MDSCO-2023-07

Maryland Climate Bulletin
July 2023

Prepared by
Dr. Alfredo Ruiz-Barradas
Maryland State Climatologist

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

DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE
Sumant Nigam, Chair

Maryland State Climatologist Office

Summary

Statewide averages show that July 2023 was warmer and wetter than normal (i.e., 1991-2020 averages). Monthly mean temperatures were in the 69 to 82°F range; maximum temperatures were between 78 to 91°F, and minimum temperatures were in the 60 to 74°F range. Monthly total precipitation was between 2.5 to 8 inches.

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

- Mean temperature was warmer than normal everywhere, notably in the southern portions of Charles, Saint Mary's, Calvert, and Dorchester counties (above 2.4°F), parts of Anne Arundel, Howard, Baltimore, Harford, Cecil, Kent, Queen Anne's, Talbot, Dorchester, Somerset, Wicomico, and Worcester counties (around 2.2°F), and Garrett County (1.8°F).

- Maximum temperature was also warmer than normal everywhere, especially over parts of Carroll, Frederick, Montgomery, Prince George's, Anne Arundel, Baltimore, Saint Mary's, Calvert, Caroline, Dorchester, Wicomico, Somerset, and Worcester counties (above 2.0°F).

- Minimum temperature was warmer than normal everywhere, notably in portions of Garrett, Cecil, Kent, Queen's Anne, Dorchester, Calvert, and Saint Mary's counties (above 2.8°F), and over parts of Charles, Anne Arundel, Howard, Baltimore, Harford, Kent, Queen Anne's, and Talbot counties (around 2.2°F).

- Precipitation was below normal in the western counties, especially over Garrett, Allegany, Washington, and Frederick counties, and the southern tips of Charles, Saint Mary's, and Calvert counties (above 0.6 inches). Precipitation was above normal in the rest of the state, especially over Cecil, Kent, and Queen Anne's counties (around 3in).

- The extent of the surface in the state under drought conditions decreased from around 93% at the end of June to around 43% at the end of July due to the above-normal precipitation in the counties of the coastal plains. Severe drought conditions occupy around 12% of the state over Frederick, Carroll, Montgomery, Howard, and small portions of Prince George's and Anne Arundel counties; moderate drought conditions now occupy around 15% of the state around the north-central counties affected by the severe drought; and around 15% of the state is under abnormally dry conditions, especially over Garret and portions of Washington, Baltimore, Prince George's, Anne Arundel, and Charles counties.

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

- All eight climate divisions were warmer than normal in July. However, the western and mountainous climate divisions 7 and 8 were drier than normal, while the rest were wetter. The warm anomalies in climate divisions 7 and 8 were smaller than the others.
- Statewide temperature and precipitation anomalies changed their sign after two consecutive months under cold and dry anomalies. While dry and cold anomalies were present in May (−2.19 in, −2.4°F) and June (−1.04 in, −2.7°F), wet and warm anomalies appeared in July (0.59 in, 1.8°F).

Historical Context (Figure 8, Tables A1 and A2)

- Mean, maximum, and minimum statewide temperatures in July (78.5, 88.5, and 68.5°F) were above the long-term (1895-2022) average and within 25% of the warmest Julys; in fact, the mean and minimum temperatures were within 10% (78.2 and 67.8ºF, respectively) of the highest values but short of their records set in 2020. July's precipitation (4.99 in) was above the long-term average but still far from any record.
- Mean temperatures in fifteen counties ranked among the ten warmest Julys (e.g., Somerset −4th and Wicomico −5th). While maximum temperatures ranked in the top ten warmest Julys only in four counties (Somerset, Worcester −7th, Wicomico −8th, Dorchester −9th), minimum temperatures, on the other hand, ranked in the ten warmest Julys in seventeen counties (e.g., Saint Mary's, Cecil −3rd, Talbot, Dorchester −4th, Calbert, Caroline −5th).

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

- Statewide temperature and cooling degree days in July showed significant trends: a warming trend (1.8°F/century), and an increasing trend (62.55°FDD/century), respectively. Statewide precipitation had no significant increasing trend (0.07 in/century).
- Regionally, July mean temperatures showed significant warming trends from Washington County to the rest of the state to the east and south. Notably, the largest trend is in Baltimore City (3.0°F/century), as it has been in April, May, and June. Trends above 2.0°F/century are also evident in the counties of the Piedmont, the Upper Coastal Plain, and the Lower Coastal Plain Provinces.
- Regionally, July precipitation has a small region of significant wet trends over northern Cecil County (~0.8 in/century). The largest no significant wet trends (0.4−0.5 in/century) are over Harford, Cecil, Howard, Baltimore, Carroll, and Prince George's counties. In contrast, the largest no significant drying trends (around 0.4 in/century) are over Washington, Talbot, and Caroline counties.

Contents

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 July 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, cooling 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 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 8/11/2023.

- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20230804) at:
  https://www.ncei.noaa.gov/pub/data/cirs/climdiv/
  Data was downloaded on 8/11/2023.

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., July 2023) are the departures of the monthly value from the corresponding month's 30-year average (i.e., from the average of 30 Julys) 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. July 2023 Maps

A. Mean Temperatures

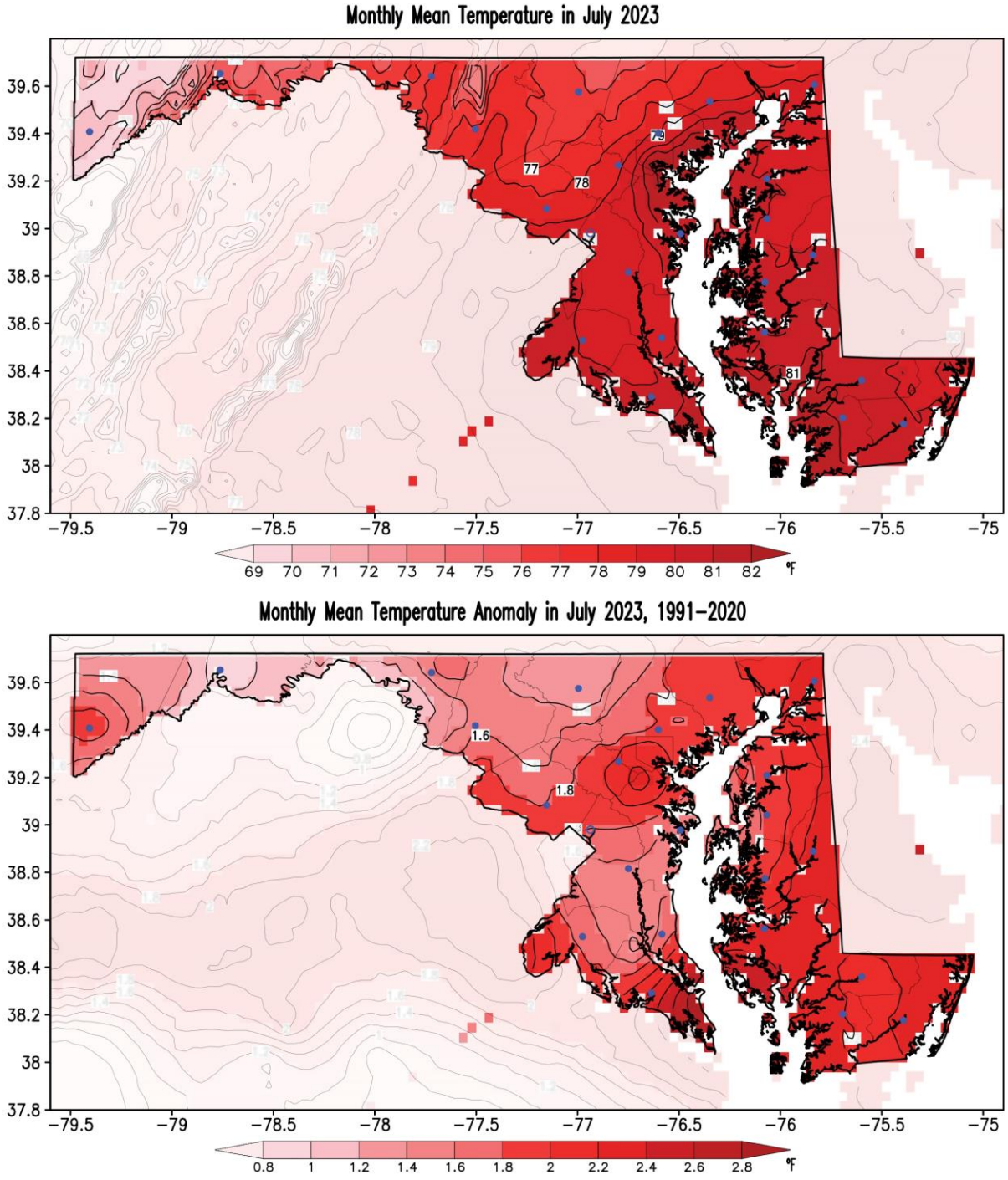

Figure 1. Monthly mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for July 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been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

