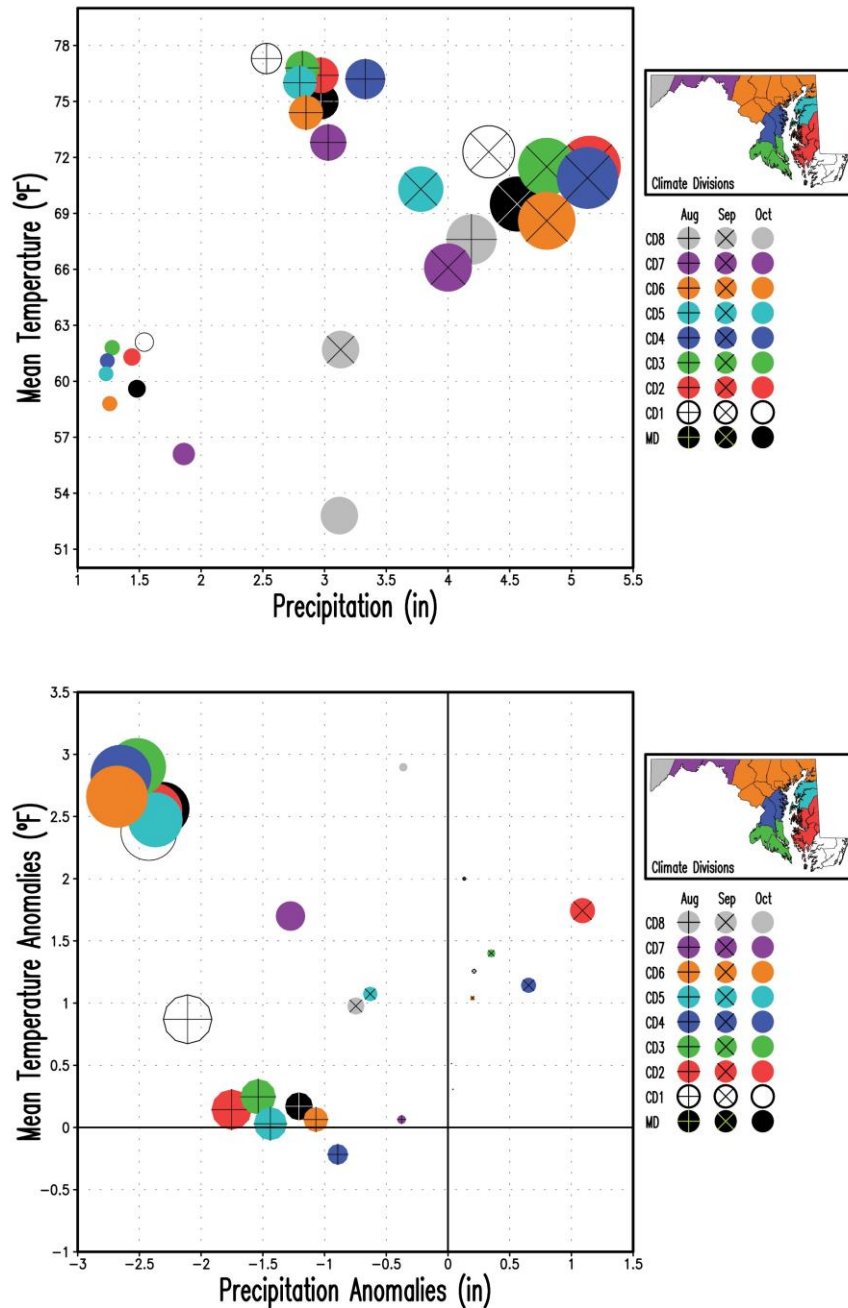


Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for August, September, and October 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. Temperatures are in °F, and precipitation is in inches. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (5.15 inches in CD2 in September, top panel) and by the maximum precipitation anomaly (-2.68 inches in CD6 in October, bottom panel) among the nine regions and three months. October is displayed with filled circles only, while September and August are displayed with superposed multiplication and addition signs, respectively.



