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Maryland Climate Bulletin
September 2022

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DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE

Maryland State Climatologist Office

Summary

September 2022 was warmer and drier than normal in average, when compared with the 1991-2020 climatology. These conditions have persisted from the previous August. Regional differences showed that the mean temperatures were below normal over the northeastern Harford and Kent counties, and above normal everywhere else with maximum above normal temperatures over the southern portions of Saint Mary's and Calvert counties and western Dorchester County. Regional differences indicated that precipitation was largely below normal in the state with the maximum negative anomalies over Charles County. The persistence of below normal precipitation and above normal temperatures over the counties of the coastal plains in the past two months have set up the land-surface for abnormally dry conditions over the majority on these counties and moderate drought conditions over Worcester County and portions of Somerset and Wicomico counties. Statewide temperature conditions in September 2022 were above the mean and median of the historical 1895-2021 record; precipitation was below the mean too but closer to the median of the historical 1895-2021 record.

Contents

1. Introduction

This bulletin is issued by the Maryland State Climate Office once per month in order to indicate in a brief format the most recent monthly surface climatic conditions in the state. Maryland is a state of great geographic diversity with miles of streams and rivers, beaches, coastal flatlands and wetlands, hills, valleys and mountains. This range of physiographic features, together with the land and water distribution and the placement of the state within the continental U.S., contribute to a comparatively wide range of climatic conditions thus the importance of their monitoring. This bulletin is addressed to all Marylanders so they can stay current with the latest climate conditions impacting their lives.

The monthly surface climate conditions for September 2022 are presented via maps of a set of variables such as mean surface air temperature, maximum surface air temperature, minimum surface air temperature, total precipitation, and their anomalies, that are complemented with drought conditions for the state, as given by the U.S. Drought Monitor (Sections 3). Statewide averages in September 2022 are contrasted against the historical record via box and whisker plots and scatter plots (Sections 4). Then statewide and climate division averages for the month are contrasted against each other via scatter plots (Section 5). Ancillary information at statewide, climate divisions and county levels are given via tables and plots, and via maps in Appendices A-D.

2. Data

Surface air temperature and total precipitation data in this report are from the following sources:

- NOAA Monthly U.S. Climate Gridded Dataset at 5km horizontal resolution (NClimGrid – Vose et al. 2014), which are given in a *preliminary* status, and available at:

  https://www.ncei.noaa.gov/data/nclimgrid-monthly/access/
  Data downloaded on 10/12/2022.

- NOAA Monthly U.S. Climate Divisional Dataset (NClimDiv – Vose et al. 2014), which is available, in a *preliminary* status (v1.0.0-20221006), at:

  https://www.ncei.noaa.gov/data/climdiv/access/
  Data downloaded on 10/12/2022

The drought conditions map is from the U.S. Drought Monitor site and available at:

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

Some useful notes are the following.

About the anomalies. Anomalies for a given month (i.e. September 2022) are the difference of the monthly values with respect to the long-term mean of the 30 months (i.e. Septembers) in the period 1991-2020; this 30-year mean is known as the climate normal, or just the climatology for short. When a value exceeds its climatological value, it is usually referred as an above normal (e.g., warmer than normal or wetter than normal) anomaly, or positive anomaly, while when the value is smaller than its climatological value, it is referred as a below normal (e.g., colder than normal or dryer than normal) anomaly, or negative anomaly.

About NOAA's Climate Divisions. The term "climate division" refers to one of the 8 divisions in the state that represent climatically homogeneous regions, as determined by NOAA:

https://www.ncei.noaa.gov/access/monitoring/dyk/us-climate-divisions

These regions are the following:

- 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, and Montgomery, as well as 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 Provinces,* Climate Divisions 3, 4 and a portion of 7 include the *Upper Coastal Plain Province*, and Climate Divisions 1, 2, 5 and a portion of 7 include the *Lower Coastal Plain Province*.

3. September 2022 Maps

A. Mean Temperatures

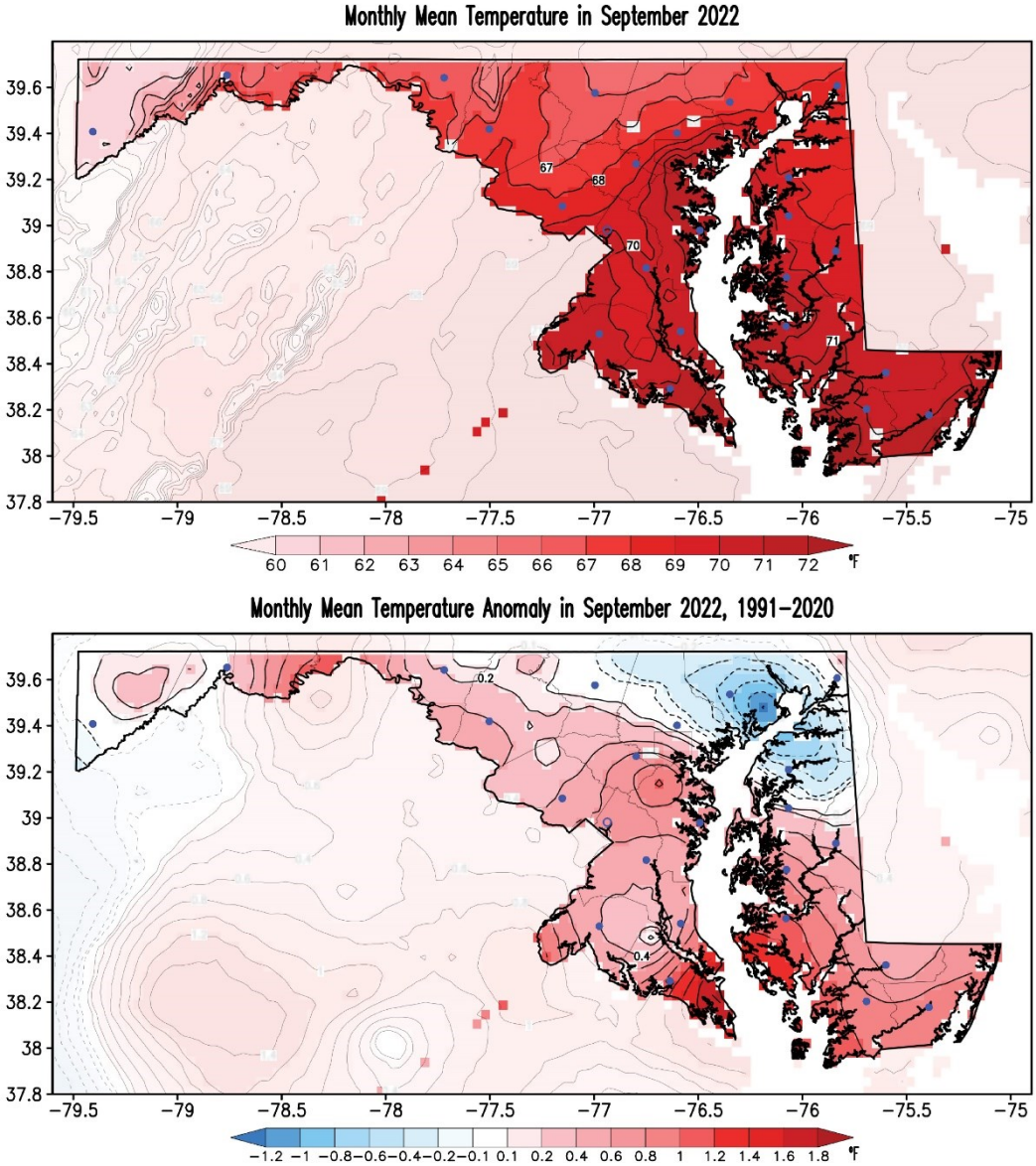

Figure 1. Mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) in September 2022. Temperatures are given in °F according to the color bars. Red/blue shading in the anomaly map shows above/below normal conditions. Note that shading outside the state has been washed out for clarity purposes. Filled blue circles mark the county seats.

