

**MDSCO-2023-08**

# **Maryland Climate Bulletin**

## **August 2023**

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



## Summary

Statewide averages show that August 2023 was warmer and drier than normal (i.e., 1991-2020 averages). Monthly mean temperatures were between 66 to 78°F; maximum temperatures were in the 75 to 87°F range, and minimum temperatures were between 56 to 70°F. Monthly total precipitation was between 2.4 to 4.8 inches. Climatologically speaking, temperatures have started to decrease.

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

- Mean temperature was warmer than normal in the eastern shore, especially over Worcester, Somerset, Wicomico counties, and southern Saint Mary's County (above 1.0°F), the Piedmont, particularly in parts of Anne Arundel, Howard, Baltimore, and Cecil counties, and Garret County (around 0.8°F). Slightly below-normal temperatures appeared over Allegany and northern Saint Mary's counties (around -0.2°F).
- Maximum temperature was also warmer than normal in some parts of the state, such as Washington, Worcester, Somerset, Wicomico, Dorchester, southern Saint Mary's counties (around 1°F), and parts of Anne Arundel, Howard, Baltimore, Carroll, and Frederick counties (around 0.6°F). Some other parts, such as Garrett, Allegany, Prince George's, Charles, Saint Mary's, Calvert, Talbot, Caroline, and Queen Anne's, were colder than normal (around -0.6°F).
- Minimum temperature was warmer than normal over Garret County, the eastern shore, notably in portions of Somerset and Worcester counties (1.2°F), and parts of the Piedmont such as Anne Arundel, Howard, Baltimore, and Montgomery counties (around 0.8°F). Colder than normal minimum temperatures appeared over Allegany, Washington, Frederick, and Carroll counties (around -0.2°F).
- Precipitation was below normal in most of the state, including the eastern shore, notably over Dorchester, Wicomico, and Worcester counties (around -2 in), the Piedmont, particularly over Baltimore, Harford, and Cecil counties, and Calvert and Saint Mary's counties (-1.8 in). Precipitation was above normal only over Garret County (around 0.9 in) and the northern halves of Washington and Frederick counties (around 0.3 in).
- The extent of the surface in the state under drought conditions decreased from around 43% at the end of July to around 26% at the end of August. However, the reason is unclear, as much of the drought-affected area has below-normal precipitation this month. Severe drought conditions were no longer present in the state; moderate drought conditions still occupied around 15% of the state (over Frederick and portions of Carroll, Howard, Montgomery, and Washington counties); and around 10% of the state was under abnormally dry conditions (especially over portions of Garret, Washington, Carroll, Baltimore, Howard, and Montgomery counties).



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

- All eight climate divisions were warmer than normal in August. However, except for the western and mountainous climate division 8, which was wetter than normal, the rest were drier.
- Statewide temperature anomalies remained warmer than normal in August, although they were around a third of the size of these in July. Precipitation anomalies, which kept on zigzagging since June, changed their sign from wet anomalies in July to dry ones in August.

### *Historical Context (Figures 8 and 9, Tables A1 and A2)*

- Mean, maximum, and minimum statewide temperatures in August (75.3, 85.1, and 65.4°F) were above the long-term (1895-2022) average but away from the records; minimum temperatures were within 25% of the highest values. August's precipitation (2.95 in) was below the long-term average and within 25% of the smallest values.
- Thus far this year, Maryland (statewide) had 38 hot days (daily maximum temperature larger than 86°F) and 9 heat waves (two or more consecutive hot days), just shy of the annual mean of 44 hot days but tied with the annual mean of 9 heat waves during 1951-2022. Similarly, Maryland (statewide) had 26 warm nights (daily minimum temperature larger than 68°F) and 6 spells of two or more consecutive warm nights; this is more than the annual mean of 22 warm nights and 5 warm spells during 1951-2022.

### *Century-Plus Trends, 1895-2023 (Figures 10, 11)*

- Statewide temperature and cooling degree days in August showed significant trends: a warming trend (2.1°F/century) and an increasing trend (70.13°FDD/century), respectively. Statewide precipitation had no significant drying trend (-0.32 in/century).
- Regionally, August mean temperatures showed significant warming trends everywhere. Notably, the largest trend is in Baltimore City (3.3°F/century), as has been the case for the previous months since April. Trends above 2.1°F/century are also evident in the Piedmont and northern counties of the eastern and western shores.
- Regionally, August precipitation has a not-so-small region of significant drying trends over the northwestern counties of the Piedmont (-1.0 in/century). The largest no significant drying trends (-0.6 in/century) are over Kent and Queen Anne's counties. In contrast, the largest no significant wet trends (around 0.2 in/century) are over portions of Garrett, Saint Mary's, and Worcester counties.



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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 August 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. Extreme heat, detrimental to crops without irrigation and population lacking air conditioning, is tracked by the count of hot days, warm nights, and their consecutive occurrence (identified from daily statewide-averaged temperatures – e.g., Tschurr et al. 2020, Barriopedro et al. 2023) and displayed in Section 6. Century-plus trends in statewide air temperature, cooling degree-days, precipitation, and state maps of air temperature and precipitation are presented in Section 7. 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 cooling 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 9/11/2023.



- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20230907) at:  
<https://www.ncei.noaa.gov/pub/data/cirs/climdiv/>  
Data was downloaded on 9/14/2023.
- NOAA Area averages of daily temperatures and precipitation dataset (NClimGrid–Daily –Durre et al. 2022, 2022a), which is available in a preliminary status (v1.0.0) at:  
<https://www.ncei.noaa.gov/pub/data/daily-grids/v1-0-0/>  
Data was downloaded on 9/4/2023.

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., August 2023) are the departures of the monthly value from the corresponding month’s 30-year average (i.e., from the average of 30 Augusts) 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.



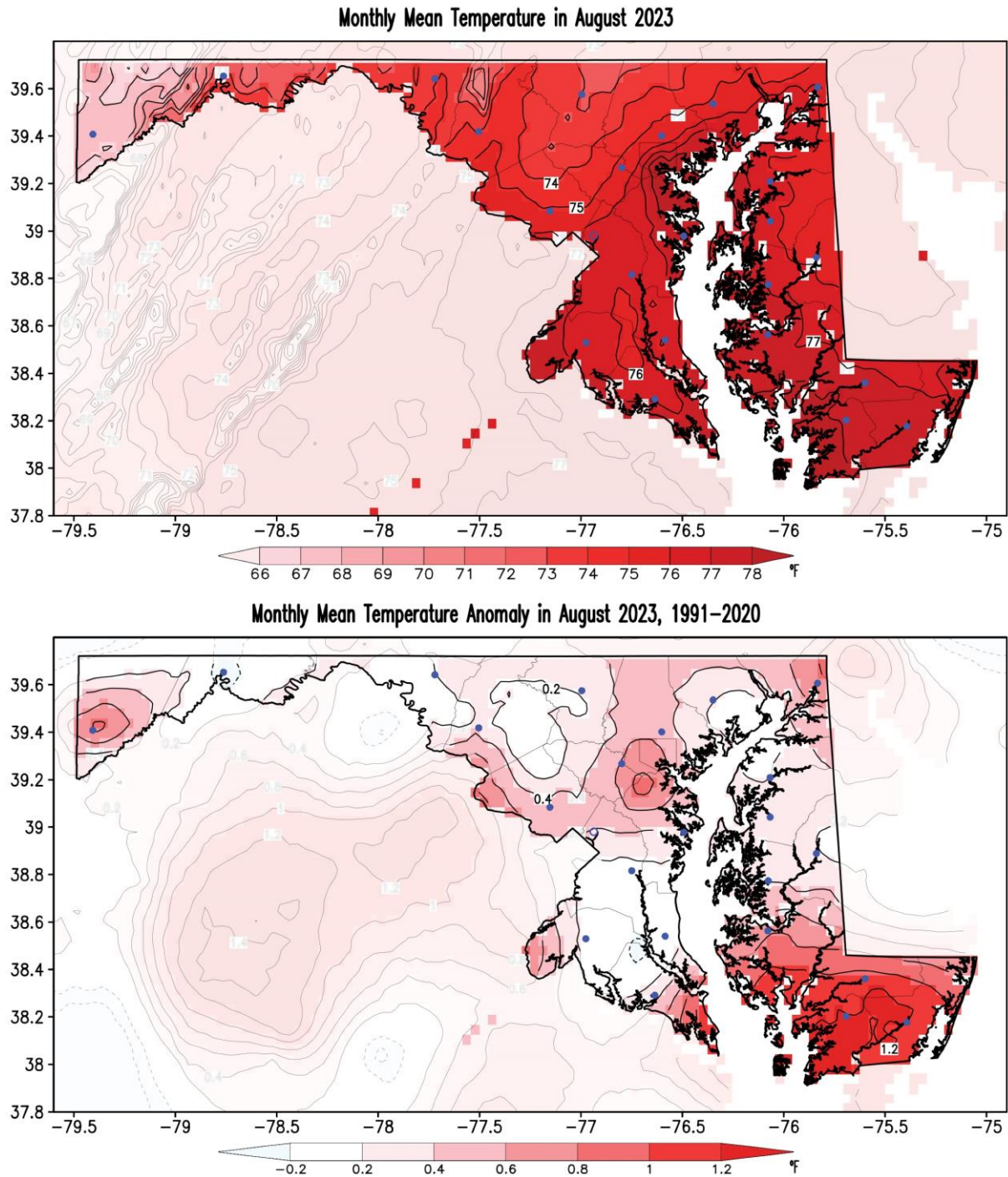
- Climate Division 7: Appalachian Mountains. It includes the counties of Allegany and Washington.
- Climate Division 8: Allegheny Plateau. It includes Garrett County.