5. October 2023 Statewide Averages in the Historical Record

A. Box and Whisker Plots

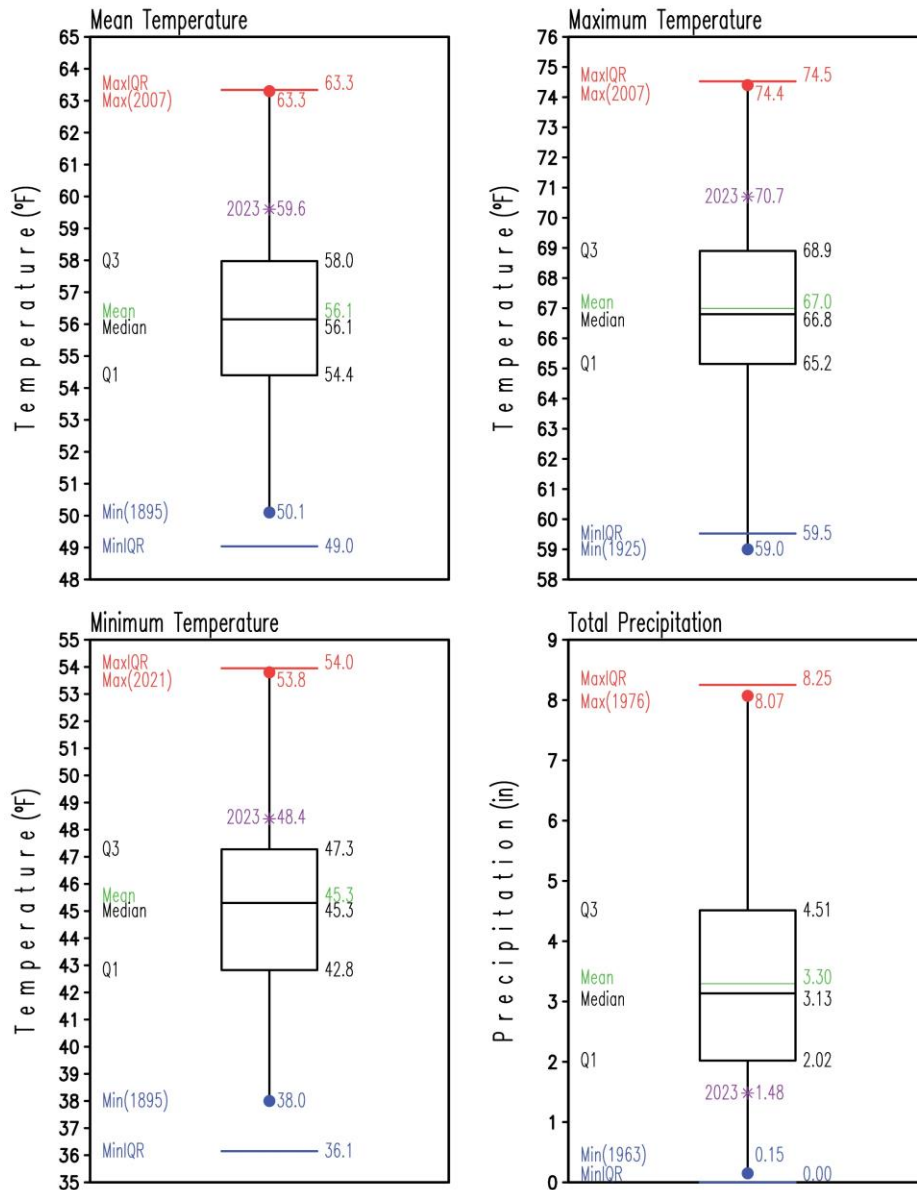


Figure 8. Box and Whisker plots of Maryland (statewide) monthly mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and total precipitation (lower right) for October for the period 1895-2022. The label and asterisk in purple represent conditions for October 2023. Statistics for the period 1895-2022 are labeled at the left side of each box and whisker plot and their values at their right. Temperatures are in °F and precipitation is in inches. The mean is the green line within the box, while the median is the black line within the box. The lower (Q1) and upper (Q3) quartiles, indicating the values of the variable that separate 25% of the smallest and largest values are the lower and upper horizontal black lines of the box, respectively. The blue and red dots mark the minimum and maximum values in the period at the end of the whiskers; the year of occurrence is shown in parenthesis. The blue and red horizontal lines represent extreme values defined by $Q1 - 1.5 \times (Q3 - Q1)$ and $Q3 + 1.5 \times (Q3 - Q1)$, respectively.