Monthly mean temperatures keep on decreasing in September 2022. Temperatures along the coastal plains were warmer (~70-72°F) than over the North Central and Appalachian Mountains climate divisions (~66-68°F) and Garrett County (~61-62°F). The mean temperatures over the state were warmer than normal over the majority of the state except by the northeast of the state and southwestern Garrett County. Anomalies over southern Saint Mary's, Calvert and western Dorchester counties were above 1.6 °F, but anomalies over Harford and Kent counties reached -1.0°F; appendices A and B show the area-averaged values. Anomalies were below the regional year-to-year variability (Appendix D).

B. Maximum Temperatures

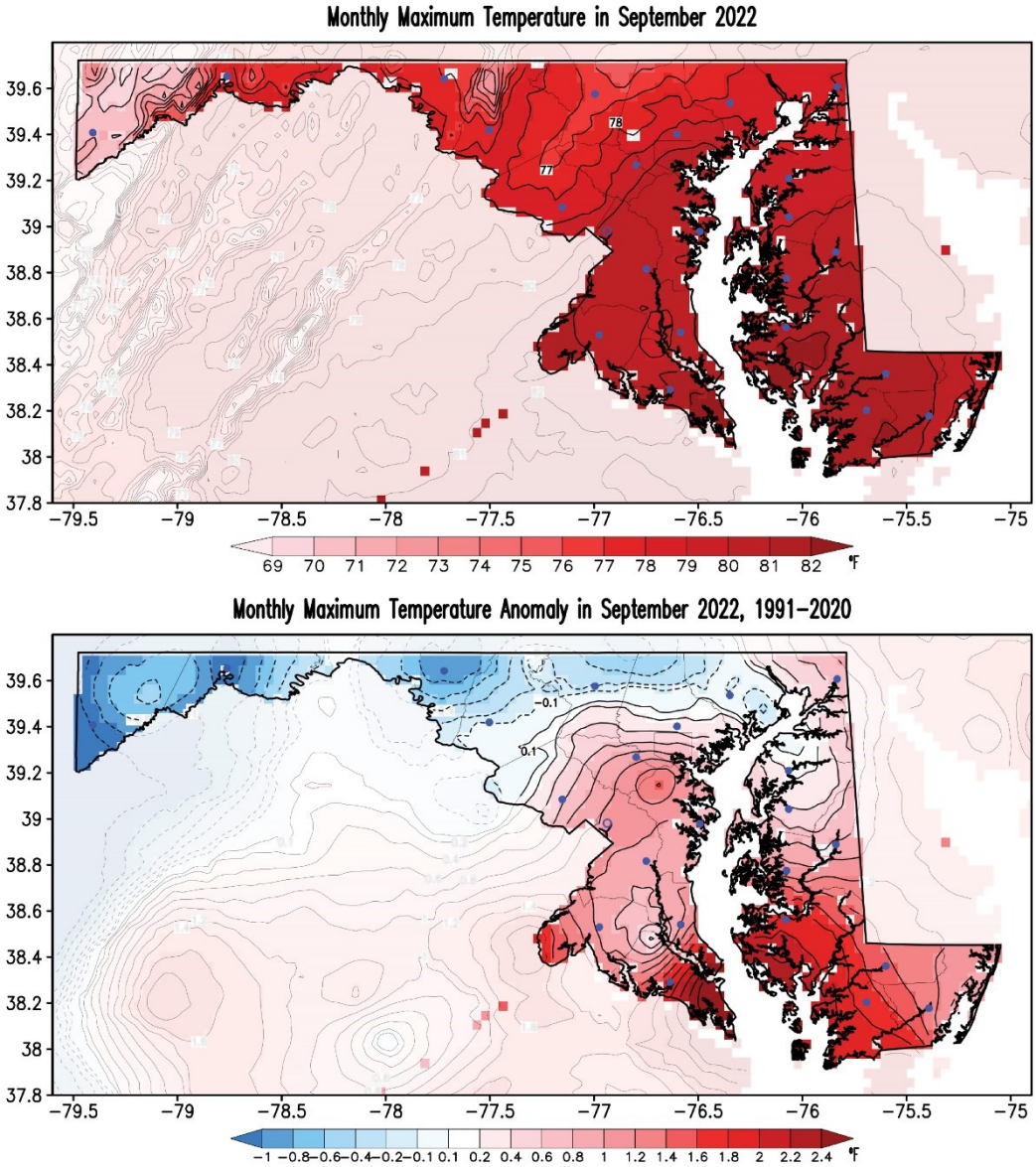

Figure 2. Maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) in September 2022. Temperatures are given in °F according to the color bars. Red shading in the anomaly map shows above normal conditions. Note that shading outside the state has been washed out for clarity purposes. Filled blue circles mark the county seats.

Monthly mean maximum temperatures in September 2022 had the same structure than the mean temperatures with maximum values over the coastal plains (~80-82°F) and minimum values over Frederick County's Blue Ridge (~73°F) and Garrett County (~69-70°F). Maximum temperatures were below normal in the northern counties to the west of Cecil County, and above normal over the coastal plains. Negative anomalies reached -1°F over Garrett and Allegany counties and the positive anomalies were beyond 2°F over southern Saint Mary's and Calvert counties and western Dorchester County; appendices A and B show the area-averaged values. The largest positive anomalies in the south reached the regional year-to-year variability (Appendix D).