B. Maximum Temperatures

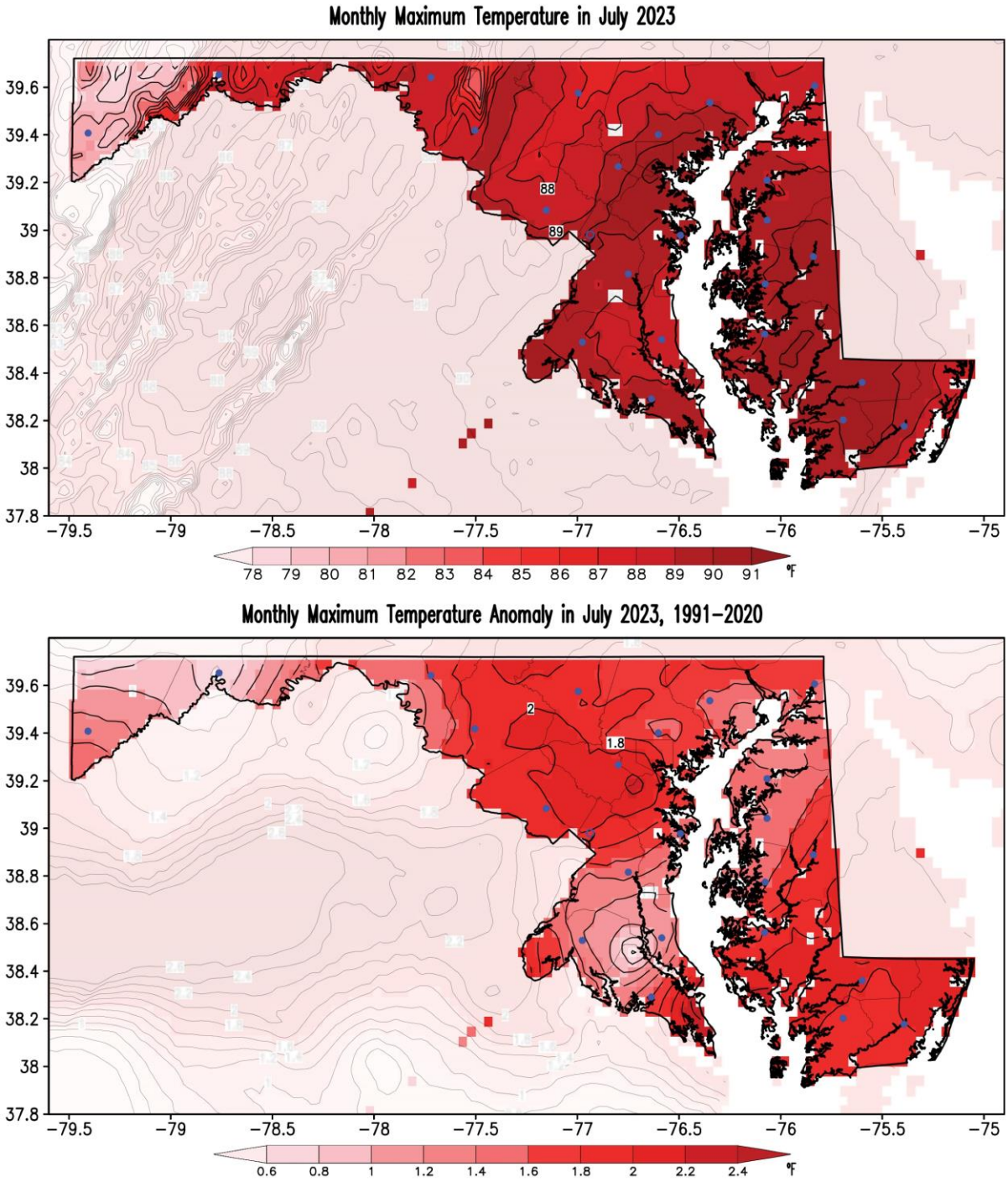

Figure 2. Monthly maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for July 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has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

C. Minimum Temperatures

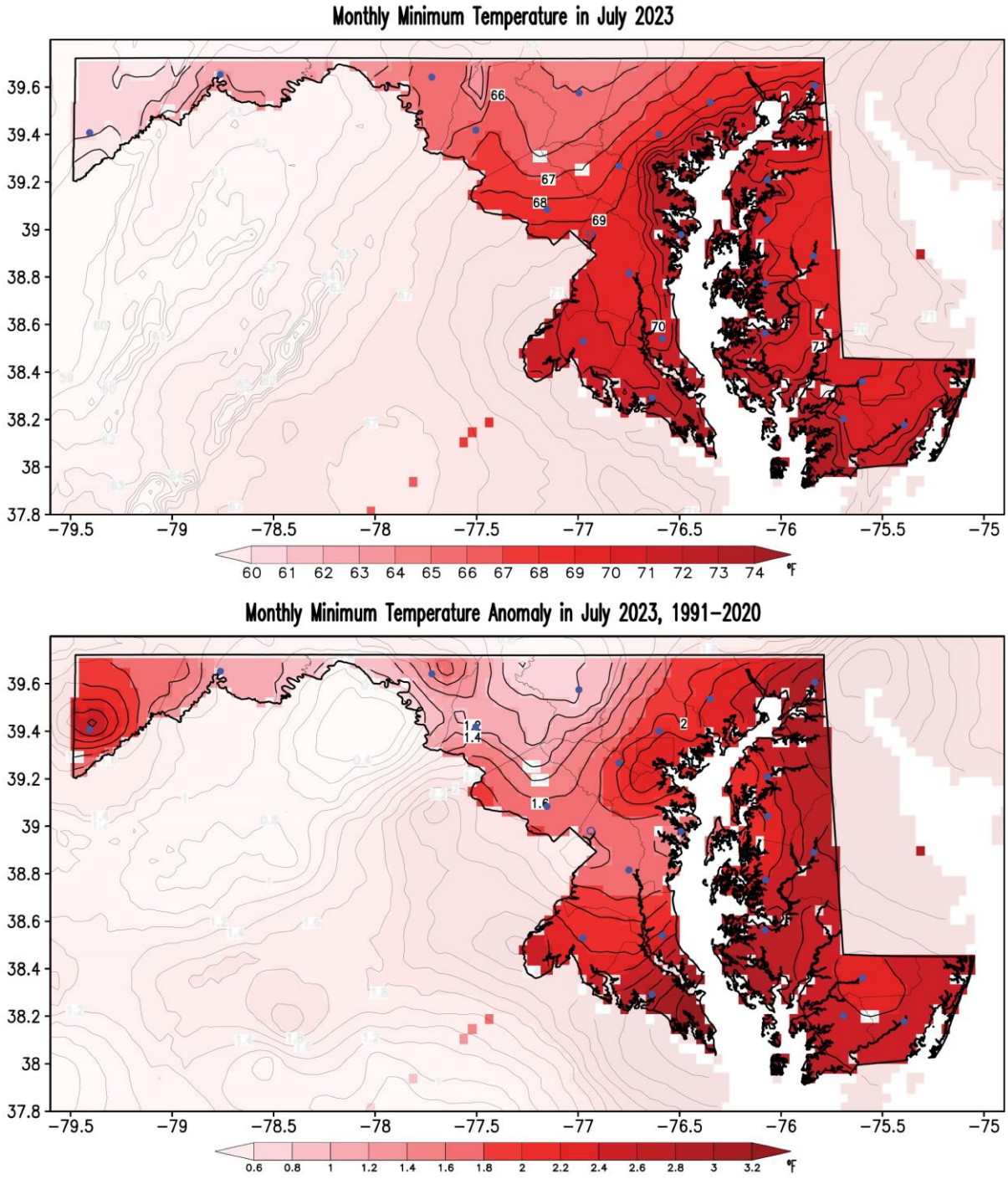

Figure 3. Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for July 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has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