6. 1895-2023 October Trends

A. Statewide Mean Temperature, Heating Degree-Days, and Precipitation

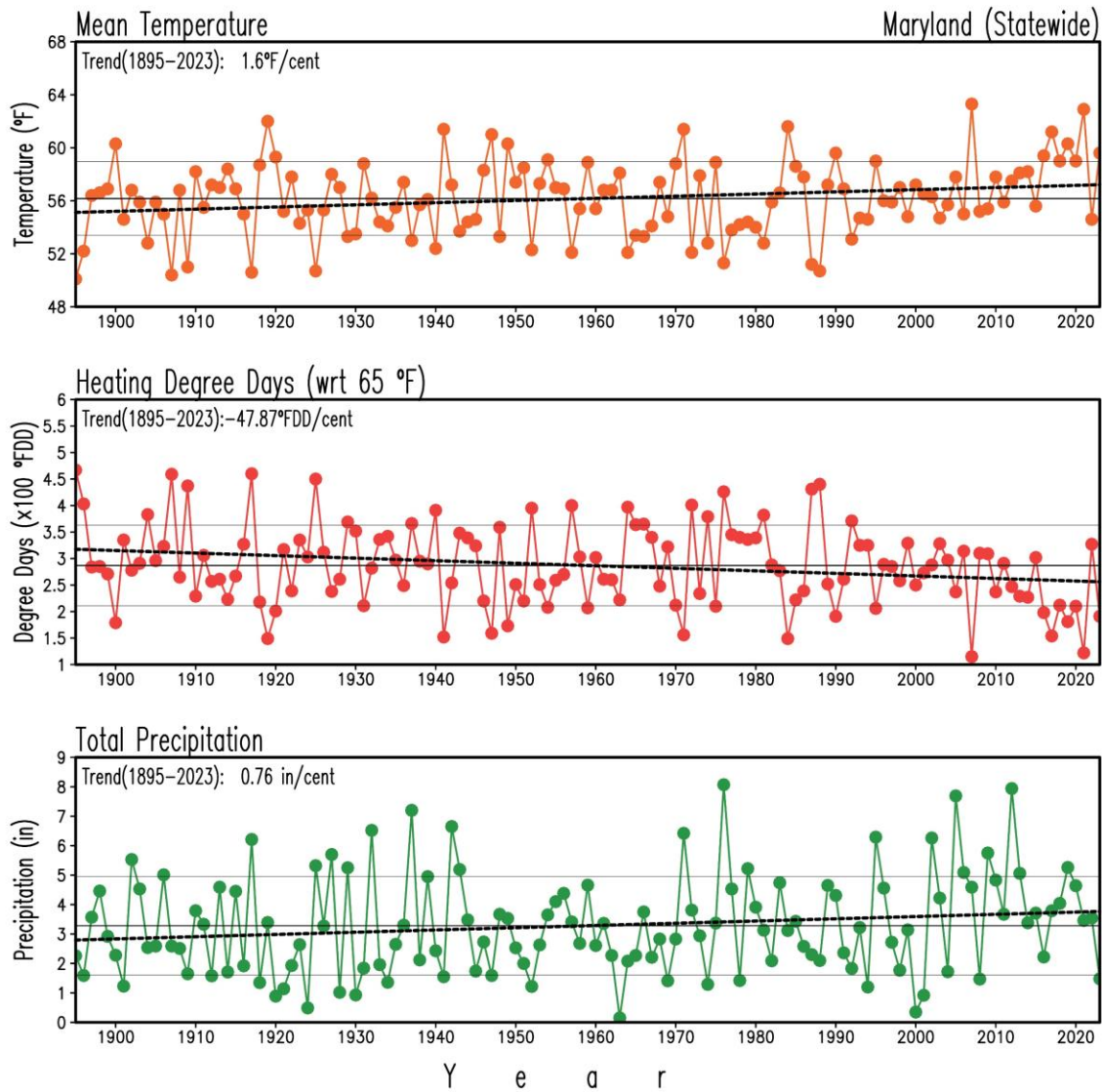


Figure 9. Maryland (statewide) mean surface air temperature, heating degree-days, and precipitation in October for the period 1895-2023. Temperature is in °F, heating degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (56.2°F, 286.89°FDD, and 3.28 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (2.8°F, 76.12°FDD, and 1.67 in) above/below the long-term mean. The thick dashed black lines show the long-term linear trend. Degree-days are the difference between the daily mean temperature (high temperature plus low temperature divided by two) and 65°F. It gives a general idea of how much energy is required to warm buildings; because energy demand is cumulative, degree-day totals for a month are the sum of each individual day's degree-day total (CPC, 2023). The warming temperature trend (1.6°F/century), the decreasing heating degree-days trend (-47.87°FDD/century) and the precipitation wetting trend (0.76 in/century) are statistically significant at the 95% level (*Student's t-test* –Santer et al. 2000).