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. August 2023 Maps

#### A. Mean Temperatures

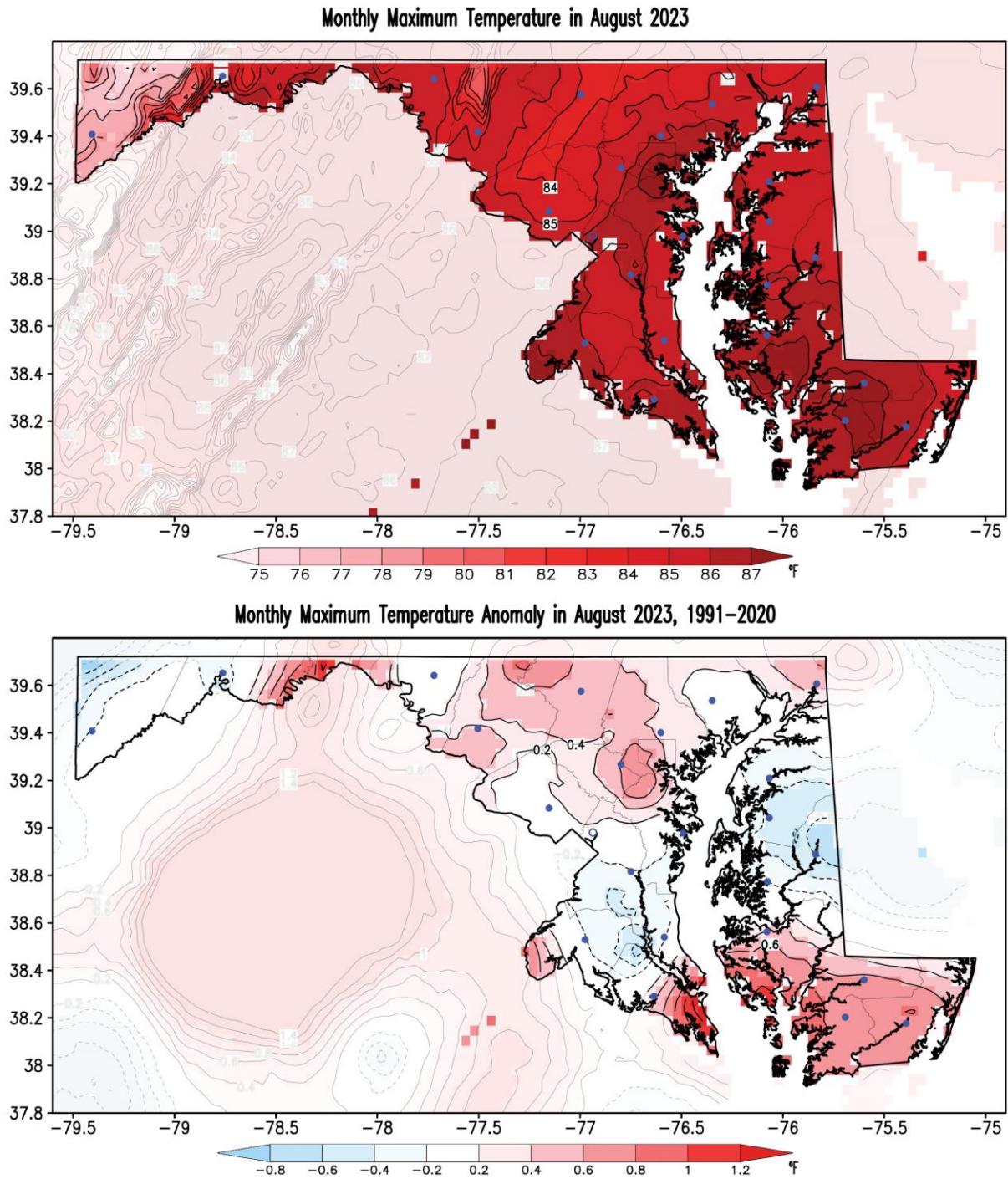


**Figure 1.** Monthly mean surface air temperature (top panel) and its anomaly with respect to the 1991–2020 climatology (bottom panel) for August 2023. Temperatures are in °F following the color bar. Blue/red shading in the anomaly map marks colder/warmer than normal conditions. Note shading outside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





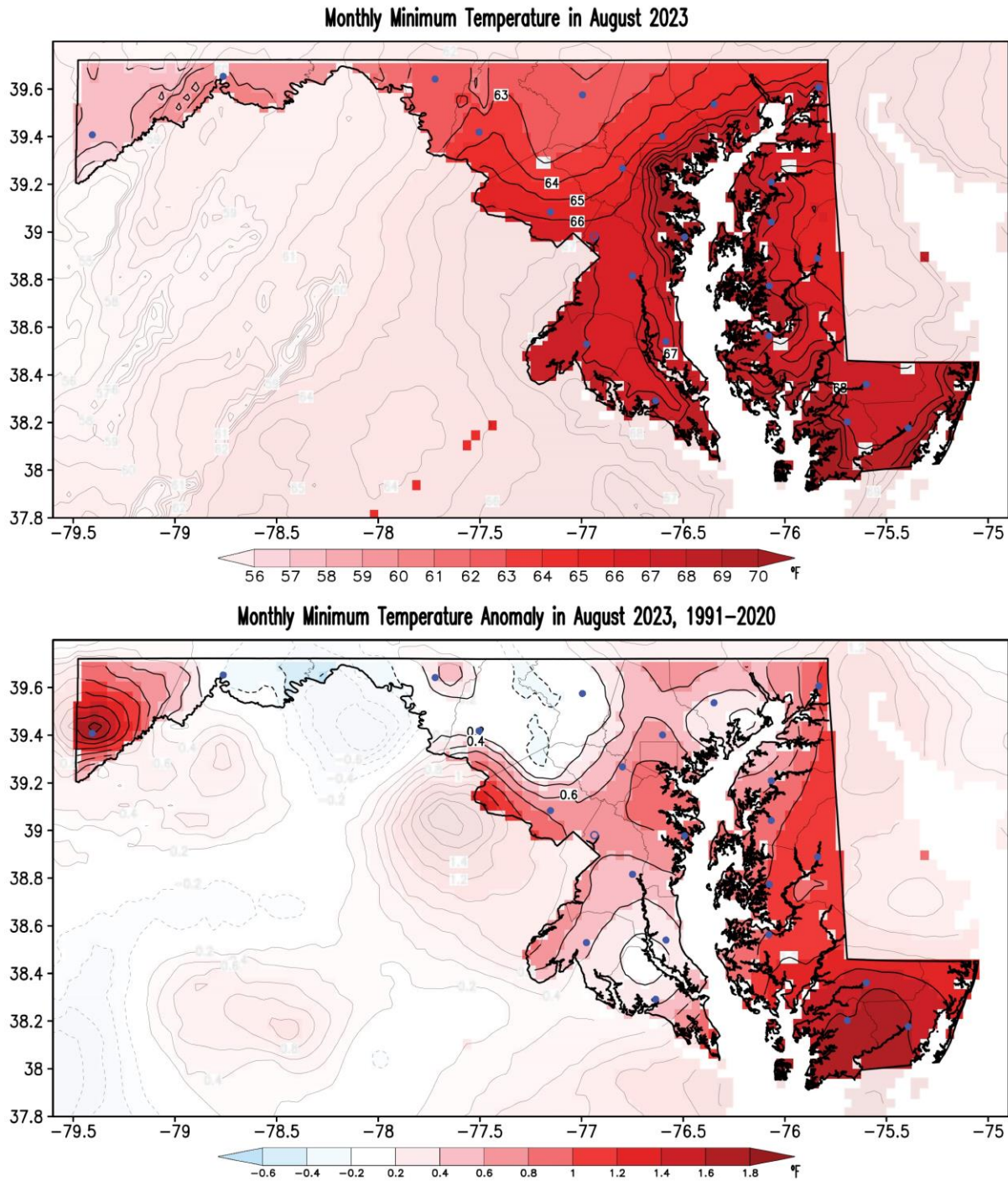
B. Maximum Temperatures



**Figure 2.** Monthly maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for August 2023. Temperatures are in °F following the color bar. Blue/red shading in the anomaly map marks colder/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.