D. Precipitation

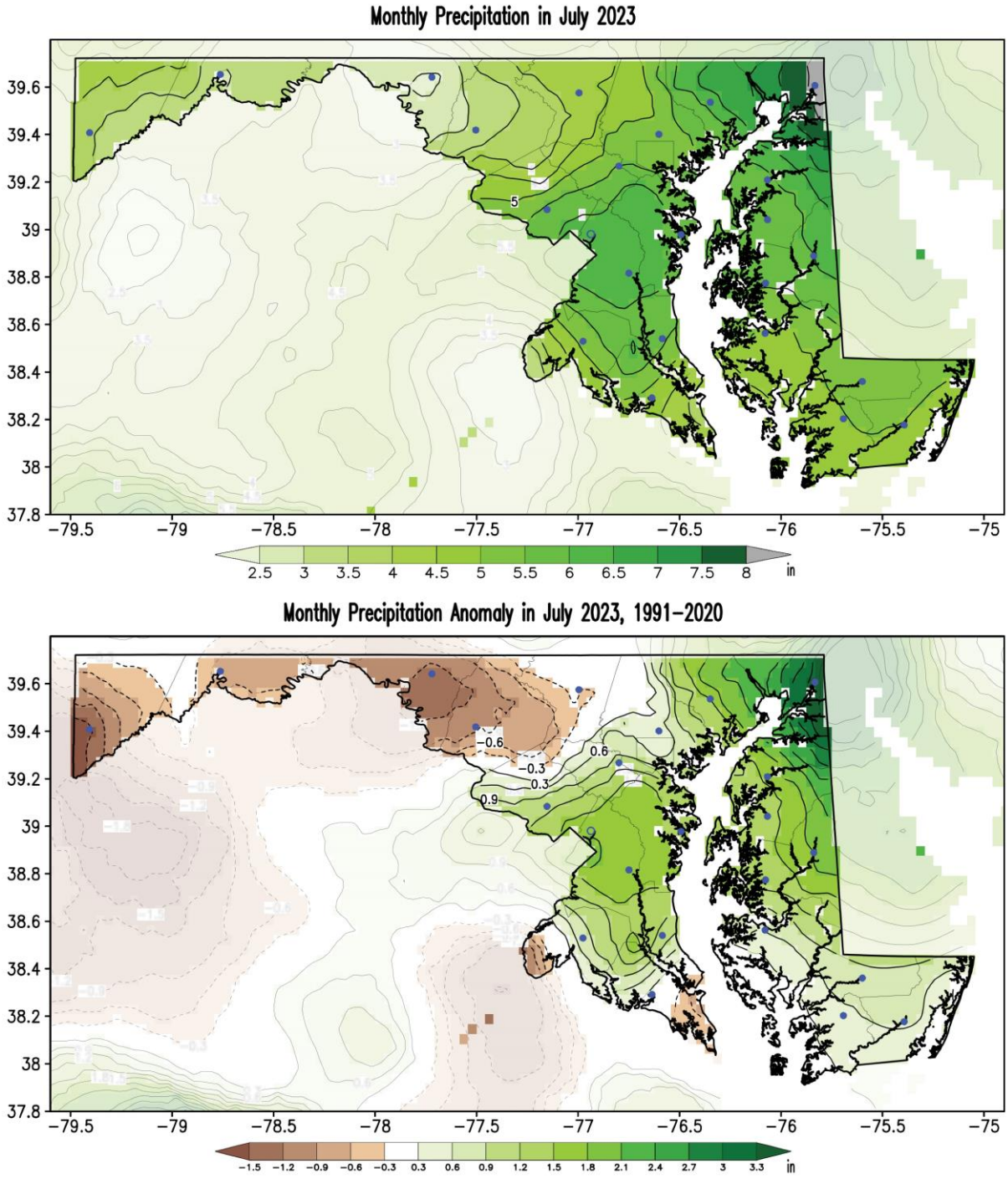

Figure 4. Monthly total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for July 2023. Precipitation is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. Note shading outside the state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

E. Drought

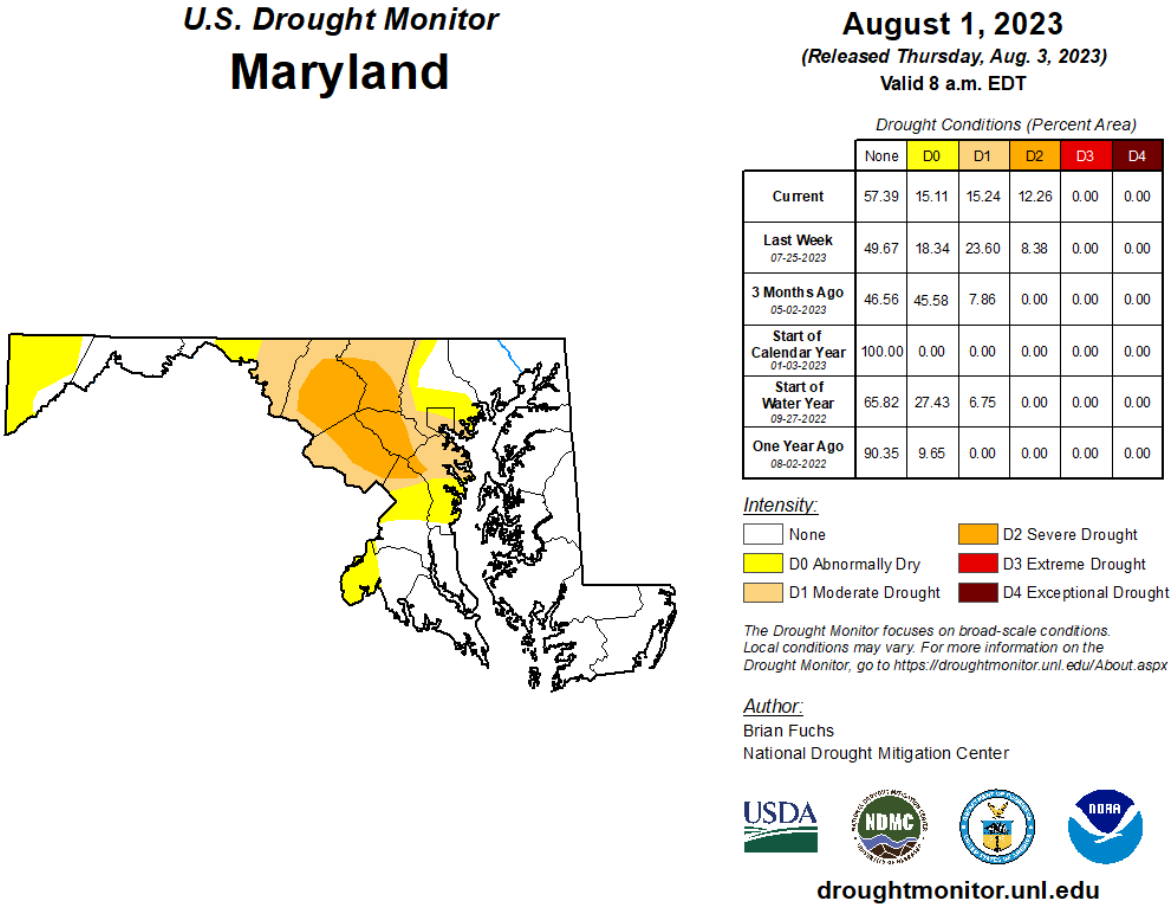

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on August 1, 2023. Yellow shading indicates regions that are abnormally dry, regions with light orange shading shows regions that are under a moderate drought, and regions with darker orange are regions under severe drought according to the inset of drought intensity. 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, 42.61% of the state was under some drought category.