B. Temperature and Precipitation Maps

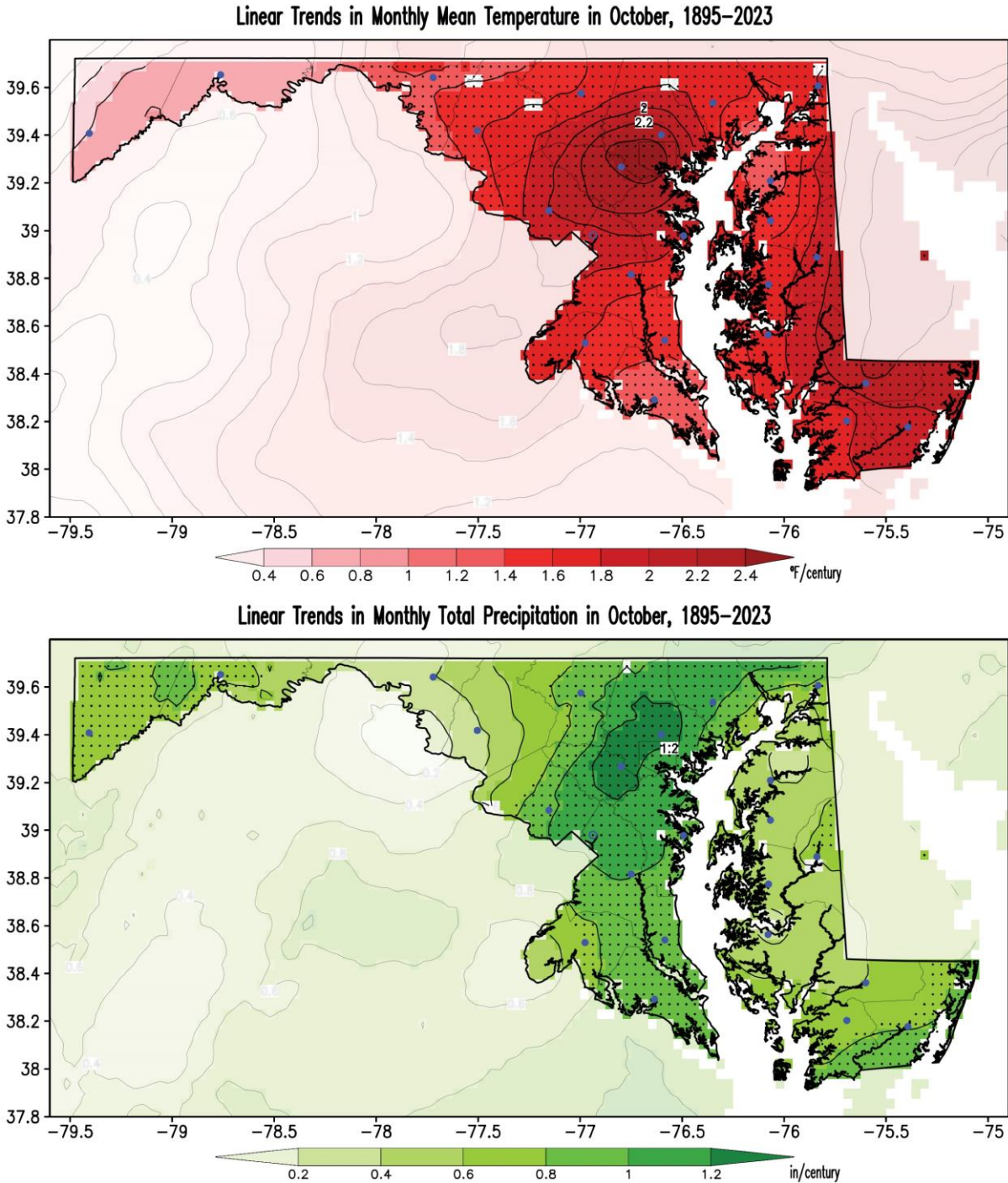


Figure 10. Linear trends in surface air mean temperature and precipitation in October for the period 1895–2023. Temperatures are in °F/century, and precipitation is in inches/century following the color bars. Red shading in the temperature map marks warming trends. Green shading in the precipitation map shows wetting trends. Stippling in the maps shows regions where trends are statistically significant at the 95% level (*Student’s t-test* –Santer et al. 2000). Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.



Appendix A. October 2023 Data Tables: Statewide, Climate Divisions, and Counties

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)	Region	Total Precipitation (in)	Rank (#)
Statewide	59.6	117	Statewide	1.48	18
Climate Division 1	62.1	114	Climate Division 1	1.54	22
Climate Division 2	61.3	116	Climate Division 2	1.44	19
Climate Division 3	61.8	118	Climate Division 3	1.28	20
Climate Division 4	61.1	117	Climate Division 4	1.24	17
Climate Division 5	60.4	114	Climate Division 5	1.23	11
Climate Division 6	58.8	117	Climate Division 6	1.26	13
Climate Division 7	56.1	104	Climate Division 7	1.86	45
Climate Division 8	52.8	115	Climate Division 8	3.12	70
Allegany	56.0	110	Allegany	2.04	52
Anne Arundel	61.4	117	Anne Arundel	1.35	20
Baltimore	59.2	118	Baltimore	1.35	18
Baltimore City	61.4	120	Baltimore City	1.28	19
Calvert	61.7	117	Calvert	1.39	21
Caroline	60.2	114	Caroline	1.52	20
Carroll	57.4	116	Carroll	1.52	24
Cecil	59.2	114	Cecil	0.74	4
Charles	61.5	119	Charles	1.19	18
Dorchester	61.9	116	Dorchester	1.36	17
Fredrick	57.5	112	Fredrick	1.60	27
Garrett	52.8	114	Garrett	3.11	69
Harford	59.4	116	Harford	1.01	10
Howard	59.2	118	Howard	1.27	19
Kent	60.5	113	Kent	1.04	9
Montgomery	59.3	118	Montgomery	1.06	13
Prince George's	60.7	117	Prince George's	1.16	16
Queen Anne's	60.4	114	Queen Anne's	1.36	14
Saint Mary's	62.3	118	Saint Mary's	1.35	17
Somerset	62.6	114	Somerset	1.40	19
Talbot	61.4	116	Talbot	1.49	17
Washington	56.2	98	Washington	1.69	37
Wicomico	61.5	115	Wicomico	1.48	20
Worcester	62.1	113	Worcester	1.69	26

Table A1. Monthly mean surface air temperature (left) and total precipitation (right) at Maryland (statewide), climate division, and county levels for October 2023. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for October 2023 occupies among the 129 Octobers after the 129 values have been arranged from the lowest to the highest in the *standard competition ranking method*. The closer to 129 the rank is, the larger (i.e., the warmer/wetter) the value of the surface variable is in the record; similarly, the closer to 1 the rank is, the smaller (i.e., the colder/drier) the value of the surface variable is in the record.