C. Minimum Temperatures

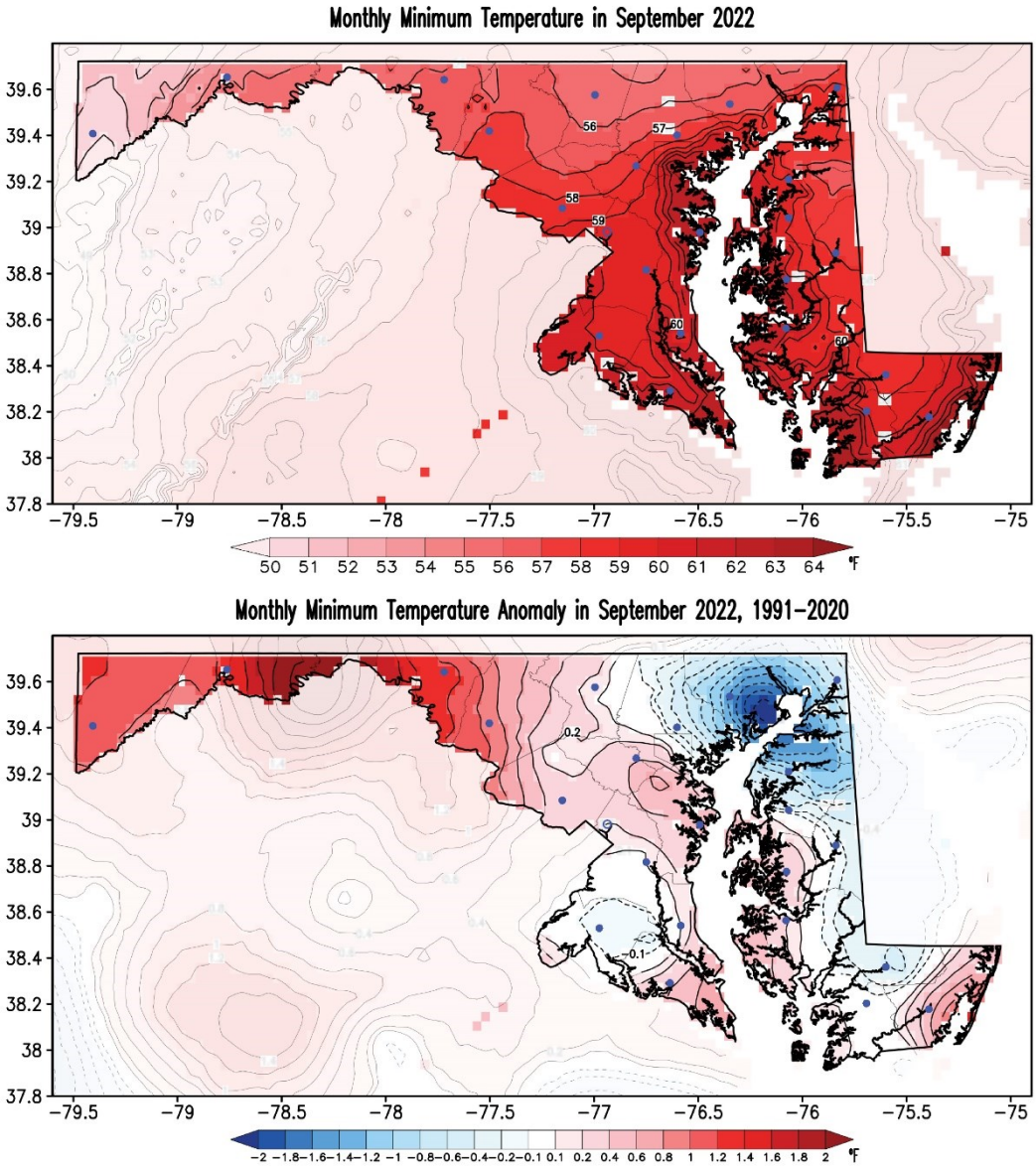

Figure 3. Minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) in September 2022. Temperatures are given in °F according to the color bars. Blue/red shading in the anomaly map shows below/above normal conditions. Note that shading outside the state has been washed out for clarity purposes. Filled blue circles mark the county seats.

Monthly mean minimum temperatures in September 2022 reached minimum values over Garrett County (~50°F) and maximum values along the coasts of the Chesapeake Bay (~60-64°F). The minimum temperatures were largely warmer than normal to the west and south of Baltimore County, and below normal to its east. Positive anomalies over western Washington and eastern Allegany counties reached the largest values (~2.2°F) and negative anomalies were the largest over Harford County (-2.0°F); appendices A and B show the area-averaged values. Anomalies were below the year-to-year variability (Appendix D).

D. Precipitation

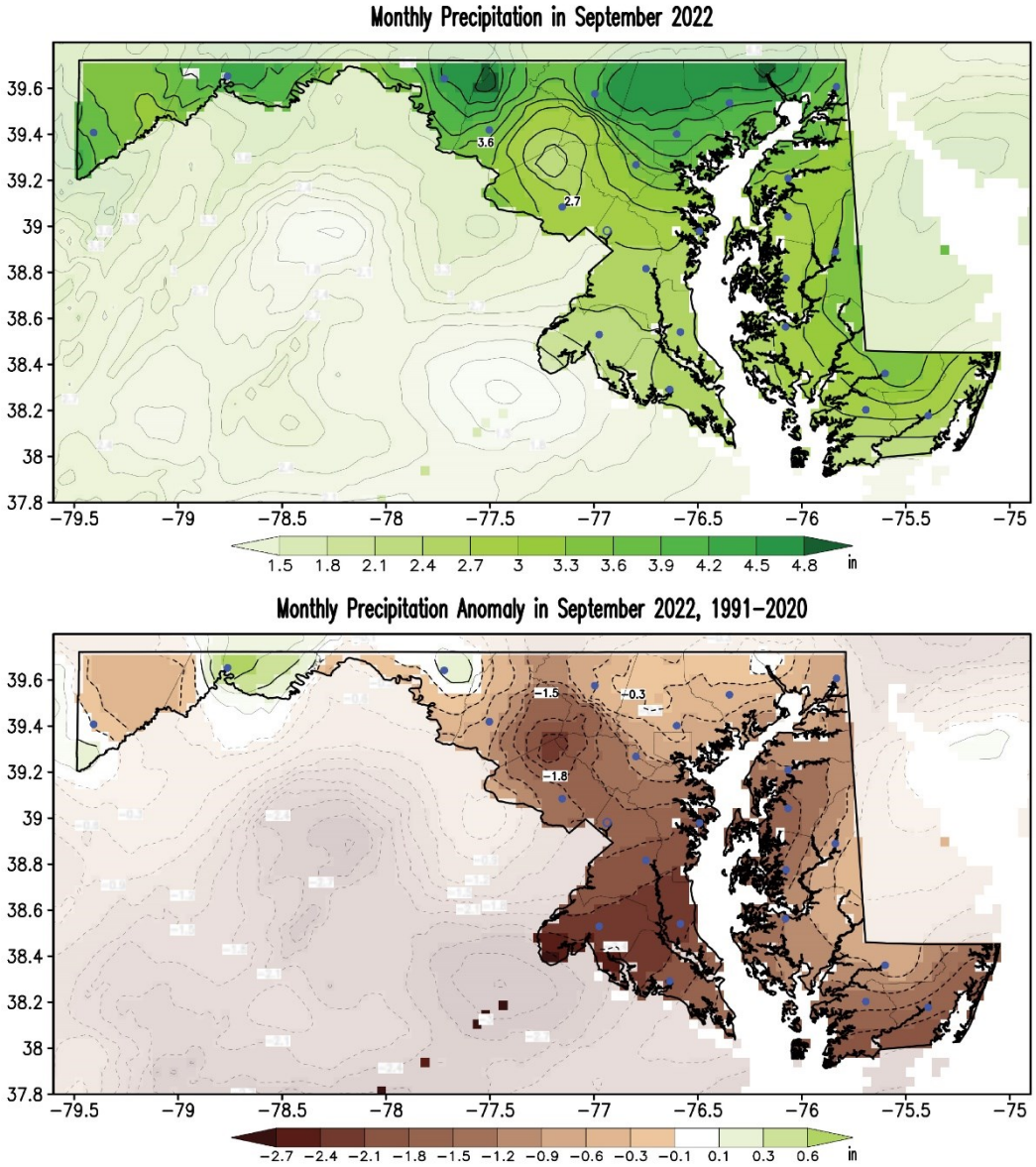

Figure 4. Precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) in September 2022. Precipitation units are given as inches according to the color bars. Brown/green shading in the anomaly map shows below/above normal conditions. Note that shading outside the state has been washed out for clarity purposes. Filled blue circles mark the county seats.

Monthly total precipitation in September 2022 reached maximum values over some northern counties. Precipitation was maximum over Harford, Cecil and Frederick counties (~4.8 in), and Allegany and Garrett counties (~3.9 in), and it was minimum over the coastal counties. Precipitation was largely below normal over the state except by the regions with the northern counties that had the largest precipitation. The largest positive anomalies were over the cited northern counties and were small (0.1-0.6 in), however the maximum negative anomalies reached the largest values over Charles County (-2.7 in) and, similarly to August 2022, over the Montgomery, Howard, Frederick and Carroll counties (-2.1 in); appendices A and B show the area-averaged values. Anomalies were below the year-to-year variability (Appendix D).