4. July and MJJ 2023 Climate Divisions Averages

A. July 2023 Scatter Plots

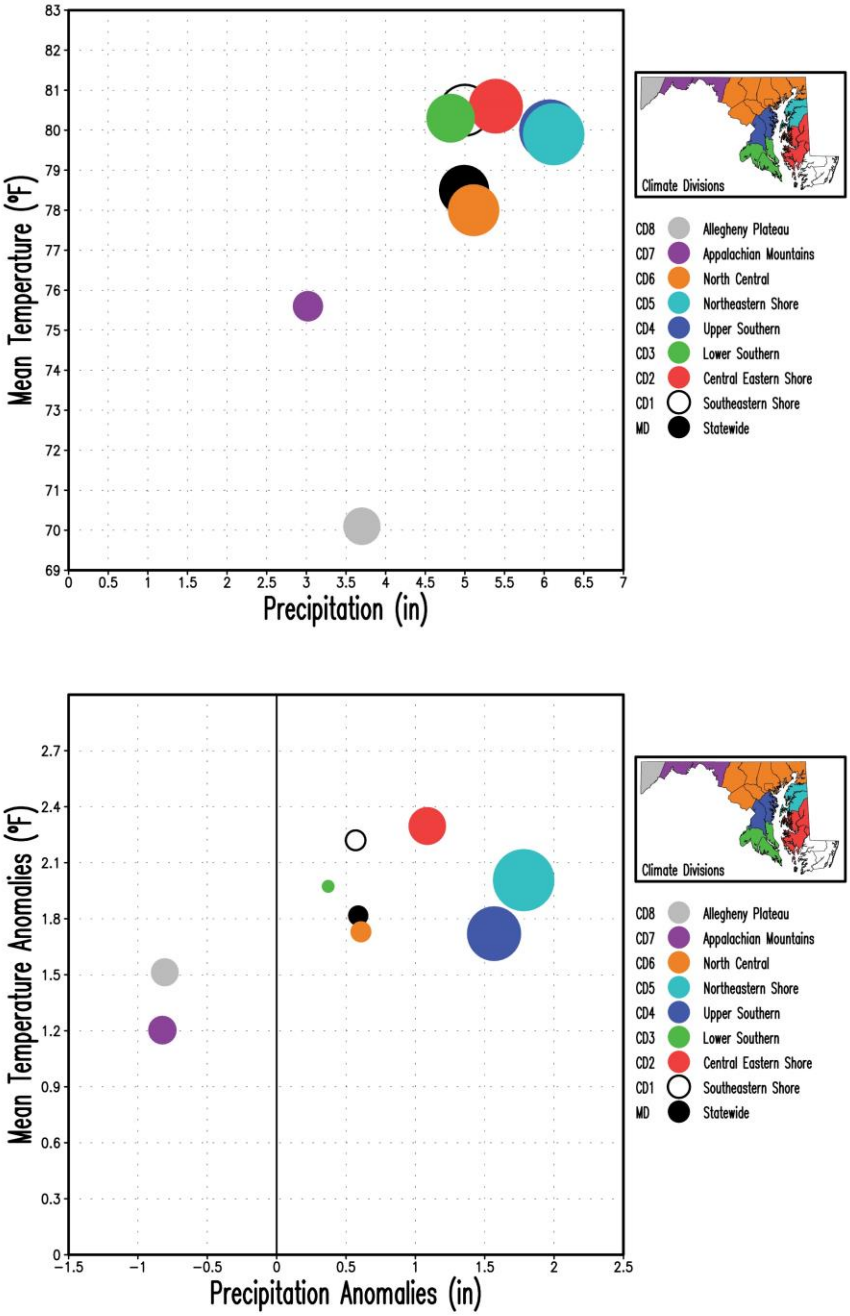

Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for July 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. 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 (6.12 inches in CD5, top panel) and by the maximum precipitation anomaly (1.78 inches in CD5, 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. May-July 2023 Scatter Plots

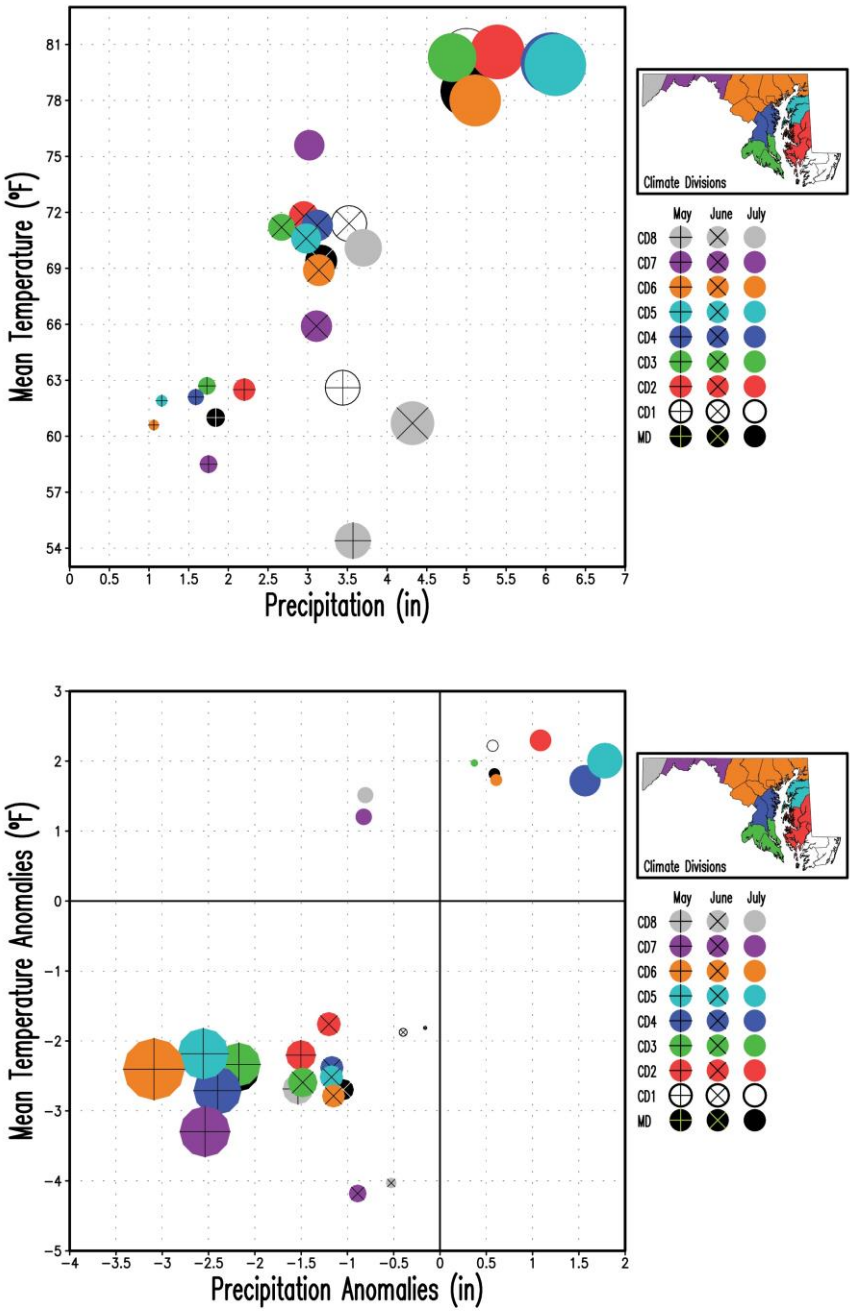

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for May, June, and July 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 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 (6.12 inches in CD5 in July, top panel) and by the maximum precipitation anomaly (|-3.09| inches in CD6 in May, bottom panel) among the nine regions and three months. July is displayed with filled circles only, while June and May are displayed with superposed multiplication and addition signs, respectively.