B. Maximum and Minimum Temperatures

Region	Maximum Air Temperature (°F)	Rank (#)	Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	70.7	118	Statewide	48.4	108
Climate Division 1	73.7	126	Climate Division 1	50.4	89
Climate Division 2	73.0	124	Climate Division 2	49.5	100
Climate Division 3	72.8	119	Climate Division 3	50.8	112
Climate Division 4	72.1	119	Climate Division 4	50.0	109
Climate Division 5	71.6	119	Climate Division 5	49.1	102
Climate Division 6	69.8	117	Climate Division 6	47.7	110
Climate Division 7	67.1	86	Climate Division 7	45.0	114
Climate Division 8	62.9	92	Climate Division 8	42.7	121
Allegany	66.8	79	Allegany	45.1	118
Anne Arundel	72.2	120	Anne Arundel	50.6	108
Baltimore	70.6	121	Baltimore	47.8	112
Baltimore City	72.3	122	Baltimore City	50.6	111
Calvert	72.6	120	Calvert	50.8	108
Caroline	72.5	122	Caroline	47.8	98
Carroll	68.7	110	Carroll	46.1	111
Cecil	69.9	118	Cecil	48.6	108
Charles	72.6	119	Charles	50.3	112
Dorchester	73.6	126	Dorchester	50.2	100
Fredrick	68.3	101	Fredrick	46.7	109
Garrett	62.9	92	Garrett	42.7	121
Harford	70.4	120	Harford	48.4	109
Howard	70.7	120	Howard	47.7	112
Kent	71.4	120	Kent	49.7	107
Montgomery	70.1	117	Montgomery	48.6	112
Prince George's	72.2	119	Prince George's	49.3	110
Queen Anne's	71.7	119	Queen Anne's	49.1	102
Saint Mary's	73.2	123	Saint Mary's	51.4	111
Somerset	73.7	125	Somerset	51.4	90
Talbot	72.5	125	Talbot	50.4	100
Washington	67.4	86	Washington	44.9	106
Wicomico	73.9	126	Wicomico	49.1	92
Worcester	73.6	125	Worcester	50.6	86

Table A2. Monthly maximum (left) and minimum (right) surface air temperatures at Maryland (statewide), climate division, and county levels for October 2023. Temperatures are in °F. The rank is the order that the variable for October 2023 occupies among the 129 Octobers after the 129 values have been arranged from the lowest to the highest using the *standard competition ranking method*. The closer to 129 the rank is, the larger (i.e., the warmer) the value of the surface variable is in the record; similarly, the closer to 1 the rank is, the smaller (i.e., the colder) the value of the surface variable is in the record.