E. Drought

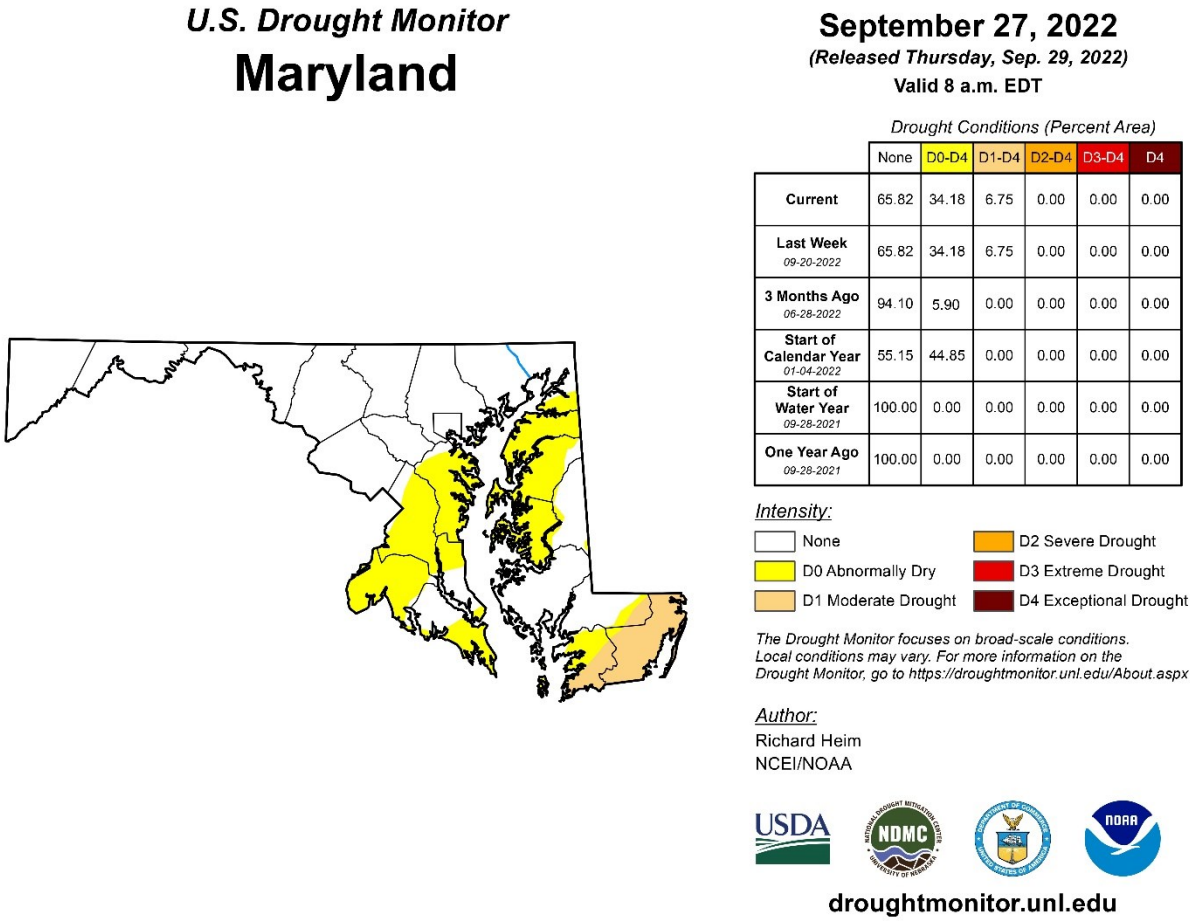

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on September 27, 2022.

Drought conditions at the end of September 2022 indicate that the abnormally dry conditions have expanded and the moderate drought persist with respect to August 2022. The decrease in precipitation and increased maximum temperatures over the coastal plains counties seem to be behind the observed abnormally dry and moderate drought conditions at the end of this month. While under the abnormally dry conditions surface water levels decline, crops are stunted, gardens begin to wilt and fire danger is elevated, under moderate drought conditions reservoir and lake levels are below normal capacity, trees, landscaping and fish are stressed, hay, grain yields and honey production are lower than normal or decline and irrigation use increases.

4. September 2022 Statewide Averages in the Historical Record

A. Box and Whisker Plots

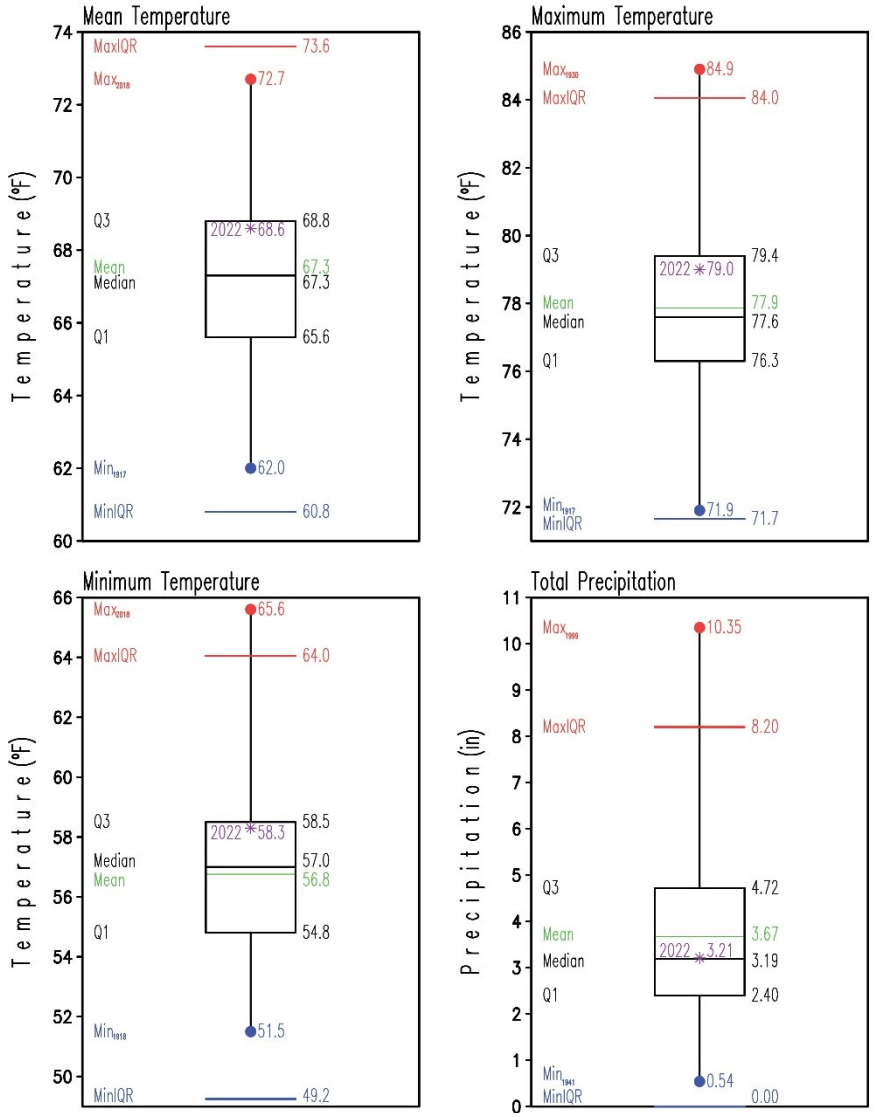

Figure 6. Box and Whisker plots of Maryland statewide mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures and total precipitation (lower right) in September for the period 1895-2021. Conditions in September 2022 are represented by the label and asterisk in purple within the boxes. Statistics for the period 1895-2021 are labeled at the left side of each box and whisker plot and their values at their right. 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 smaller and larger values respectively, are the lower and upper horizontal black lines of the box respectively. The minimum and maximum values in the period are marked by the blue and red dots at the end of the whiskers; the year of occurrence is shown as a subscript to their labels. The blue and red horizontal lines represent extreme values defined by Q1-1.5×(Q3-Q1) and Q3+1.5×(Q3-Q1), respectively.

Statewide temperatures (68.6, 79.0, 58.3°F) in September 2022 were above the mean and median of the 1895-2021 historical record, while precipitation was below the mean but similar to the median. In the historical context, September 2022 was warmer and drier and far of the extremes.