5. July 2023 Statewide Averages in the Historical Record

A. Box and Whisker Plots

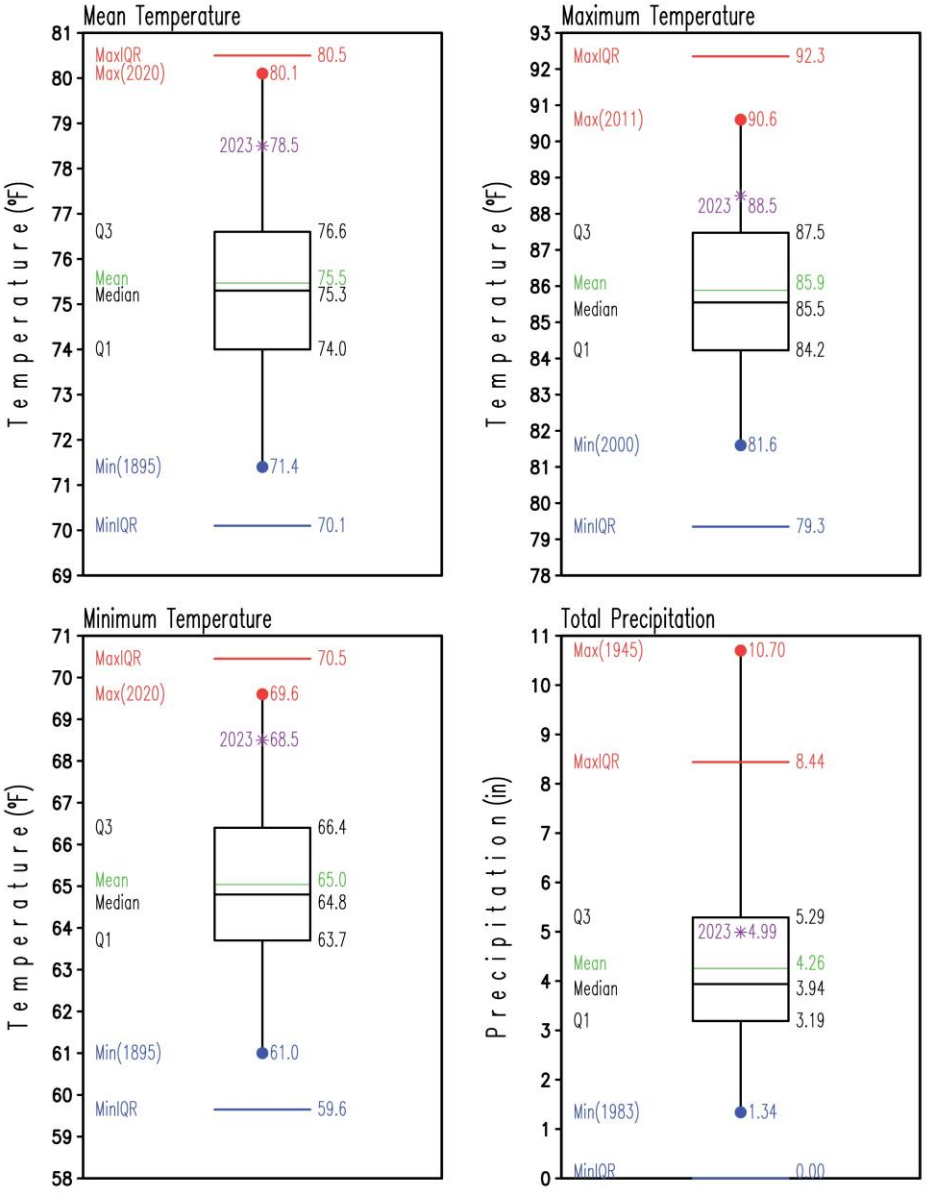

Figure 8. Box and Whisker plots of Maryland (statewide) monthly mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and total precipitation (lower right) for July for the period 1895-2022. The label and asterisk in purple represent conditions for July 2023. Statistics 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×(Q3-Q1) and Q3+1.5×(Q3-Q1), respectively.

6. 1895-2023 July Trends

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

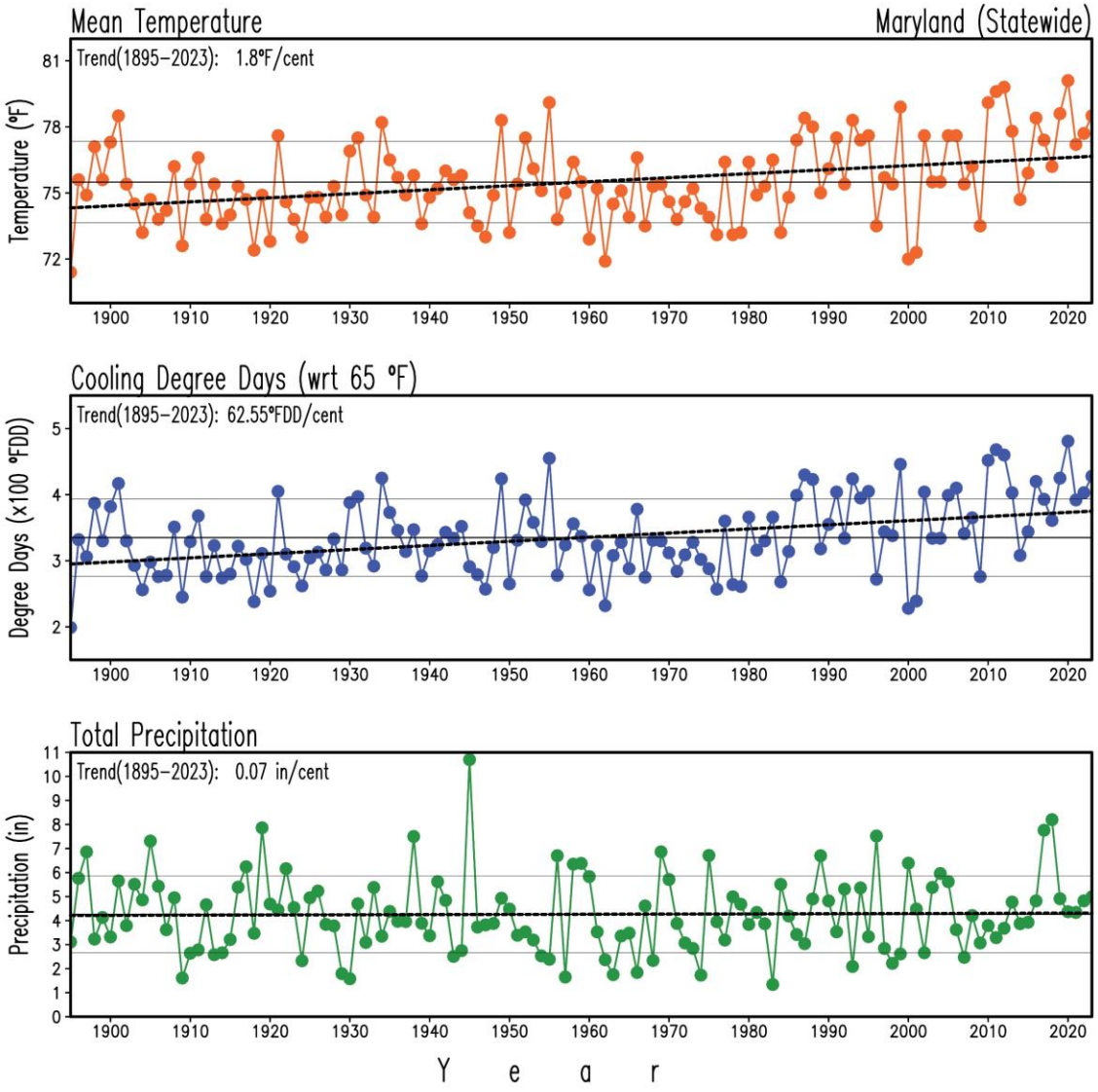

Figure 9. Maryland (statewide) mean surface air temperature, cooling degree-days, and precipitation in July for the period 1895-2023. Temperature is in °F, cooling degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (75.5°F, 335.02°FDD, and 4.26 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (1.9°F, 58.32°FDD, and 1.60 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 (1.8°F/century), and the increasing cooling degree-days trend (62.55°FDD/century) are statistically significant at the 95% level (*Student's t-test* –Santer et al. 2000) but not the small precipitation trend (0.07 in/century).