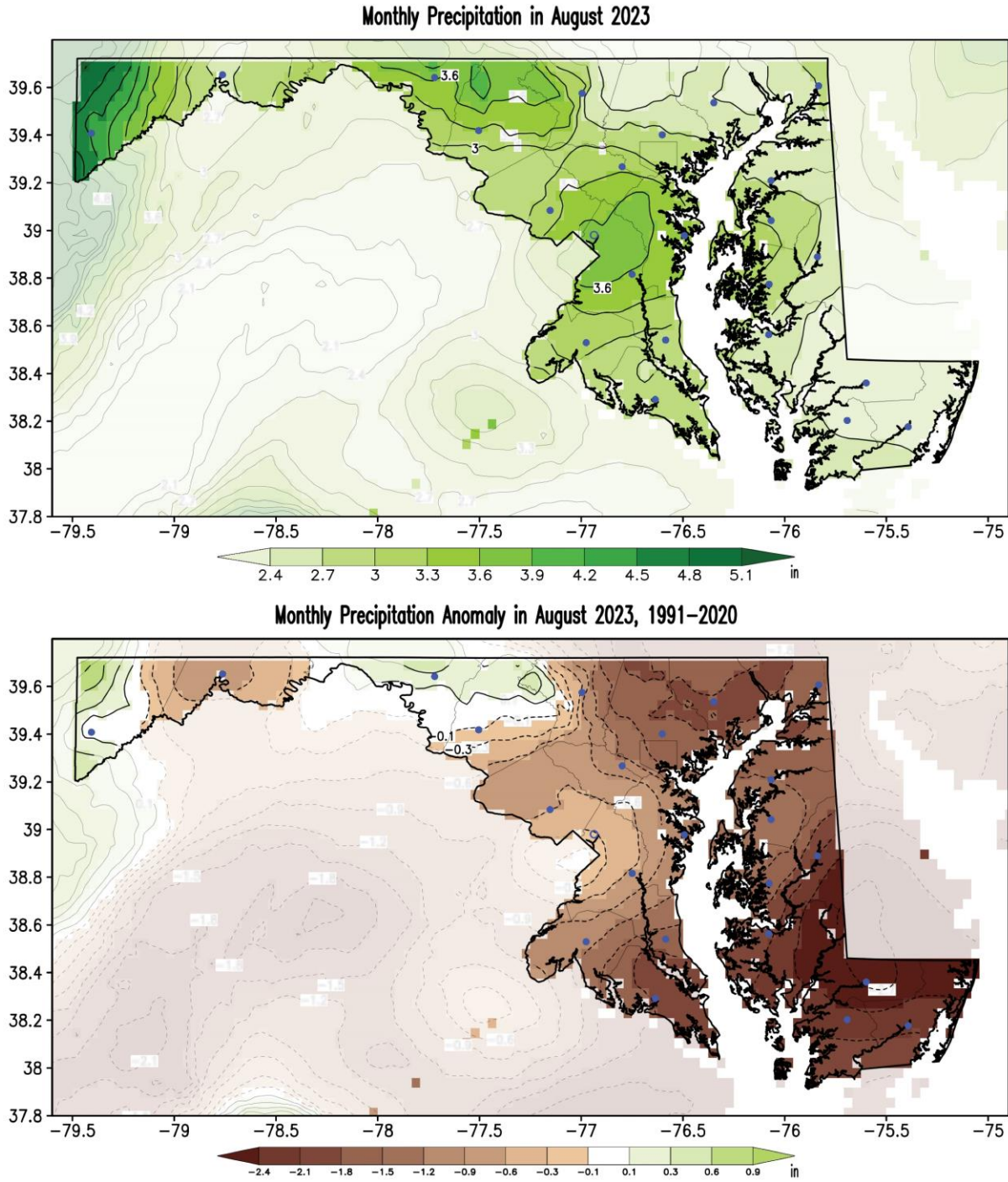
C. Minimum Temperatures



**Figure 3.** Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for August 2023. Temperatures are in °F following the color bar. Blue/red shading in the anomaly map marks colder/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



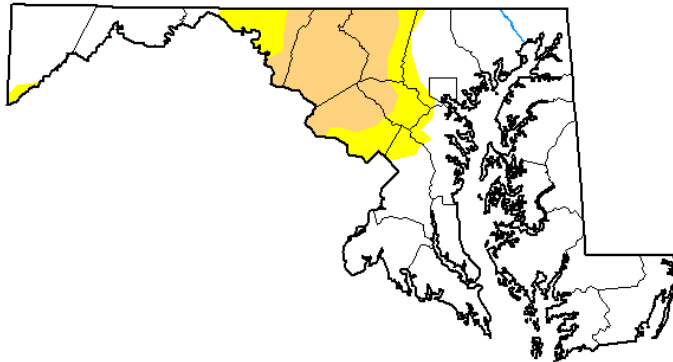
**Figure 4.** Monthly total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for August 2023. Precipitation is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. Note shading outside the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



E. Drought

**U.S. Drought Monitor  
Maryland**

**August 29, 2023**  
(Released Thursday, Aug. 31, 2023)  
Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0	D1	D2	D3	D4
<b>Current</b>	73.72	10.49	15.78	0.00	0.00	0.00
<b>Last Week</b> 08-22-2023	73.81	10.51	15.68	0.00	0.00	0.00
<b>3 Months Ago</b> 05-30-2023	33.92	45.96	20.11	0.00	0.00	0.00
<b>Start of Calendar Year</b> 01-03-2023	100.00	0.00	0.00	0.00	0.00	0.00
<b>Start of Water Year</b> 09-27-2022	65.82	27.43	6.75	0.00	0.00	0.00
<b>One Year Ago</b> 08-30-2022	81.40	11.80	6.79	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>

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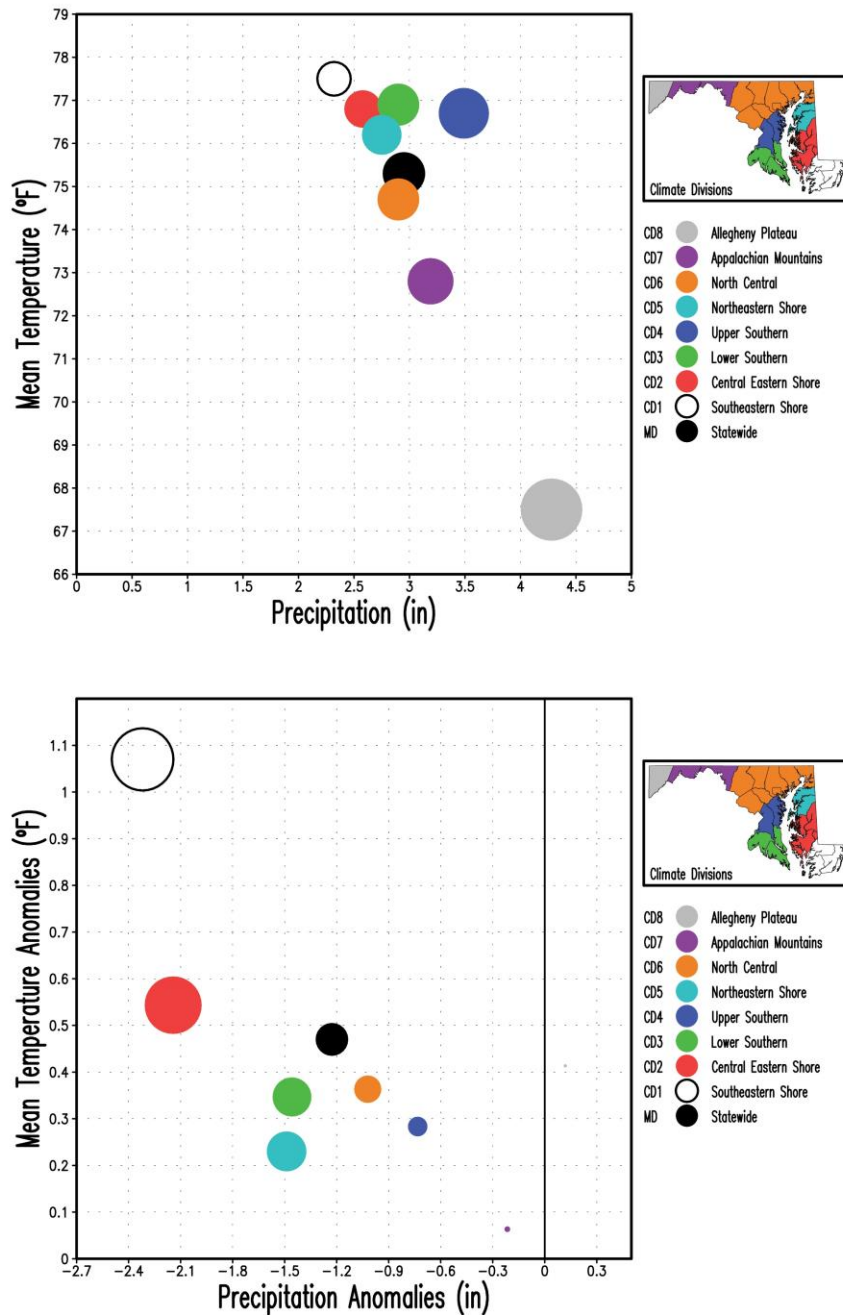
[droughtmonitor.unl.edu](https://droughtmonitor.unl.edu)