Appendix B. October 2023 Bar Graphs: Statewide, Climate Divisions, and Counties

A. Temperatures and Precipitation

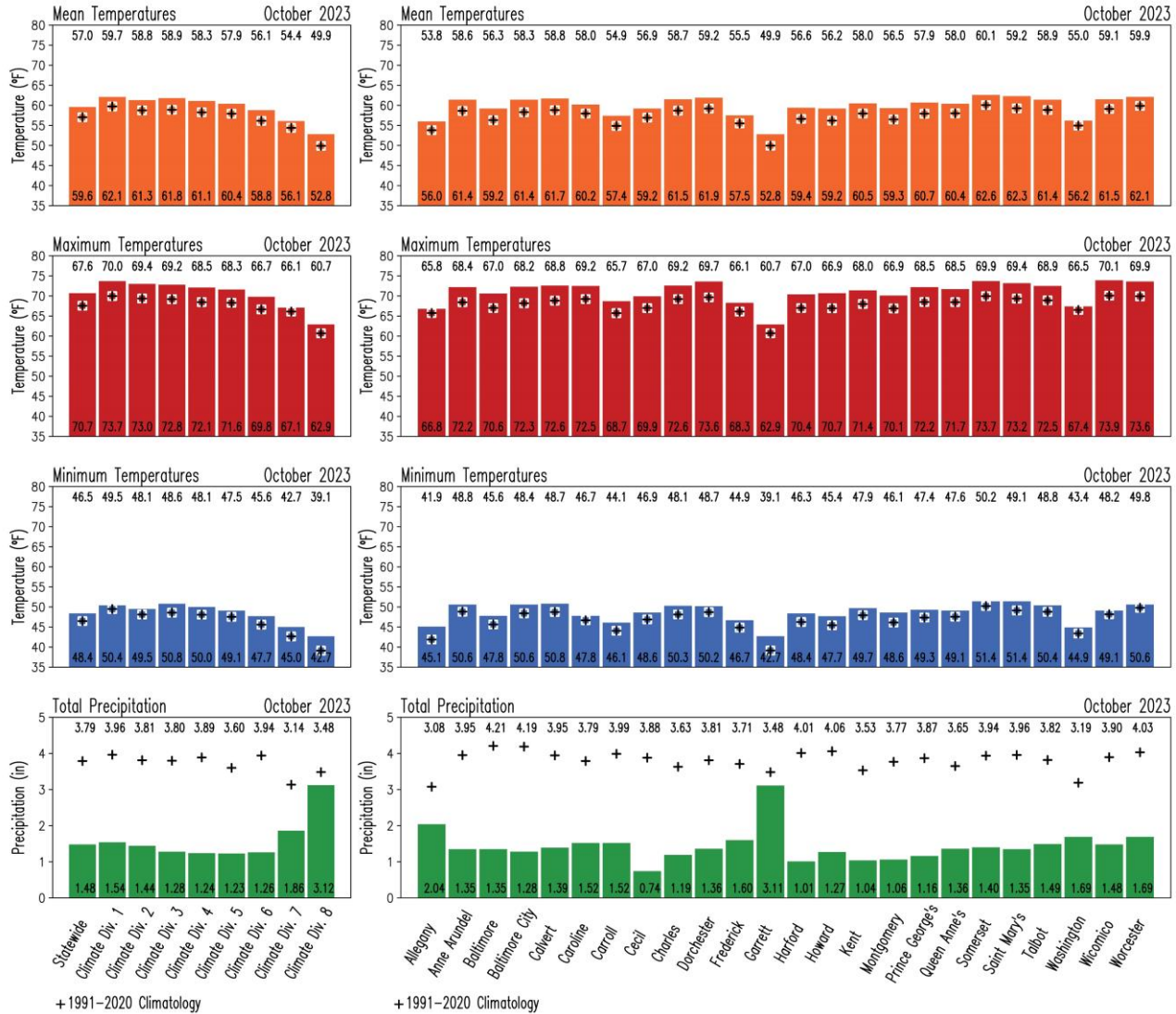


Figure B1. Monthly surface variables in Maryland for October 2023. Color bars represent the variables as follows: mean surface air temperature (orange), maximum surface air temperature (red), minimum surface air temperature (blue) and total precipitation (green) at statewide and climate division (left column), and at county (right column) levels. Temperatures are in °F and precipitation is in inches. The numbers at the base of the bars indicate the magnitude of the variable for October 2023. For comparison, the corresponding 1991-2020 climatological values for October are displayed as black addition signs, and their magnitude are shown at the top of the panels.