B. Temperature and Precipitation Maps

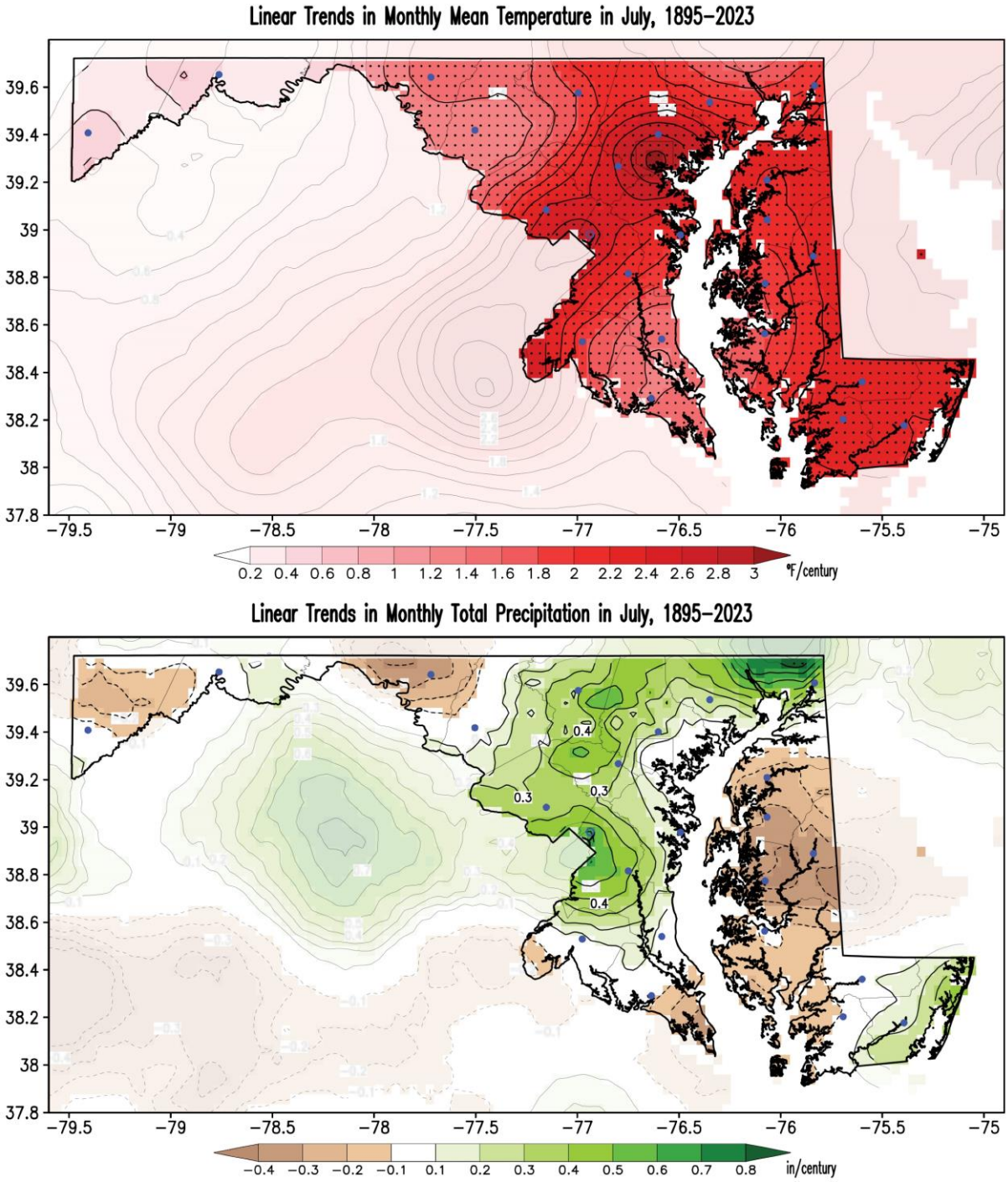

Figure 10. Linear trends in surface air mean temperature and precipitation in July for the period 1895-2023. Temperatures are in °F/century, and precipitation is in inches/century following the color bars. Red shading in the temperature map marks warming trends. Brown/green shading in the precipitation 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. July 2023 Data Tables: Statewide, Climate Divisions, and Counties

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)
Statewide	78.5	121
Climate Division 1	80.5	125
Climate Division 2	80.6	124
Climate Division 3	80.3	122
Climate Division 4	80.0	120
Climate Division 5	79.9	123
Climate Division 6	78.0	119
Climate Division 7	75.6	107
Climate Division 8	70.1	106
Allegany	74.6	103
Anne Arundel	80.4	121
Baltimore	78.4	122
Baltimore City	80.8	123
Calvert	79.9	119
Caroline	80.1	124
Carroll	76.5	111
Cecil	79.1	123
Charles	80.3	122
Dorchester	80.9	124
Fredrick	77.0	112
Garrett	70.1	105
Harford	78.9	123
Howard	78.1	123
Kent	80.0	123
Montgomery	78.3	119
Prince George's	79.6	118
Queen Anne's	79.9	123
Saint Mary's	80.6	124
Somerset	81.1	126
Talbot	80.5	123
Washington	76.6	107
Wicomico	80.5	125
Worcester	80.1	124

Region	Total Precipitation (in)	Rank (#)
Statewide	4.99	95
Climate Division 1	5.00	88
Climate Division 2	5.39	99
Climate Division 3	4.82	83
Climate Division 4	6.07	108
Climate Division 5	6.12	104
Climate Division 6	5.11	94
Climate Division 7	3.02	43
Climate Division 8	3.70	44
Allegany	3.30	54
Anne Arundel	6.04	103
Baltimore	5.17	94
Baltimore City	5.22	90
Calvert	5.36	93
Caroline	5.96	105
Carroll	4.25	78
Cecil	7.60	122
Charles	4.73	88
Dorchester	4.93	90
Fredrick	3.51	59
Garrett	3.70	44
Harford	6.37	106
Howard	5.15	93
Kent	6.30	109
Montgomery	5.11	96
Prince George's	6.13	108
Queen Anne's	5.98	105
Saint Mary's	4.77	78
Somerset	4.86	79
Talbot	5.52	101
Washington	2.76	39
Wicomico	5.16	92
Worcester	4.99	88

Table A1. Monthly mean surface air temperature (left) and total precipitation (right) at Maryland (statewide), climate division, and county levels for July 2023. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for July 2023 occupies among the 129 Julys 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 (#)
Statewide	88.5	112
Climate Division 1	89.8	123
Climate Division 2	90.3	120
Climate Division 3	89.4	110
Climate Division 4	89.7	115
Climate Division 5	89.4	114
Climate Division 6	88.5	113
Climate Division 7	87.5	101
Climate Division 8	80.1	82
Allegany	86.6	95
Anne Arundel	89.9	115
Baltimore	88.8	110
Baltimore City	90.5	117
Calvert	88.8	104
Caroline	90.5	118
Carroll	87.7	109
Cecil	88.4	114
Charles	89.7	108
Dorchester	90.4	121
Fredrick	88.1	115
Garrett	80.1	82
Harford	88.7	111
Howard	88.7	117
Kent	89.1	112
Montgomery	88.5	115
Prince George's	89.5	112
Queen Anne's	89.5	114
Saint Mary's	89.4	111
Somerset	90.0	123
Talbot	89.8	117
Washington	88.3	105
Wicomico	90.4	122
Worcester	89.2	123

Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	68.5	122
Climate Division 1	71.3	124
Climate Division 2	70.8	126
Climate Division 3	71.2	126
Climate Division 4	70.3	123
Climate Division 5	70.3	125
Climate Division 6	67.6	120
Climate Division 7	63.7	109
Climate Division 8	60.1	122
Allegany	62.5	108
Anne Arundel	71.0	124
Baltimore	68.0	124
Baltimore City	71.1	125
Calvert	71.0	125
Caroline	69.7	125
Carroll	65.2	109
Cecil	69.9	127
Charles	70.8	124
Dorchester	71.3	126
Fredrick	66.0	111
Garrett	60.1	122
Harford	69.0	124
Howard	67.4	118
Kent	70.8	125
Montgomery	68.0	117
Prince George's	69.6	122
Queen Anne's	70.2	125
Saint Mary's	71.7	127
Somerset	72.3	125
Talbot	71.1	126
Washington	64.9	109
Wicomico	70.5	124
Worcester	71.1	124