**Figure 5.** Drought conditions as reported by the U.S. Drought Monitor on August 29, 2023. Yellow shading indicates abnormally dry regions, and light orange shading shows regions under moderate drought. Numbers in the table indicate the percentage of the state covered under the particular drought conditions at the cited time in the left column. At this time, 26.27% of the state was under some drought category, which was a reduction with respect to the 42.61% of the state under drought at the end of July.



## 4. August and JJA 2023 Climate Divisions Averages

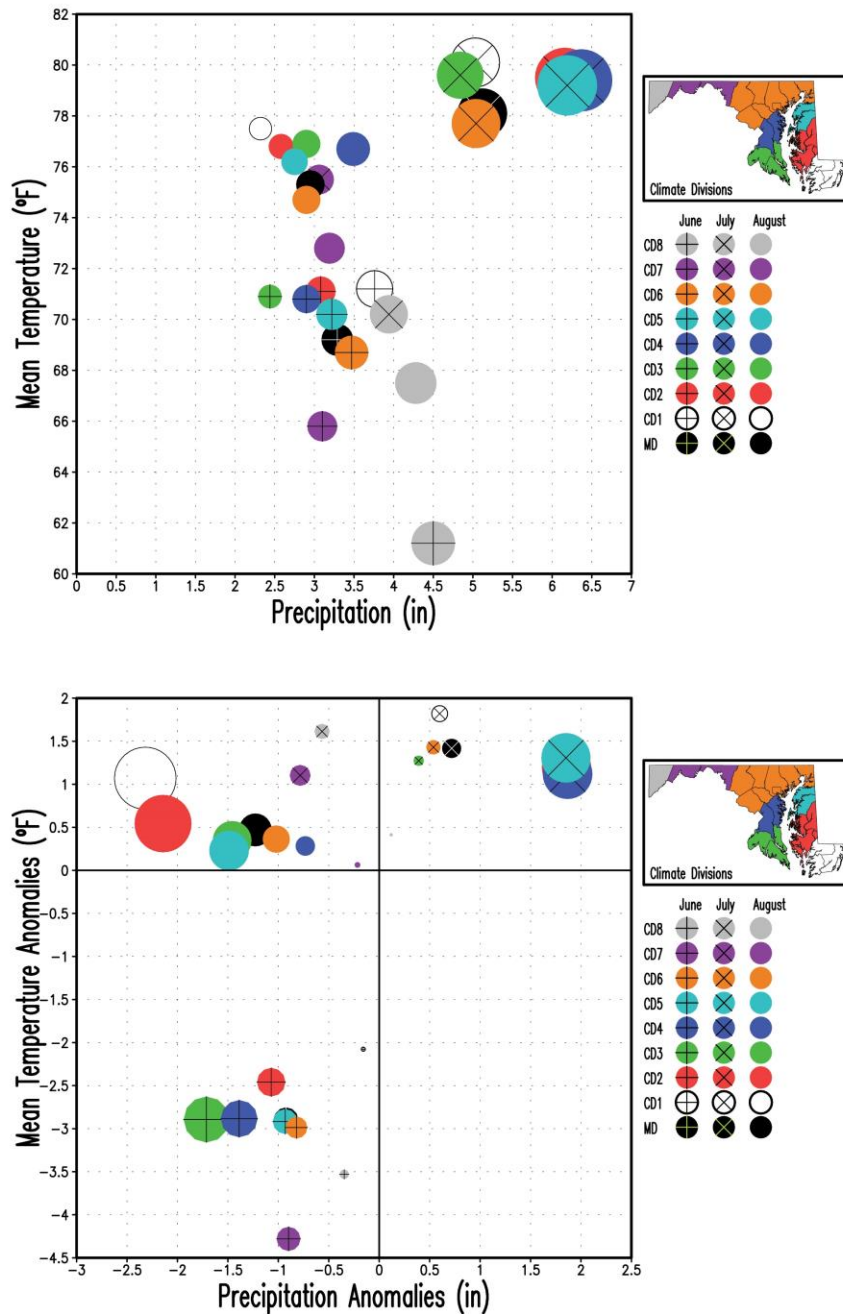
### A. August 2023 Scatter Plots



**Figure 6.** Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for August 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 (4.28 inches in CD8, top panel) and by the maximum precipitation anomaly (|-2.23| inches in CD1, 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. June-August 2023 Scatter Plots