B. Scatter Plots

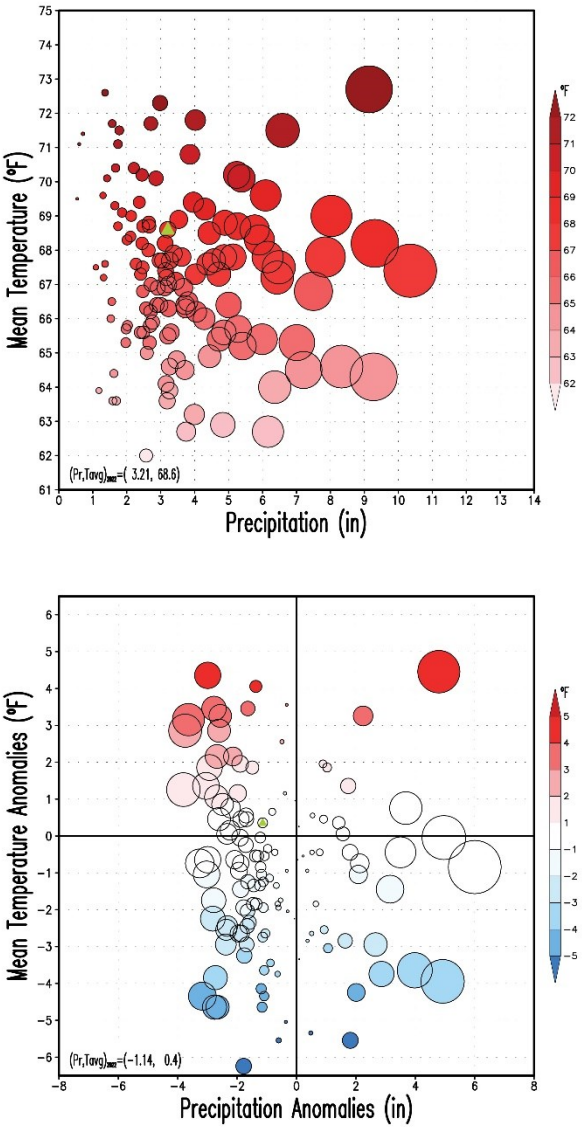

Figure 7. Scatter plot of averaged Maryland statewide mean surface air temperature vs total precipitation in September for the period 1895-2022. Upper panel shows the mean temperature and total precipitation in September, and bottom panel displays their anomalies with respect to the 1991-2020 climatology. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation on record (10.35 in in 1999, top panel) and by the maximum precipitation anomaly (6.00 in in 1999, bottom panel). The red shading of the circles in the top panel denotes temperatures above 32°F, and the blue/red shading of the circles in the bottom panel denotes below/above climatology. September 2022 is marked by the yellow/green filled triangle.

The statewide total precipitation and mean temperature of 3.21 in and 68.6°F, as also indicated by the box and whisker plots, are within the upper and left side of the data cloud in the historical record of 128 years. The statewide anomalies, with respect to the current 1991-2020 climatology, of -1.14 in and 0.4 °F also indicate an anomalous dry and slightly warm September 2022. The ranking of the temperatures and precipitation in September 2022 within the historical record at state, climate division and county level are displayed in the tables in Appendix A.

5. September and JAS 2022 Climate Divisions Averages

A. September 2022 Scatter Plots

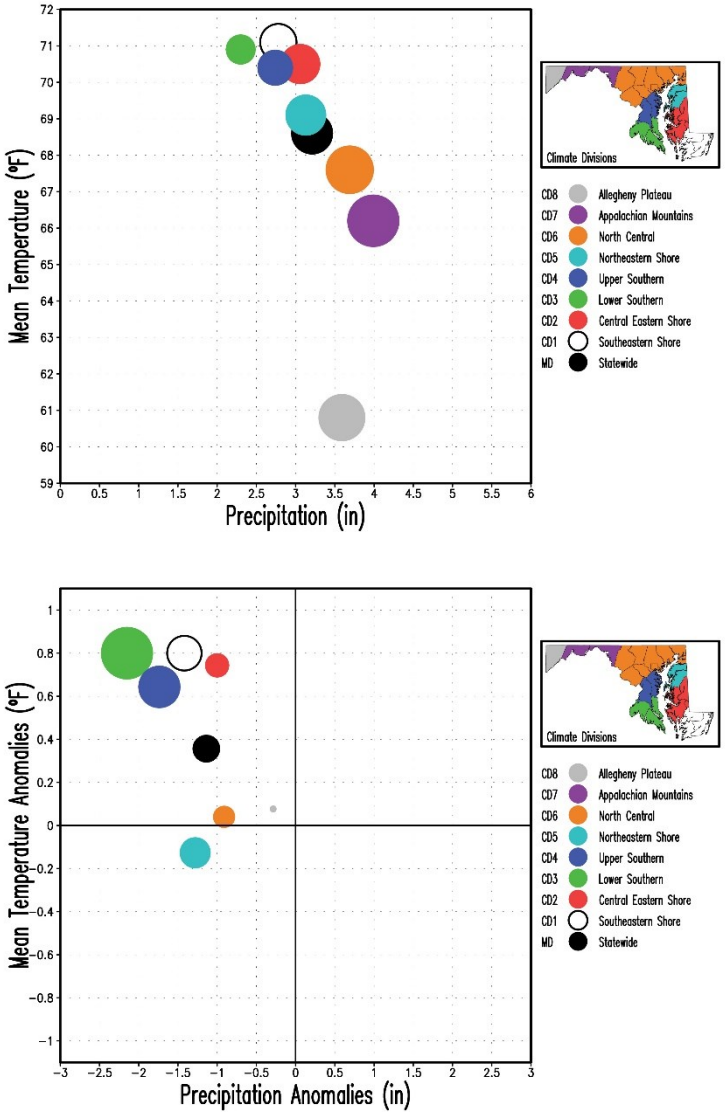

Figure 8. Scatter plot of averaged Maryland statewide and Climate Divisions (CD#) mean surface air temperature vs total precipitation for September 2022. Upper panel shows the mean temperature and total precipitation, and bottom panel displays their anomalies with respect to the 1991-2020 climatology. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (3.99 in in CD7, top panel) and by the maximum precipitation anomaly (|-2.15| in in CD3, 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.

The northern climate divisions (CD6-CD8) were colder than the central and southern divisions (CD1-CD5) and the statewide mean, with CD8 been the coldest and CD1 been the warmest. The driest division was CD3, followed by divisions CD1, CD2 and CD4, while CD7 was the wettest. In the mean all divisions were drier than normal and except by CD5, that had below normal temperatures, the rest were warmer than normal. The values of the surface variables and their anomalies at state, climate division and county level are displayed in Appendix B bar graphs.