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

A. Temperatures and Precipitation

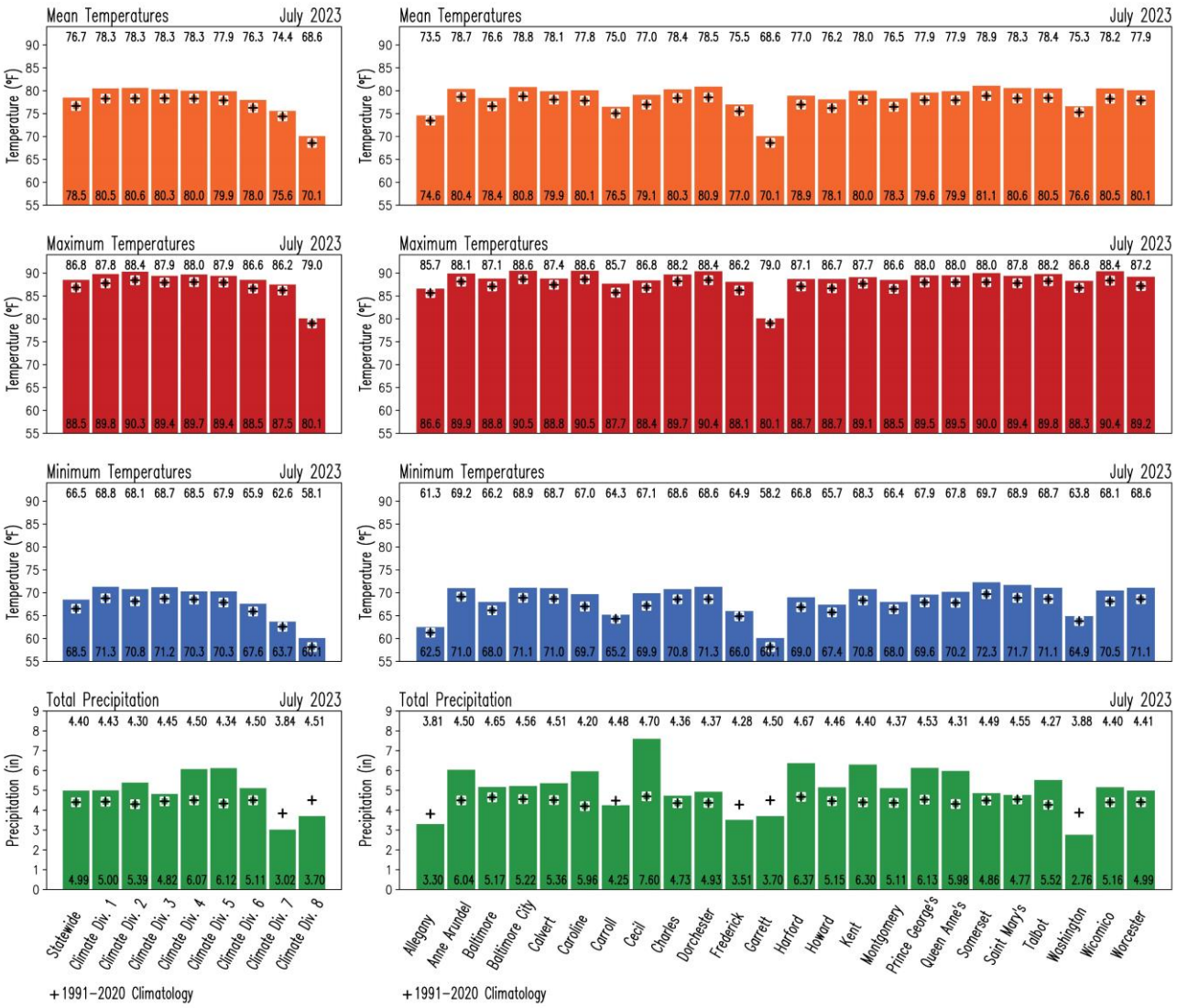

Figure B1. Monthly surface variables in Maryland for July 2023. Color bars represent the variables as follows: mean surface air temperature (orange), maximum surface air temperature (red), minimum surface air temperature (blue) and total precipitation (green) at statewide and climate division (left column), 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 July 2023. For comparison, the corresponding 1991-2020 climatological values for July are displayed as black addition signs, and their magnitude are shown at the top of the panels.

B. Temperature and Precipitation Anomalies

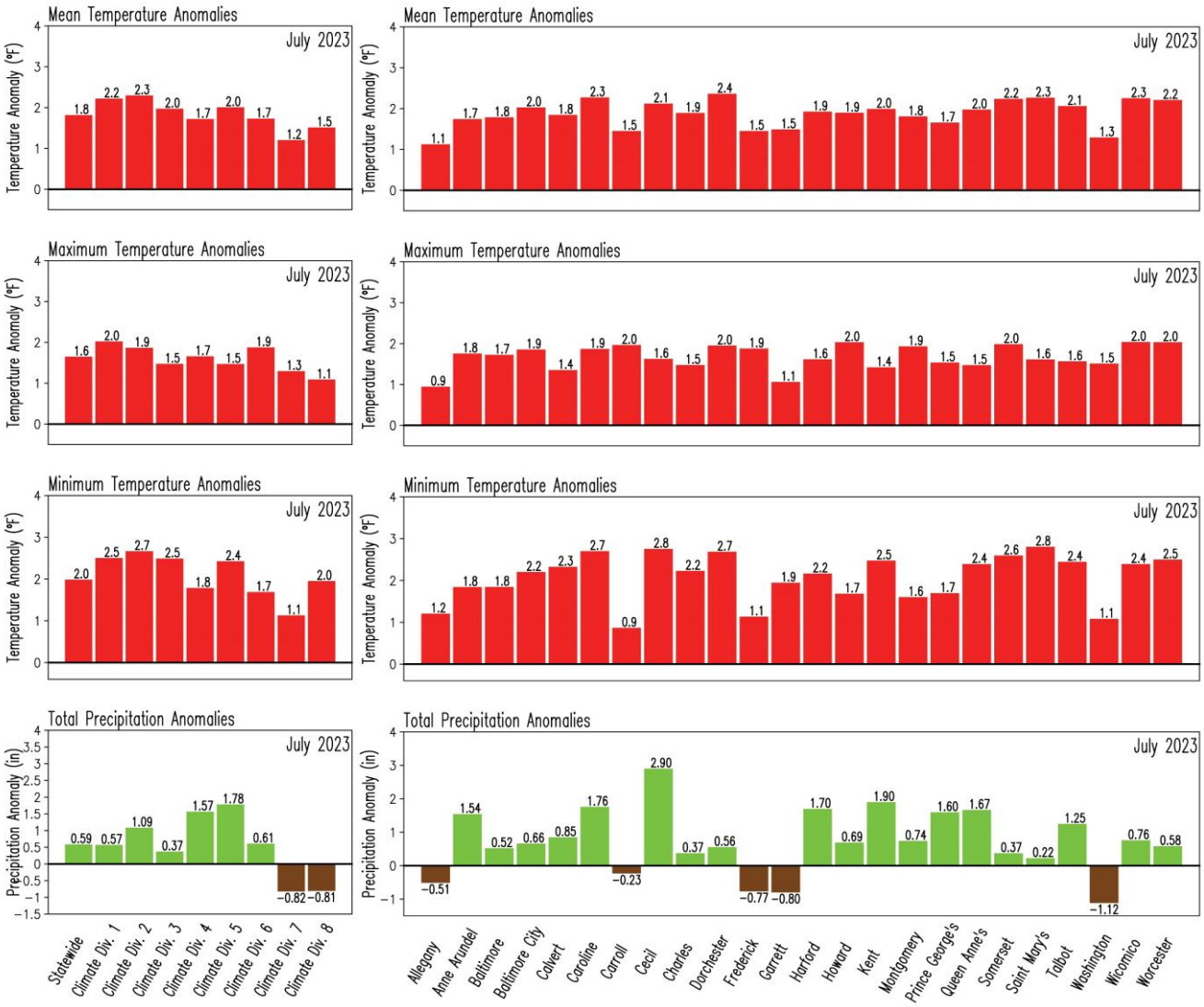

Figure B2. Anomalies of the monthly surface variables in Maryland for July 2023. Anomalies are with respect to the 1991-2020 climatology. Red color represents positive anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top), while brown/green color indicates negative/positive 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 July 2023.