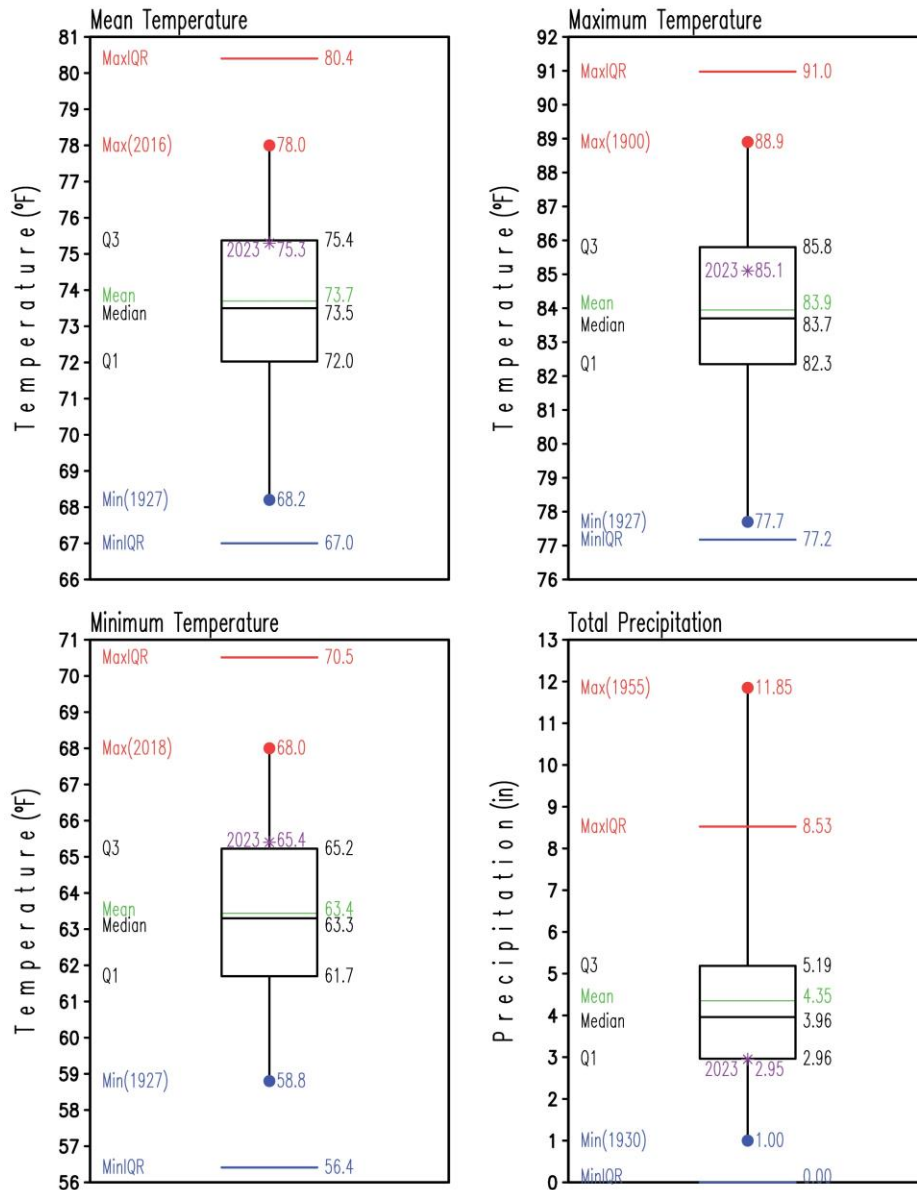


**Figure 7.** Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for June, July, and August 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect 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 (6.37 inches in CD4 in July, top panel) and by the maximum precipitation anomaly (|-2.32| inches in CD1 in August, bottom panel) among the nine regions and three months. August is displayed with filled circles only, while July and June are displayed with superposed multiplication and addition signs, respectively.



## 5. August 2023 Statewide Averages in the Historical Record

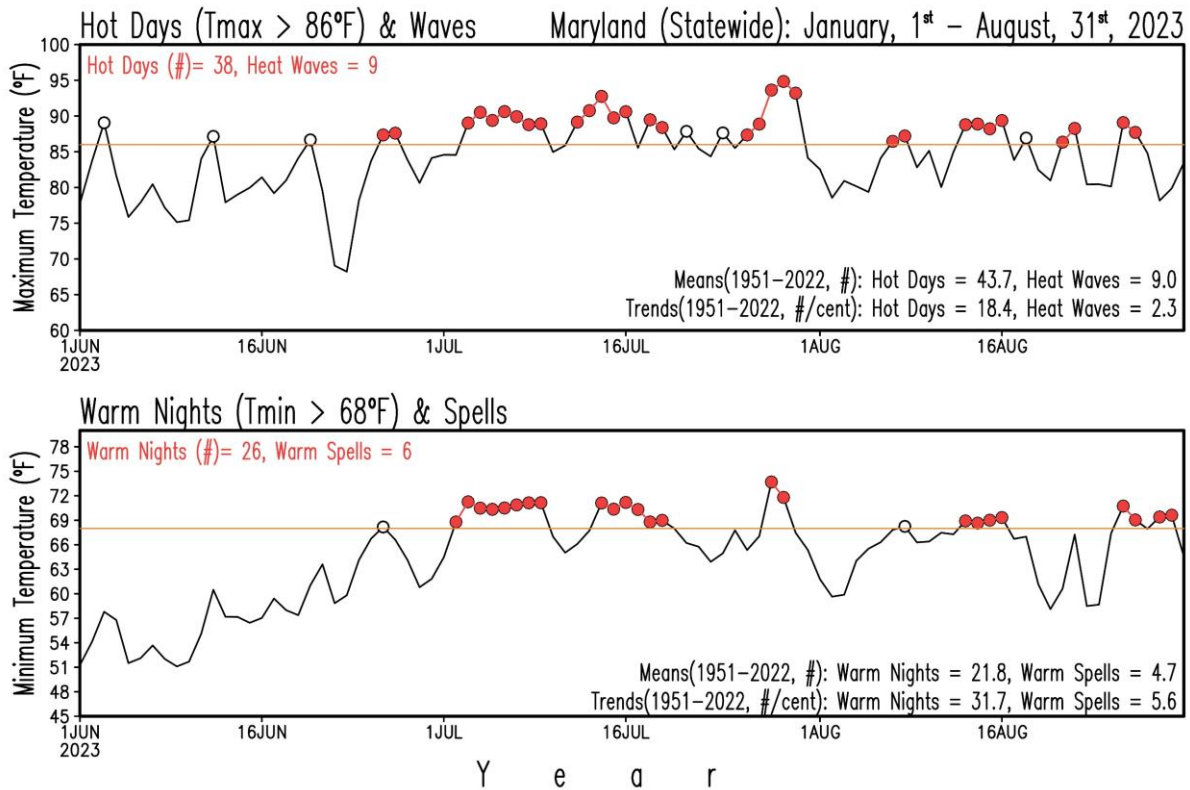
### A. Box and Whisker Plots



**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 August for the period 1895-2022. The label and asterisk in purple represent conditions for August 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. Hots Days and Warm Nights in 2023



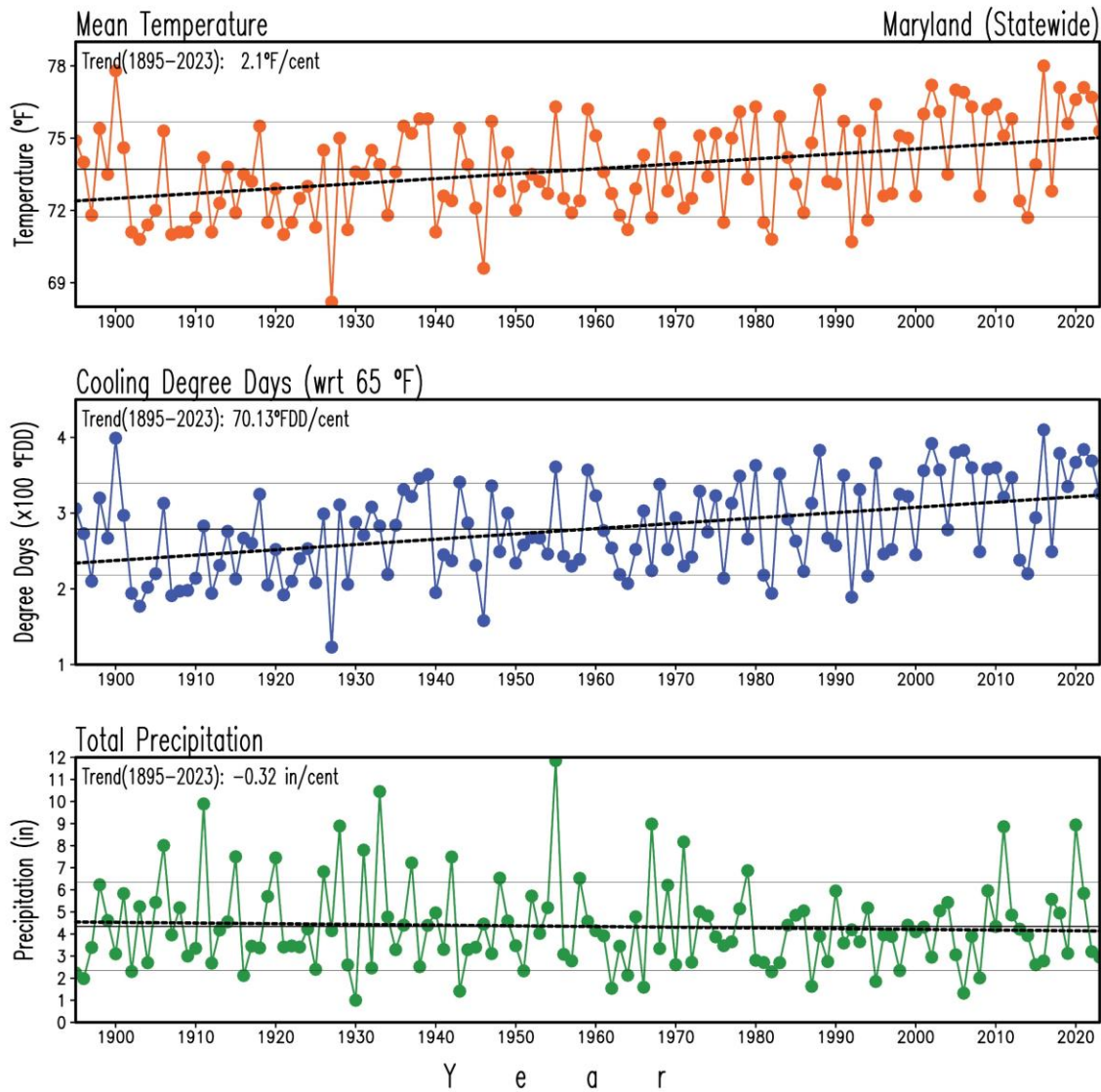
**Figure 9.** Maryland (statewide) number of hot days, warm nights, and their consecutive occurrence for the period January 1 - August 31, 2023. A hot day is defined as one when the maximum temperature is greater than 86°F (open circles), while a warm night is when the minimum temperature is greater than 68°F. When these conditions persist for two or more days, they are called heat waves (daytime) and warm spells (nighttime). Upper panel shows hot days in open circles and heat waves in red-filled circles from daily maximum temperatures. Lower panel shows warm nights in open circles and warm spells in red-filled circles from daily minimum temperatures. The orange line in each panel marks the threshold temperatures of 86°F and 68°F for each case. By the end of August, the number of hot days and heat waves was 38 and 9, respectively; for reference, the annual means are 43.7 days and 9 heat waves, respectively, for the period 1951-2022. Similarly, by the end of August, the number of warm nights and warm spells was 26 and 6, respectively; for reference, the annual means are 21.8 days and 4.7 warm spells, respectively, for the same 1951-2022 period. Linear trends obtained from the same period indicate increasing trends of 18.4 hot days/century, 2.3 heat waves/century, 31.7 warm nights/century, and 5.6 warm spells/century. Humans, animals, and plants are sensitive to extreme heat. Crops without irrigation and populations without air conditioning, especially pregnant women, children, the elderly, and the sick, are very vulnerable to heat waves and warm spells. The threshold temperatures are an attempt to track the extreme heat for crops and humans (e.g., Tschurr et al. 2020, Barriopedro et al. 2023). For reference, in July, the climatological (1991-2020) monthly maximum and minimum temperatures reach maximum values of 86.9°F and 66.5°F, respectively; the 90th-percentile values for the period 1951-2022 of the daily maximum and minimum temperatures are 86.9°F and 66.1°F, respectively.