B. July-August-September 2022 Scatter Plots

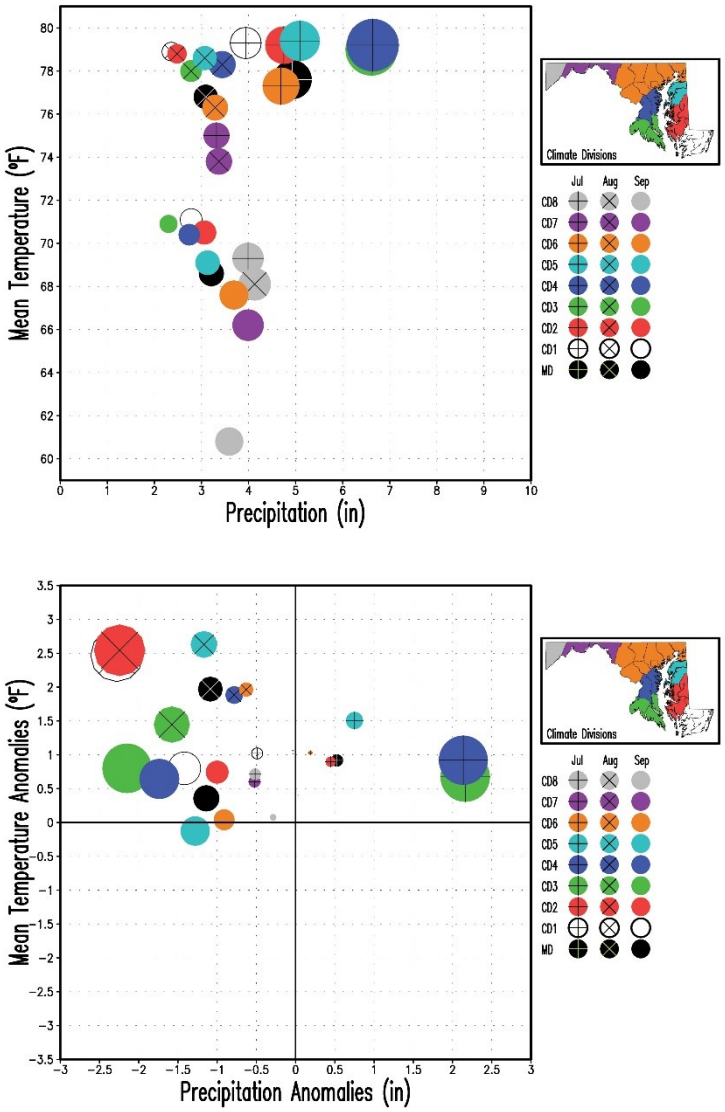

Figure 9. Scatter plot of averaged Maryland statewide and Climate Divisions (CD#) mean surface air temperature vs total precipitation for July, August and September 2022. Upper panel shows the mean temperature and total precipitation, and bottom panel displays their anomalies with respect to the 1991-2020 climatology. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (6.64 in in CD4 in July, top panel) and by the maximum precipitation anomaly (|-2.28| in in CD1 in August, bottom panel) among the nine regions and months. Note that September is displayed with filled circles only, while August and July are displayed with superposed multiplication and addition signs respectively.

Mean temperatures and precipitation, after peaking in July, decreased statewide in August and September 2022. Temperatures decreased the most from August to September (~ -8°F) than from July to August (~ -0.8°F). Except by CD5 in September, mean temperatures were above normal in the past three months while precipitation moved from above normal conditions in July to below normal in August and September. Above normal temperatures decreased in September from those in August while below normal precipitation was similar in both months.

Appendix A. September 2022 Tables: Statewide, Climate Divisions and Counties

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)
Statewide	68.6	91
Climate Division 1	71.1	102
Climate Division 2	70.5	102
Climate Division 3	70.9	99
Climate Division 4	70.4	98
Climate Division 5	69.1	84
Climate Division 6	67.6	90
Climate Division 7	66.2	86
Climate Division 8	60.8	72
Allegany	65.6	79
Anne Arundel	70.8	98
Baltimore	67.8	90
Baltimore City	70.2	96
Calvert	70.7	100
Caroline	69.5	94
Carroll	66.4	87
Cecil	68.2	85
Charles	70.6	98
Dorchester	71.1	105
Fredrick	67.0	85
Garrett	60.8	72
Harford	67.5	68
Howard	68.0	98
Kent	69.0	75
Montgomery	68.2	91
Prince George's	70.0	97
Queen Anne's	69.3	86
Saint Mary's	71.4	103
Somerset	71.7	105
Talbot	70.6	98
Washington	66.8	90
Wicomico	70.5	101
Worcester	71.1	103

Region	Total Precipitation (in)	Rank (#)
Statewide	3.21	65
Climate Division 1	2.78	48
Climate Division 2	3.06	58
Climate Division 3	2.30	42
Climate Division 4	2.74	51
Climate Division 5	3.13	61
Climate Division 6	3.69	70
Climate Division 7	3.99	97
Climate Division 8	3.59	82
Allegany	3.90	96
Anne Arundel	2.90	56
Baltimore	4.20	78
Baltimore City	3.80	74
Calvert	2.40	44
Caroline	3.30	66
Carroll	3.70	74
Cecil	3.90	74
Charles	2.10	38
Dorchester	2.90	51
Fredrick	3.50	75
Garrett	3.50	79
Harford	4.30	78
Howard	3.00	60
Kent	3.20	63
Montgomery	2.80	54
Prince George's	2.60	50
Queen Anne's	2.90	55
Saint Mary's	2.40	45
Somerset	2.50	44
Talbot	2.70	46
Washington	4.00	93
Wicomico	3.20	64
Worcester	2.60	47

Table A1. Mean surface air temperature (left) and total precipitation (right) at statewide, climate division and county levels in September 2022. Temperature is given in °F and precipitation in in. The rank is the order that the variable in September 2022 occupies among the 128 Septembers after the 128 values have been arranged from the lowest to the highest value by using the standard competition ranking method. The closer to 128 is the rank, the larger the value of the surface variable is in the record.

B. Maximum and Minimum Temperatures

Region	Maximum Air Temperature (°F)	Rank (#)
Statewide	79.0	87
Climate Division 1	81.3	110
Climate Division 2	81.3	105
Climate Division 3	81.0	102
Climate Division 4	80.4	97
Climate Division 5	79.7	83
Climate Division 6	78.0	80
Climate Division 7	77.0	56
Climate Division 8	70.7	45
Allegany	76.8	57
Anne Arundel	80.4	96
Baltimore	78.4	81
Baltimore City	80.2	97
Calvert	80.6	100
Caroline	80.8	98
Carroll	77.0	73
Cecil	78.7	90
Charles	80.9	97
Dorchester	81.8	109
Fredrick	77.3	77
Garrett	70.7	45
Harford	78.3	80
Howard	78.7	97
Kent	79.4	81
Montgomery	78.3	82
Prince George's	80.4	94
Queen Anne's	79.8	83
Saint Mary's	81.4	107
Somerset	81.8	111
Talbot	80.7	96
Washington	77.4	61
Wicomico	81.5	108
Worcester	80.7	106

Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	58.3	91
Climate Division 1	60.9	87
Climate Division 2	59.7	85
Climate Division 3	60.7	88
Climate Division 4	60.3	96
Climate Division 5	58.5	76
Climate Division 6	57.2	85
Climate Division 7	55.4	101
Climate Division 8	51.0	100
Allegany	54.5	99
Anne Arundel	61.2	98
Baltimore	57.2	85
Baltimore City	60.4	97
Calvert	60.8	89
Caroline	58.1	80
Carroll	55.7	87
Cecil	57.6	69
Charles	60.2	88
Dorchester	60.4	86
Fredrick	56.8	91
Garrett	51.0	99
Harford	56.8	67
Howard	57.4	99
Kent	58.6	69
Montgomery	58.1	92
Prince George's	59.6	94
Queen Anne's	58.8	79
Saint Mary's	61.3	88
Somerset	61.6	85
Talbot	60.6	90
Washington	56.1	102
Wicomico	59.5	82
Worcester	61.4	88

Table A2. Maximum (left) and minimum (right) surface air temperatures at statewide, climate division and county levels in September 2022. Temperature is given in °F. The rank is the order that the variable in September 2022 occupies among the 128 Septembers after the 128 values have been arranged from the lowest to the highest value by using the standard competition ranking method. The closer to 128 is the rank, the larger the value of the surface variable is in the record.