B. Temperatures and Precipitation Anomalies

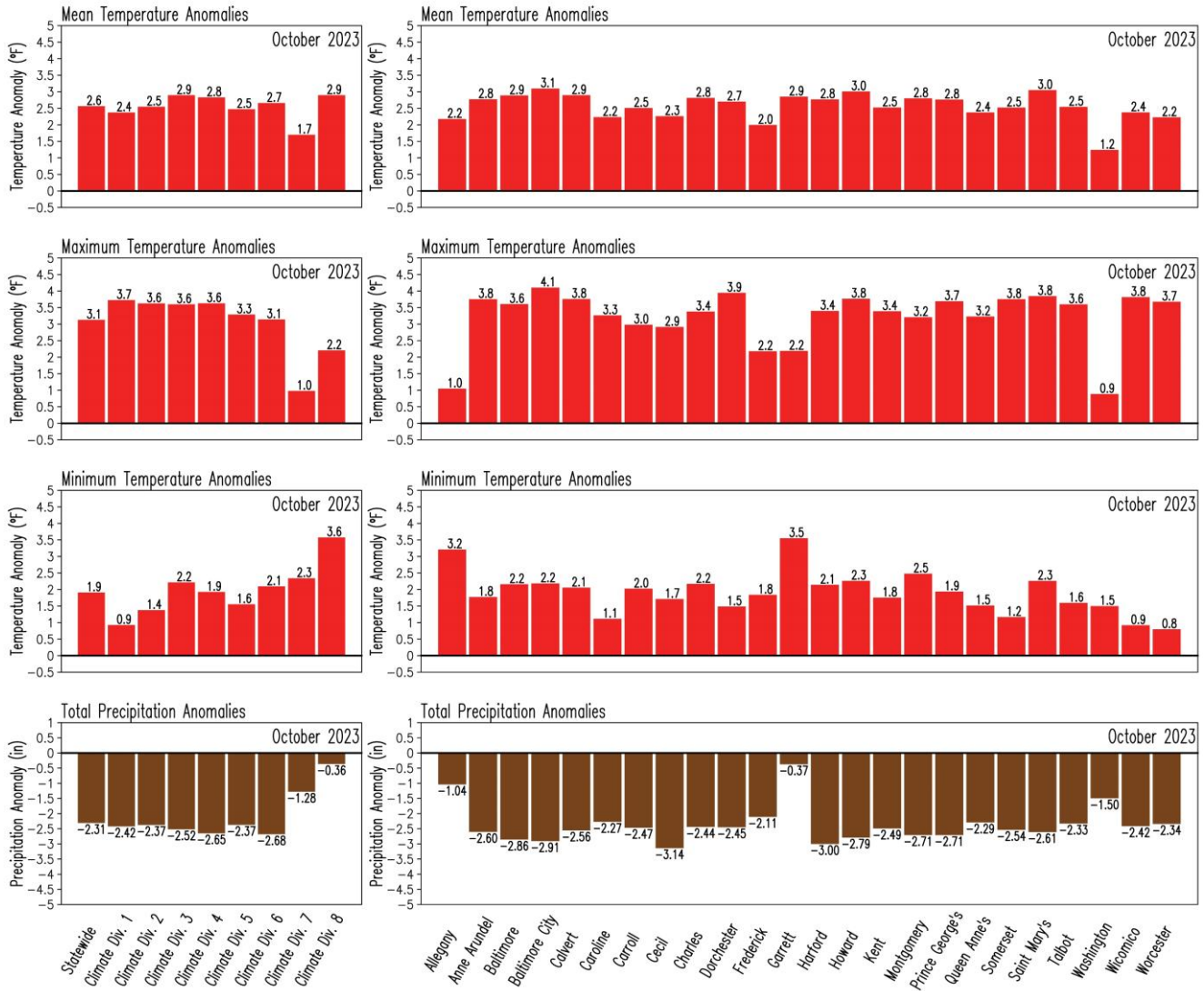


Figure B2. Anomalies of the monthly surface variables in Maryland for October 2023. Anomalies are with respect to the 1991-2020 climatology. Red color represents positive anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top), while brown color indicates negative anomalies in total precipitation (bottom row) at statewide and climate division (left column), and at county (right column) levels. Temperatures are in °F, and precipitation is in inches. The numbers outside of the bars indicate the magnitude of the anomaly for October 2023.



Appendix C. October 1991-2020 Climatology Maps

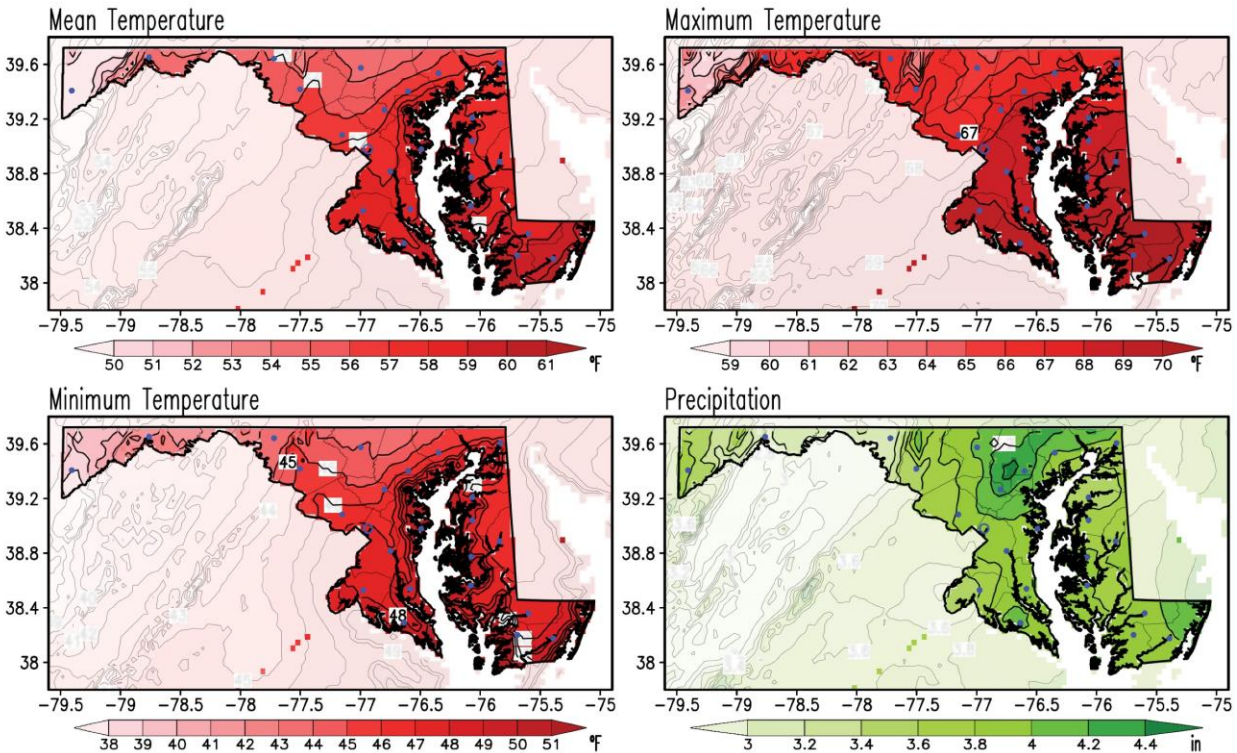


Figure C1. October climatology of the monthly mean, maximum and minimum surface air temperatures, and total precipitation for the period 1991-2020. Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the October 2023 conditions are compared to obtain the October 2023 anomalies. Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

Weather and climate are closely related, but they are not the same. Weather represents the state of the atmosphere (temperature, precipitation, humidity, wind, sunshine, cloudiness, etc.) at any given time. On the other hand, climate refers to the time average of the weather elements when the average is over long periods. If the average period is long enough, we can start to characterize the climate of a particular region.