## 7. 1895-2023 August Trends

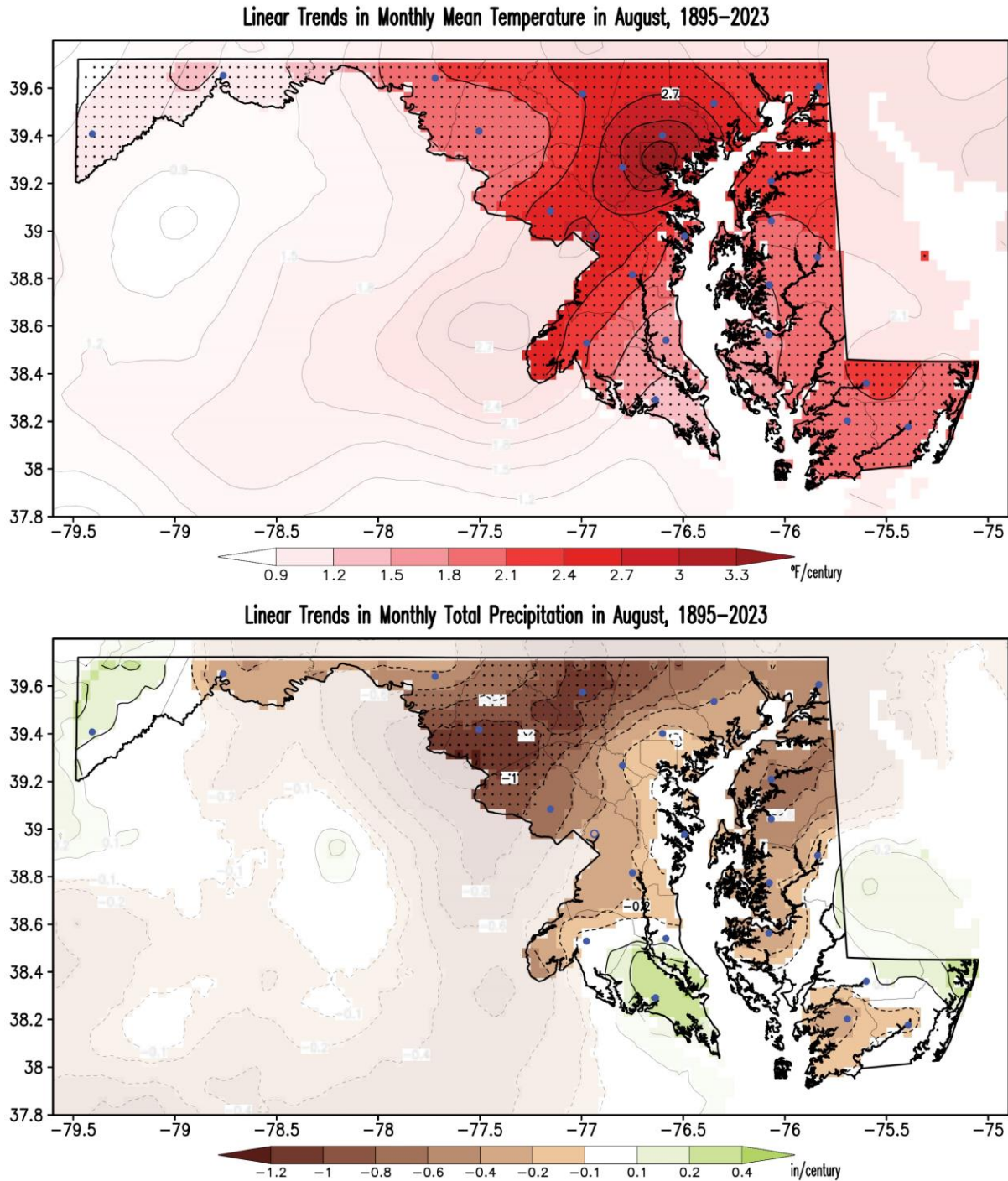
### A. Statewide Mean Temperature, Cooling Degree-Days, and Precipitation



**Figure 10.** Maryland (statewide) mean surface air temperature, cooling degree-days, and precipitation in August for the period 1895-2023. Temperature is in °F, cooling 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 (73.7°F, 278.88°FDD, and 4.34 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (2.0°F, 60.73°FDD, and 2.00 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 cool 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 (2.1°F/century), and the increasing cooling degree-days trend (70.13°FDD/century) are statistically significant at the 95% level (*Student's t-test* –Santer et al. 2000) but not the precipitation drying trend (–0.32 in/century).



B. Temperature and Precipitation Maps



**Figure 11.** Linear trends in surface air mean temperature and precipitation in August 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. Brown/green shading in the precipitation map shows drying/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. August 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	75.3	95	Statewide	2.95	32
Climate Division 1	77.5	110	Climate Division 1	2.32	19
Climate Division 2	76.8	98	Climate Division 2	2.58	28
Climate Division 3	76.9	90	Climate Division 3	2.90	34
Climate Division 4	76.7	94	Climate Division 4	3.49	54
Climate Division 5	76.2	91	Climate Division 5	2.75	32
Climate Division 6	74.7	97	Climate Division 6	2.90	37
Climate Division 7	72.8	80	Climate Division 7	3.19	62
Climate Division 8	67.5	91	Climate Division 8	4.28	79
Allegany	72.0	80	Allegany	2.91	52
Anne Arundel	77.2	99	Anne Arundel	3.48	55
Baltimore	75.1	99	Baltimore	2.59	30
Baltimore City	77.3	105	Baltimore City	2.89	39
Calvert	76.5	88	Calvert	2.93	40
Caroline	76.0	91	Caroline	2.59	35
Carroll	73.3	92	Carroll	2.98	43
Cecil	75.7	97	Cecil	2.55	25
Charles	76.9	89	Charles	3.01	39
Dorchester	77.4	106	Dorchester	2.49	26
Fredrick	73.9	92	Fredrick	3.39	59
Garrett	67.5	91	Garrett	4.27	79
Harford	75.3	95	Harford	2.42	24
Howard	74.6	96	Howard	3.21	48
Kent	76.4	93	Kent	2.64	31
Montgomery	75.0	94	Montgomery	3.06	44
Prince George's	76.3	91	Prince George's	3.55	57
Queen Anne's	76.2	89	Queen Anne's	2.86	35
Saint Mary's	77.0	89	Saint Mary's	2.74	36
Somerset	78.1	110	Somerset	2.44	23
Talbot	76.9	91	Talbot	2.89	39
Washington	73.6	86	Washington	3.45	64
Wicomico	77.2	108	Wicomico	2.24	16
Worcester	77.3	109	Worcester	2.29	19

**Table A1.** Monthly mean surface air temperature (left) and total precipitation (right) at Maryland (statewide), climate division, and county levels for August 2023. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for August 2023 occupies among the 129 Augusts 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