Appendix B. September 2022 Bar Graphs: Statewide, Climate Divisions and Counties

A. Temperatures and Precipitation

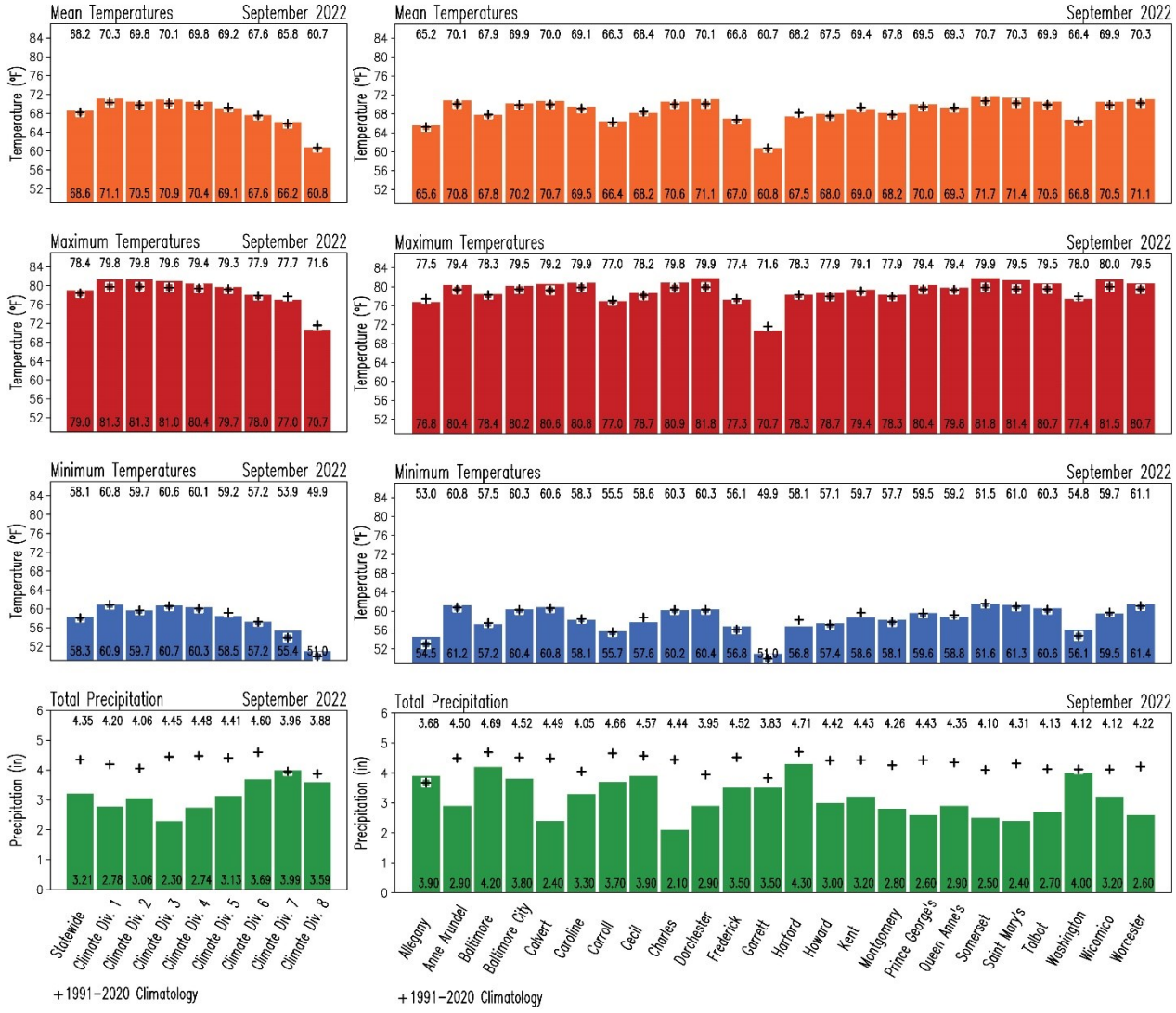

Figure B1. Area-averaged surface variables in Maryland in September 2022. Color bars represent the variables as follows: mean surface air temperature (orange, °F), maximum surface air temperature (red, °F), minimum surface air temperature (blue, °F) and total precipitation (green, in) at statewide and climate divisions (left column), and at county (right column) level. The numbers at the base of the bars indicate the magnitude of the variable in September 2022. For comparison, the corresponding 1991-2020 climatological values for September are displayed as black addition signs, and their magnitude are shown at the top of the panels.

B. Temperature and Precipitation Anomalies

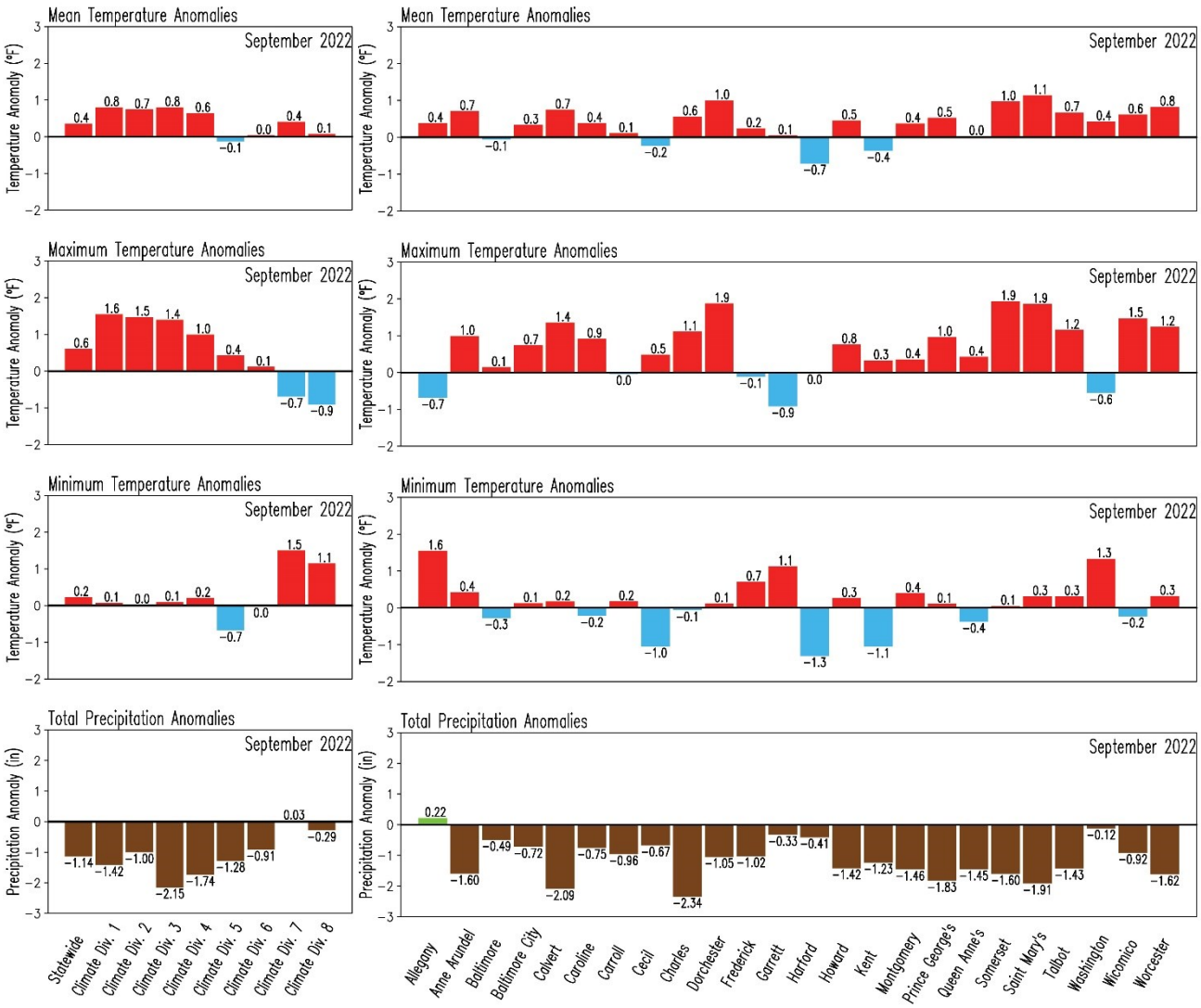

Figure B2. Area-averaged anomalies of the surface variables in Maryland in September 2022. Anomalies are with respect to the 1991-2020 climatology. Red and blue colors represent positive and negative anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top) while green and brown colors indicate positive and negative anomalies in total precipitation (bottom row) at statewide and climate divisions (left column), and at county (right column) level. The numbers outside of the bars indicate the magnitude of the anomaly in September 2022. Units are °F for the temperatures and in for precipitation.