Appendix C. July 1991-2020 Climatology Maps

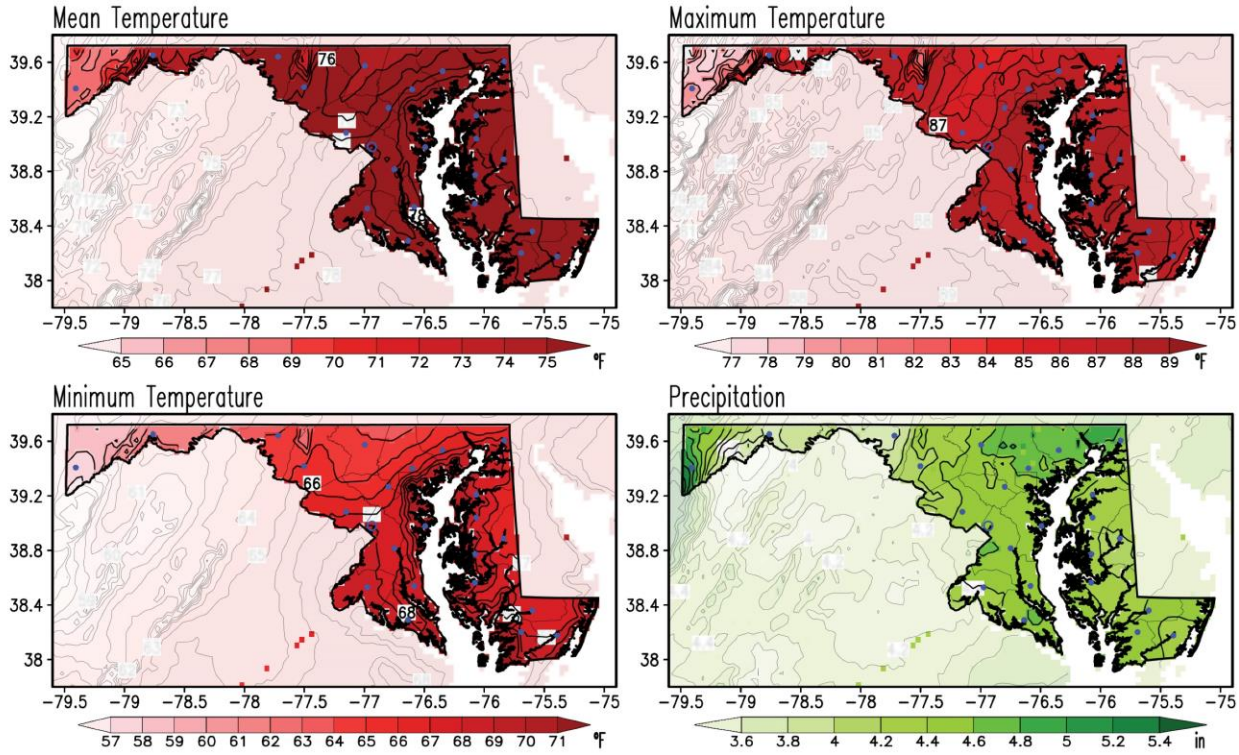

Figure C1. July climatology of the monthly mean, maximum and minimum surface air temperatures, and total precipitation for the period 1991-2020. Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the July 2023 conditions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

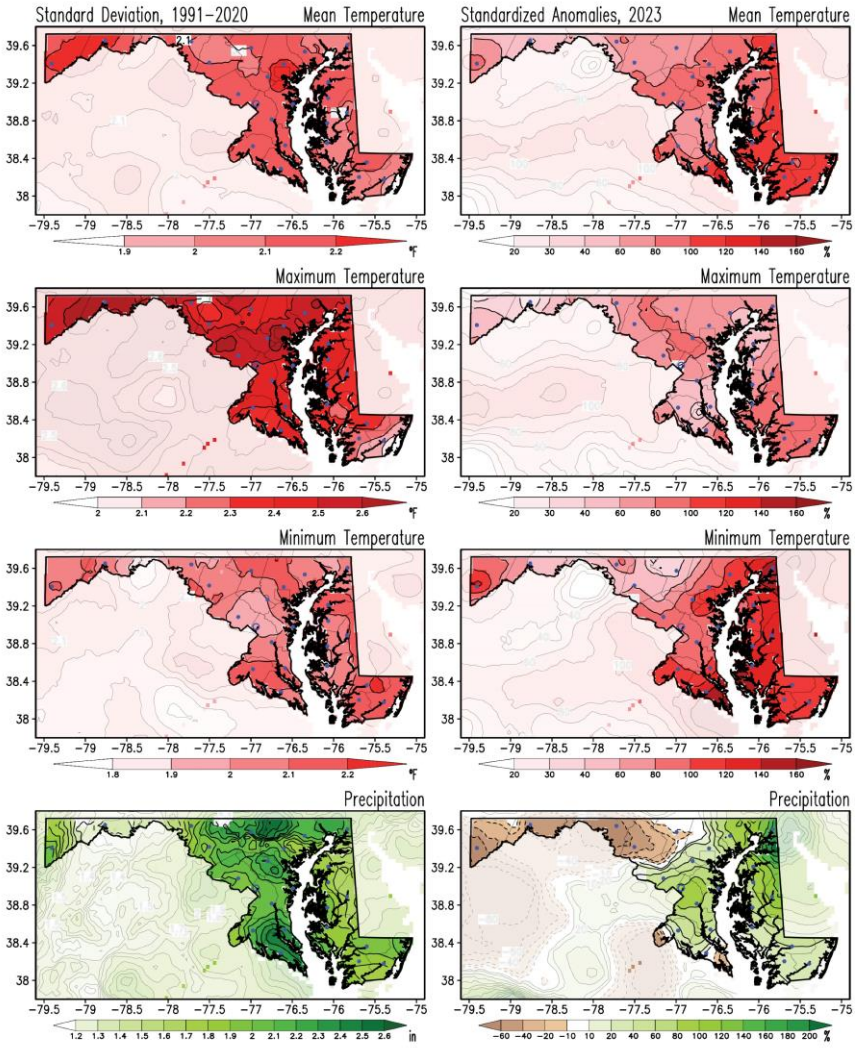

Figure D1. Standard deviation for July and standardized anomalies of temperatures and precipitation for July 2023. Standard deviations for monthly mean, maximum, and minimum surface air temperatures and total precipitation were obtained for the 1991-2020 period (left column). Anomalies for July 2023 (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*.

References

Arguez A., I. Durre, S. Applequist, R. S. Vose, M. F. Squires, X. Yin, R. R. Heim Jr, and T. W. Owen, 2012. NOAA's 1981-2010 U. S. Climate Normals. An Overview. *Bulletin of the American Meteorological Society*. 93, 1687-1697, doi:10.1175/BAMS-D-11-00197.1 https://www1.ncdc.noaa.gov/pub/data/normals/1981-2010/documentation/1981-2010-normals-overview.pdf.

CPC, 2023. Degree Days Explanation. https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/ddayexp.shtml

Kunkel, K. E., and A. Court, 1990. Climatic Means and Normals—A Statement of the American Association of State Climatologists (AASC), *Bulletin of the American Meteorological Society*, 71(2), 201-204. Retrieved Aug 20, 2022, from https://journals.ametsoc.org/view/journals/bams/71/2/1520-0477-71_2_201.xml

Santer, B. D., and co-authors, 2000: Statistical significance of trends and trend differences in layer-averaged atmospheric temperature time series. *J. Geophys. Res.*, 105, 7337–7356, doi:10.1029/1999JD901105.

Vose and co-authors, 2014. NOAA Monthly U.S. Climate Gridded Dataset (NClimGrid), Version 3. *NOAA National Centers for Environmental Information*. DOI:10.7289/V5SX6B56 .

WMO, 2017. WMO Guidelines on the Calculation of Climate Normals. WMO-No. 1203, Series. 29pp. https://library.wmo.int/doc_num.php?explnum_id=4166.