It is customary to follow the World Meteorological Organization (WMO) recommendation and use 30 years for the average. The 30-year averaged weather data is traditionally known as Climate Normal (Kunkel and Court 1990), which is updated every ten years (WMO 2017). Establishing a climate normal or climatology is important as it allows one to compare a specific day, month, season, or even another normal period with the current normal. Such comparisons characterize anomalous weather and climate conditions, climate variability and change, and help define extreme weather and climate events (Arguez et al. 2012).

Appendix D. October Standard Deviation and October 2023 Standardized Anomalies Maps

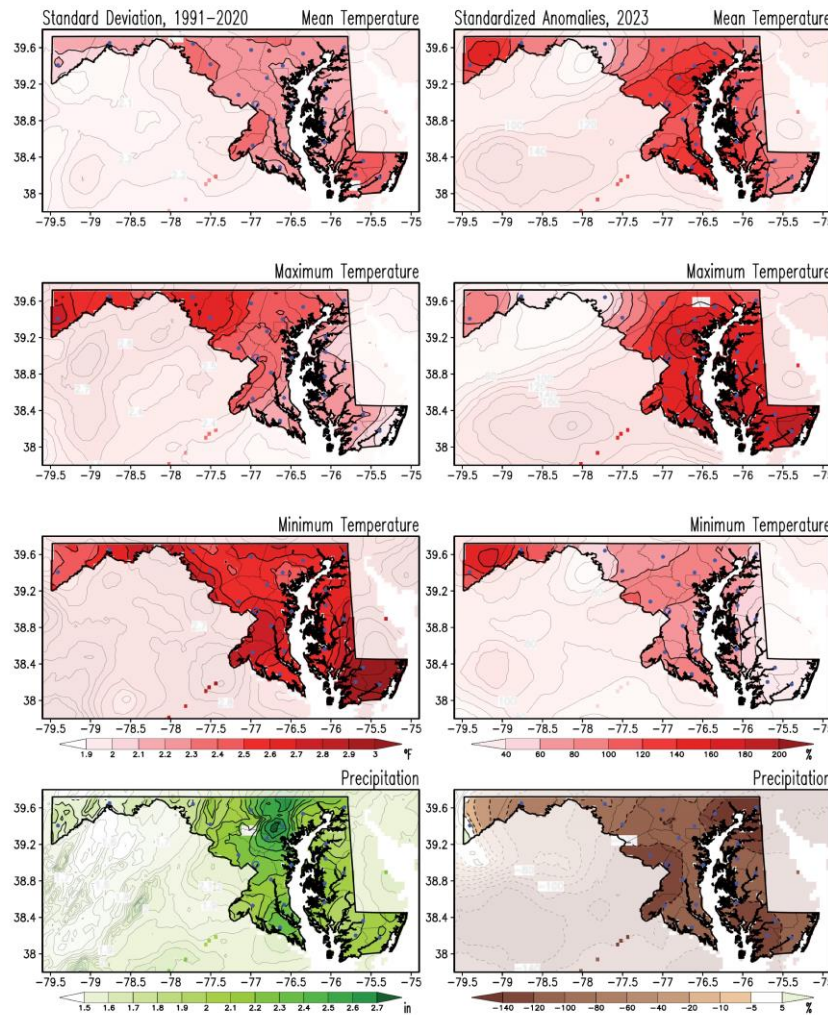


Figure D1. Standard deviation for October and standardized anomalies of temperatures and precipitation for October 2023. Standard deviations for monthly mean, maximum, and minimum surface air temperatures and total precipitation were obtained for the 1991-2020 period (left column). Anomalies for October 2023 (right column) are obtained as a percentage of the standard deviations. The standard deviations in temperatures are in °F, and those in precipitation are in inches according to the color bars. Red shading in the anomaly temperature maps marks warmer than normal conditions; brown/green shading in the anomaly precipitation map marks drier/wetter than normal conditions. The standardized anomalies are obtained by dividing the raw anomalies (from Figures 1 to 4) by the standard deviation (from left column panels) and multiplying that ratio by 100; hence, units are in percent (%). Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

The monthly standard deviation measures a climate variable’s year-to-year, or interannual, variability. Anomalies are sometimes compared against that variability to identify extremes in the climate record. When the anomalies are divided by the standard deviation, they are named *standardized anomalies*.



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