Appendix C. September 1991-2020 Climatology Maps

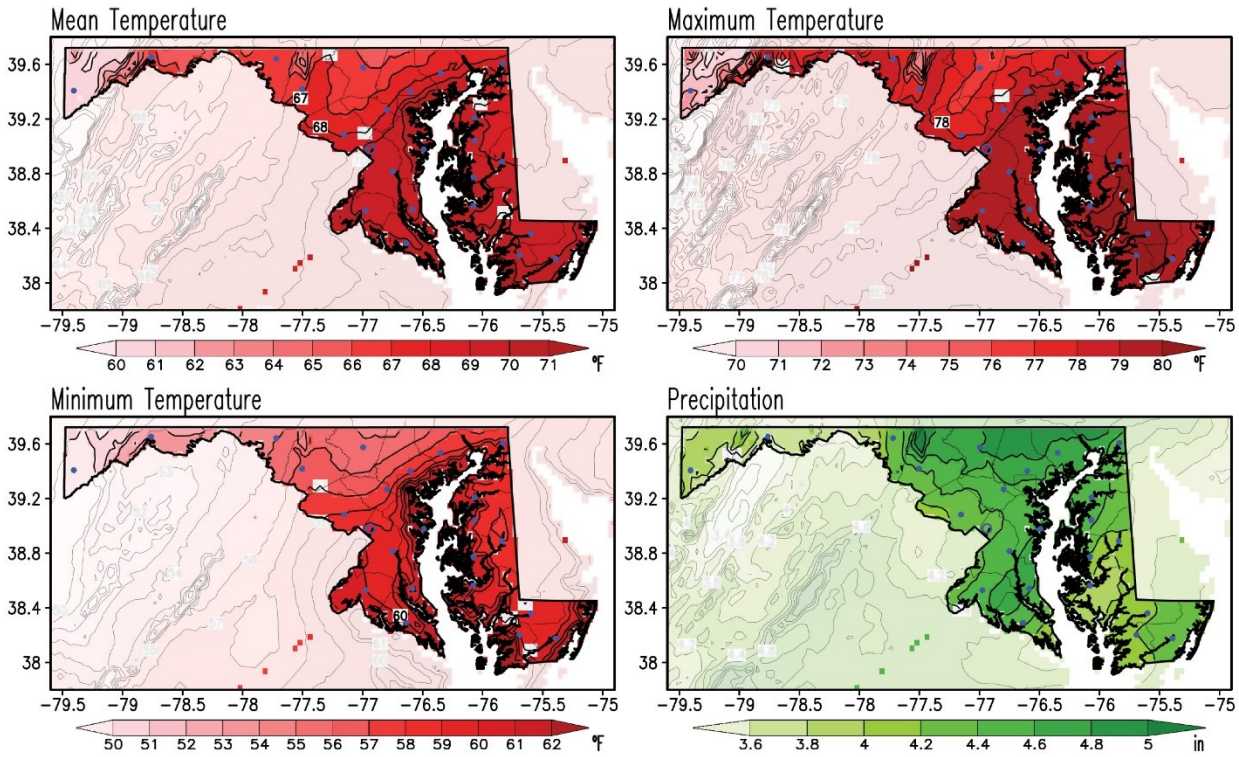

Figure C1. September climatology of the mean, maximum and minimum surface air temperatures and total precipitation for the period 1991-2020. Temperatures are given in °F and precipitation is in inches according to the color bars. This is the current climate normal against which the September 2022 conditions are compared with to obtain the September 2022 anomalies. Note that shading outside the state has been washed out for clarity purposes. 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.) and ocean (sea-level, sea surface temperature, etc.) at any given time, while climate refers to the time-average of the weather elements when the average is over long periods. If the averaging 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 a 30-year period 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). The establishment of a climate normal or climatology is important as it allows one to compare a specific day, month, season, or even another period normal 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. September Standard Deviation and September 2022 Standardized Anomalies Maps

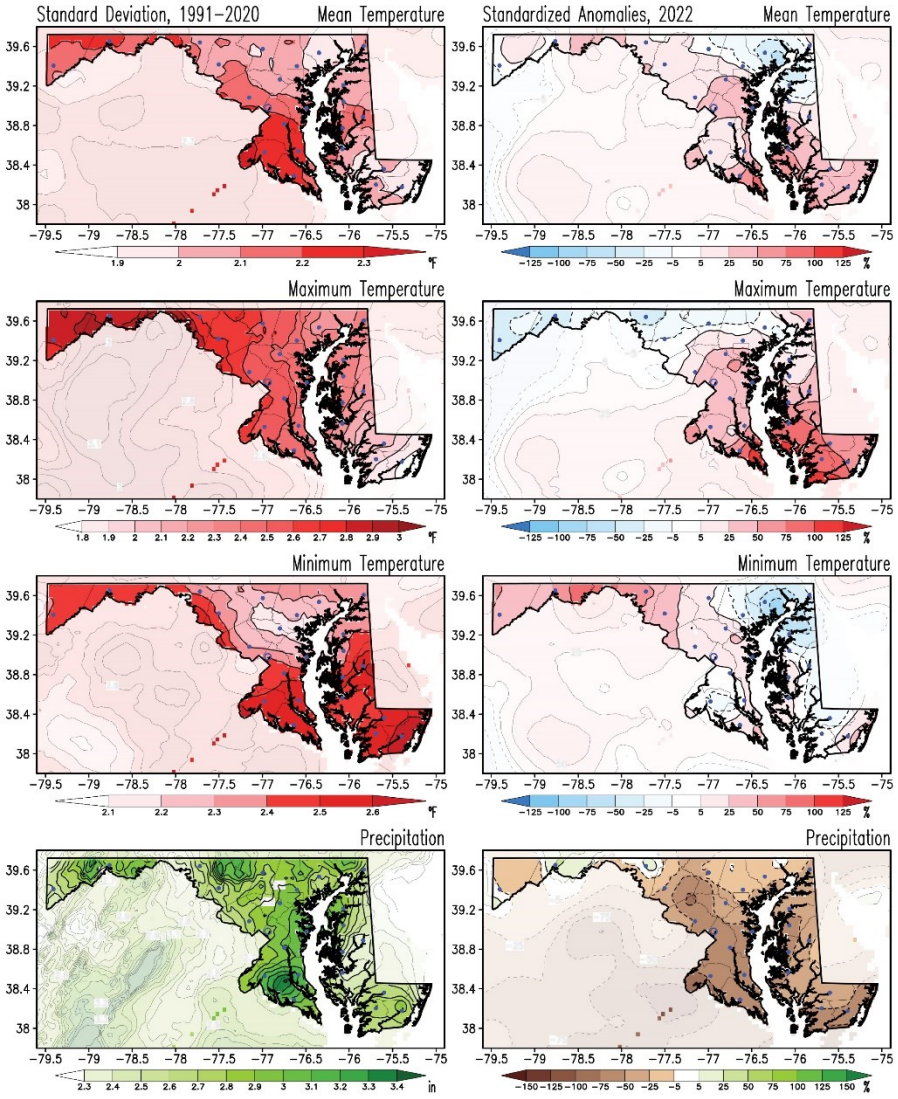

Figure D1. Standard deviation in September and standardized anomalies of temperatures and precipitation in September 2022. Standard deviations for mean, maximum and minimum surface air temperatures and precipitation are obtained for the period 1991-2020 (left column). Anomalies in September 2022 (right column) are obtained as percentage of the standard deviations. The standard deviations in temperatures are given in °F and those in precipitation are in inches according to the color bars. 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, so units are in percent (%). Note that shading outside the state has been washed out for clarity purposes. Filled blue circles mark the county seats.

The standard deviation is a measure of the year-to-year, or interannual, variability of a climate variable. In this case the standard deviation is calculated for the same period as the climatology. Anomalies sometimes are compared against that variability in order to identity extremes in the climate record. When the anomalies are divided by the standard deviation they are named *standardized anomalies*.

References

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