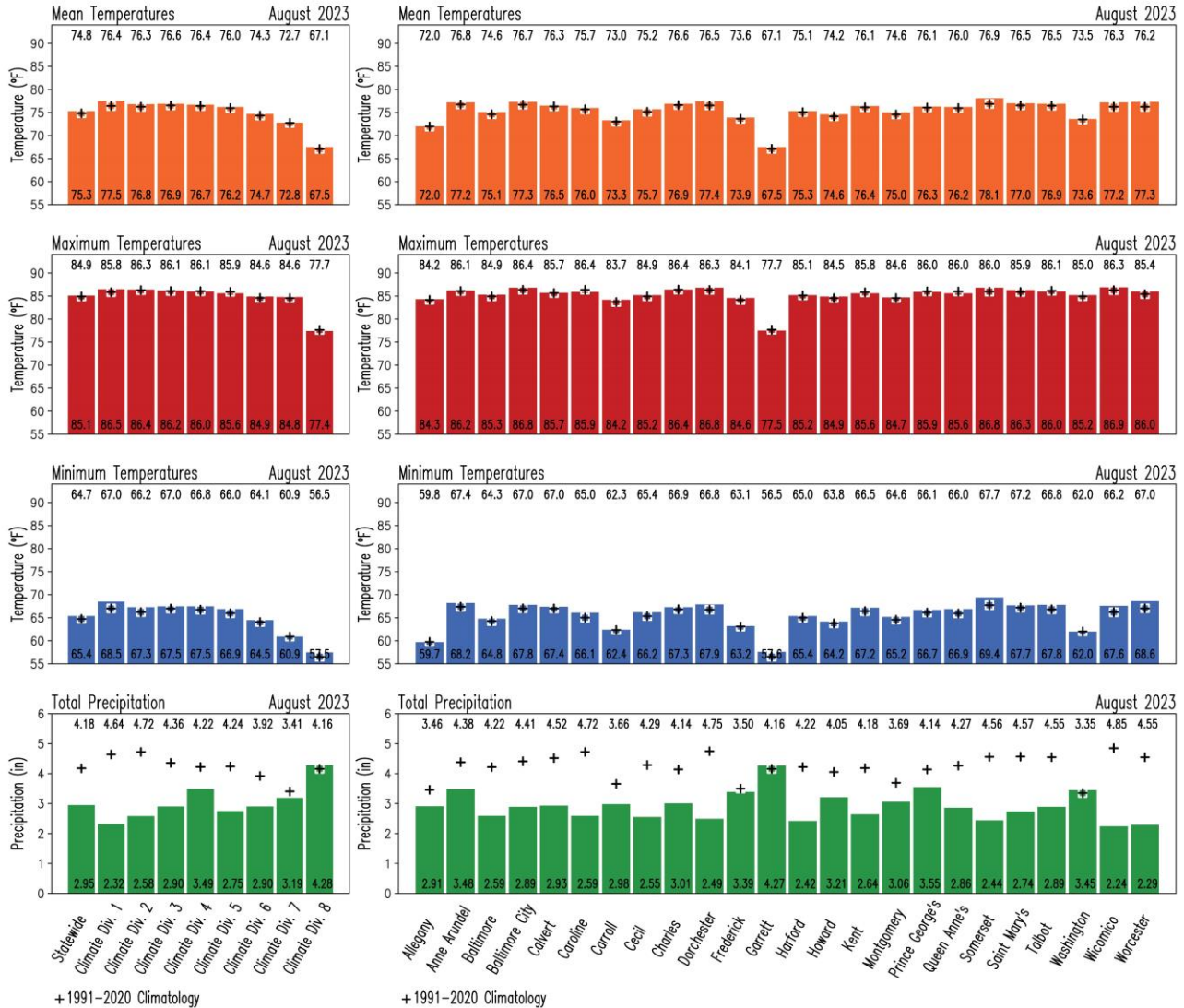
Region	Maximum Air Temperature (°F)	Rank (#)	Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	85.1	85	Statewide	65.4	99
Climate Division 1	86.5	102	Climate Division 1	68.5	113
Climate Division 2	86.4	88	Climate Division 2	67.3	104
Climate Division 3	86.2	81	Climate Division 3	67.5	104
Climate Division 4	86.0	82	Climate Division 4	67.5	106
Climate Division 5	85.6	79	Climate Division 5	66.9	103
Climate Division 6	84.9	88	Climate Division 6	64.5	98
Climate Division 7	84.8	84	Climate Division 7	60.9	85
Climate Division 8	77.4	59	Climate Division 8	57.5	100
Allegany	84.3	78	Allegany	59.7	83
Anne Arundel	86.2	84	Anne Arundel	68.2	107
Baltimore	85.3	89	Baltimore	64.8	105
Baltimore City	86.8	98	Baltimore City	67.8	108
Calvert	85.7	81	Calvert	67.4	101
Caroline	85.9	79	Caroline	66.1	103
Carroll	84.2	87	Carroll	62.4	90
Cecil	85.2	92	Cecil	66.2	100
Charles	86.4	81	Charles	67.3	105
Dorchester	86.8	97	Dorchester	67.9	105
Fredrick	84.6	90	Fredrick	63.2	86
Garrett	77.5	59	Garrett	57.6	100
Harford	85.2	85	Harford	65.4	96
Howard	84.9	88	Howard	64.2	100
Kent	85.6	80	Kent	67.2	102
Montgomery	84.7	88	Montgomery	65.2	102
Prince George's	85.9	80	Prince George's	66.7	105
Queen Anne's	85.6	79	Queen Anne's	66.9	102
Saint Mary's	86.3	87	Saint Mary's	67.7	98
Somerset	86.8	100	Somerset	69.4	113
Talbot	86.0	81	Talbot	67.8	101
Washington	85.2	85	Washington	62.0	87
Wicomico	86.9	101	Wicomico	67.6	110
Worcester	86.0	102	Worcester	68.6	111

**Table A2.** Monthly maximum (left) and minimum (right) surface air temperatures at Maryland (statewide), climate division, and county levels for August 2023. Temperatures are in °F. The rank is the order that the variable for August 2023 occupies among the 129 Augusts 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. August 2023 Bar Graphs: Statewide, Climate Divisions, and Counties

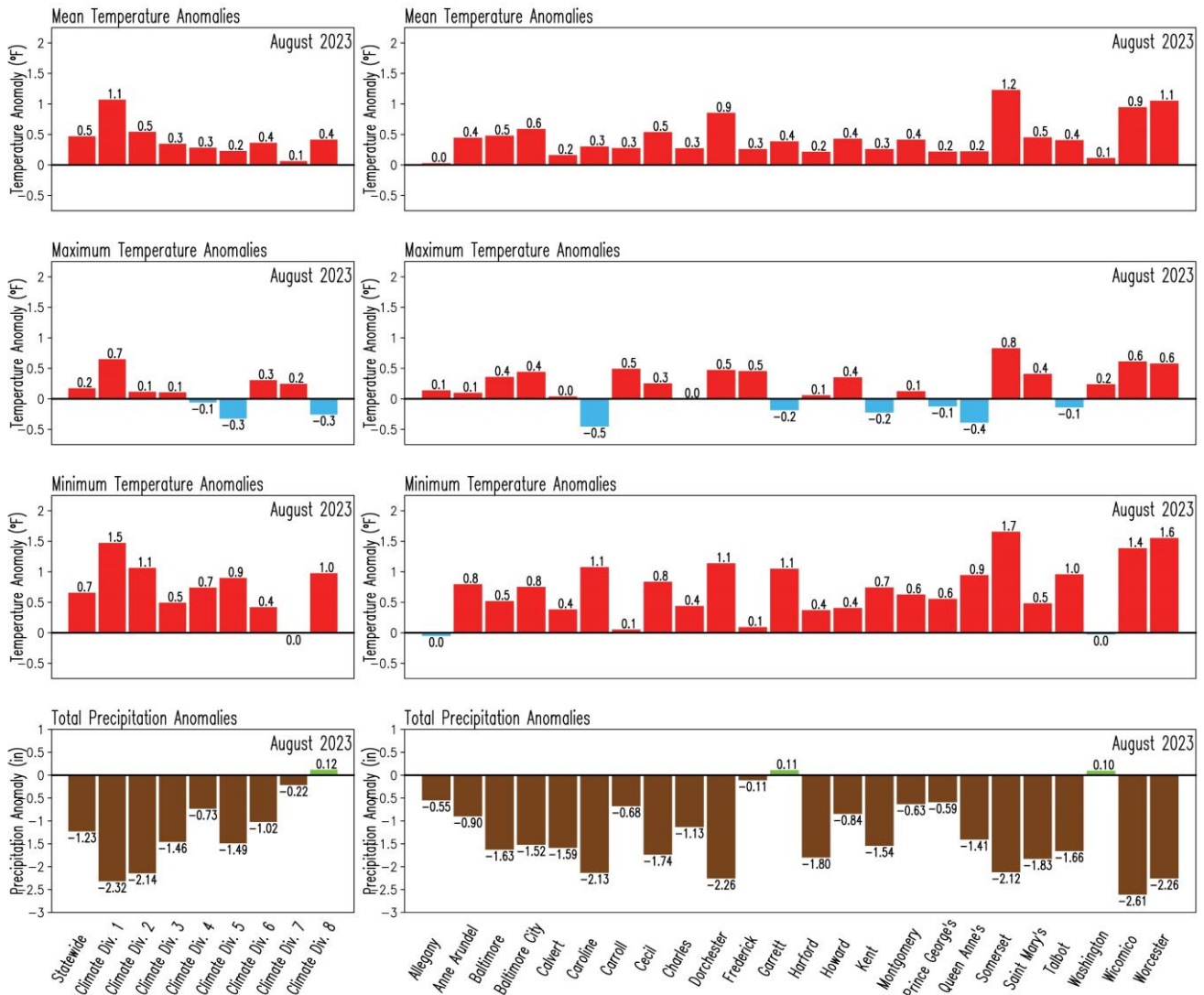
### A. Temperatures and Precipitation



**Figure B1.** Monthly surface variables in Maryland for August 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 August 2023. For comparison, the corresponding 1991-2020 climatological values for August are displayed as black addition signs, and their magnitude are shown at the top of the panels.



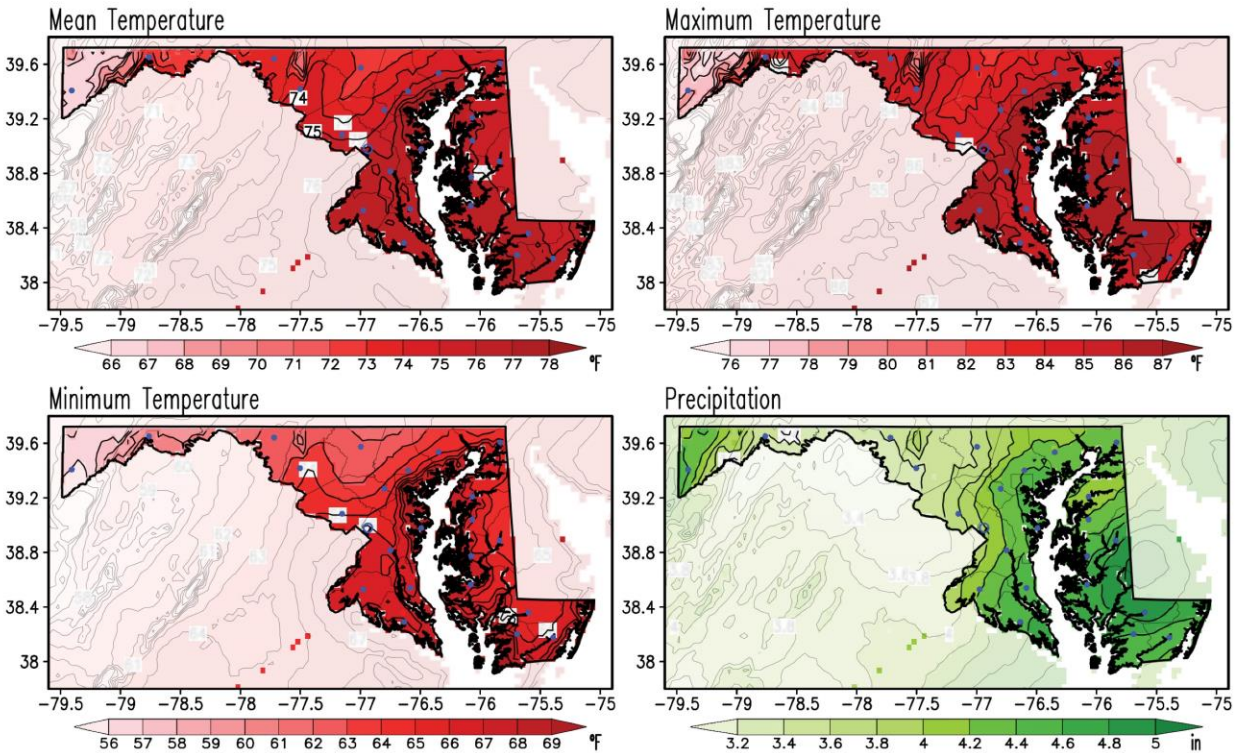
B. Temperatures and Precipitation Anomalies



**Figure B2.** Anomalies of the monthly surface variables in Maryland for August 2023. Anomalies are with respect to the 1991-2020 climatology. Red/blue color represents positive/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/brown color indicates positive/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 August 2023.



## Appendix C. August 1991-2020 Climatology Maps

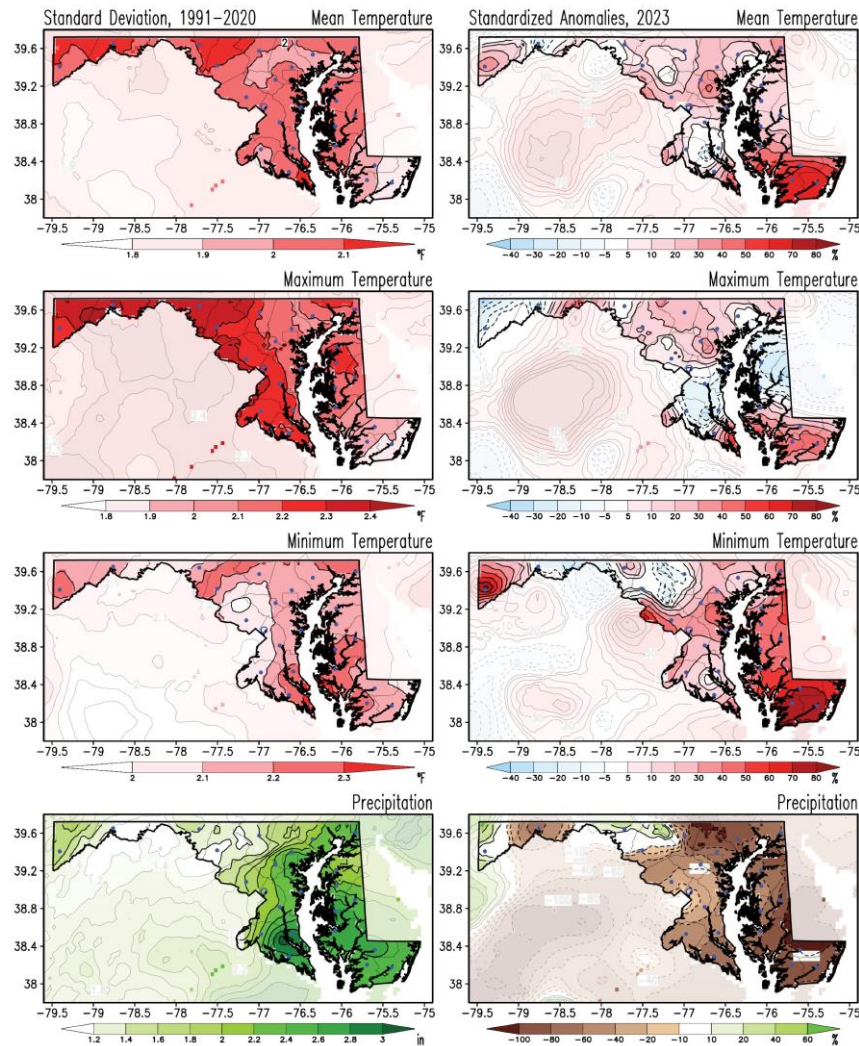


**Figure C1.** August climatology of the monthly mean, maximum and minimum surface air temperatures, and total precipitation for the period 1991-2020. Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the August 2023 conditions are compared to obtain the August 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. August Standard Deviation and August 2023 Standardized Anomalies Maps



**Figure D1.** Standard deviation for August and standardized anomalies of temperatures and precipitation for August 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 August 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. Blue/red shading in the anomaly temperature maps marks colder/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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