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Maryland Climate Bulletin March 2023

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DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE
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Maryland State Climatologist Office

Summary

March 2023 was warmer and much drier than normal (i.e., 1991-2020 averages). Monthly mean temperatures were in the 37 to 49°F; maximum temperatures were in the 47 to 60°F range, and minimum temperatures were between 26 to 39°F. Monthly total precipitation was in the 1.0 to 3.8 inches range.

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

- Mean temperature was warmer than normal everywhere, notably in portions of Anne Arundel, Calvert, Saint Mary's, Talbot, and Dorchester counties (above 2.4°F).

- Maximum temperature was also warmer than normal everywhere, especially over Garrett, Anne Arundel, Calvert, Saint Mary's, Talbot, and Dorchester counties (above 2.7°F).

- Minimum temperature was warmer than normal over most of the state, notably in portions of Frederick, Montgomery, Charles, Calvert, Saint Mary's, Talbot, and Dorchester counties (above 2.1°F). The region between Allegany and Washington counties was close to normal.

- Precipitation was below normal everywhere, especially over the counties around the Chesapeake Bay, by 2.4 in and more.

- Drought conditions covered around two-thirds of the state over counties of the Upper and Lower Coastal Plains and most of the counties in the Piedmont Province. While most of this region was under abnormally dry conditions, moderate drought conditions appeared over southern Prince George's, Anne Arundel, Charles, Saint Mary's, Somerset, and large portions of Dorchester, Wicomico, and Worcester counties.

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

- All eight climate divisions were warmer and drier than normal. Climate Divisions 2, 3, and 4 (Central Eastern Shore, Lower Southern, and Upper Southern) were the most affected, with warmer than normal temperatures (above 2°F) and drier than normal precipitation (above 2 in).

- Warm and dry anomalies changed notably from the previous two months. In March, statewide warm temperature anomalies (1.8°F) decreased by more than three times, and dry precipitation anomalies (–2.14 in) increased around twice as much as those seen in January and February.

Historical Context (Figure 8, Tables A1 and A2)

- March's mean, maximum, and minimum statewide temperatures (45.4, 56.0, and 34.7°F) were all above the long-term (1895-2022) average. March's precipitation (1.82 in) was below the average and below the mark of 25% of the smallest values.

- Statewide mean temperature in March 2023 was not close to the record as it was the 28th warmest, but precipitation in this month was the 11th driest among the 129 Marches in the 1895-2023 period. However, Dorchester County had the 4th driest March, while Charles, Caroline, Somerset, Wicomico, and Worcester counties had the 5th driest March on record.

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

- March statewide temperature showed a significant 1.9°F/century warming trend, and the heating degree-days a significant −60.12°F degree-days trend. On the other hand, statewide precipitation showed a non-significant trend (0.01 in/century).
- Regionally, March temperatures showed a significant warming trend everywhere except in Allegany and Garrett counties. Trends are larger than 2°F/century along Caroline, Talbot, Dorchester, Somerset, Wicomico, and Worcester counties in the southeast, and over the Montgomery−Frederick and Carroll−Howard boundaries, over Harford, Cecil, and Baltimore counties into Baltimore City, where it reaches 3°F/century.
- Regionally, there are no significant wet or drying trends in March.

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 March 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 4/11/2023.

- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20230406) at:
  https://www.ncei.noaa.gov/pub/data/cirs/climdiv/
  Data was downloaded on 4/10/2023.

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

A. Mean Temperatures

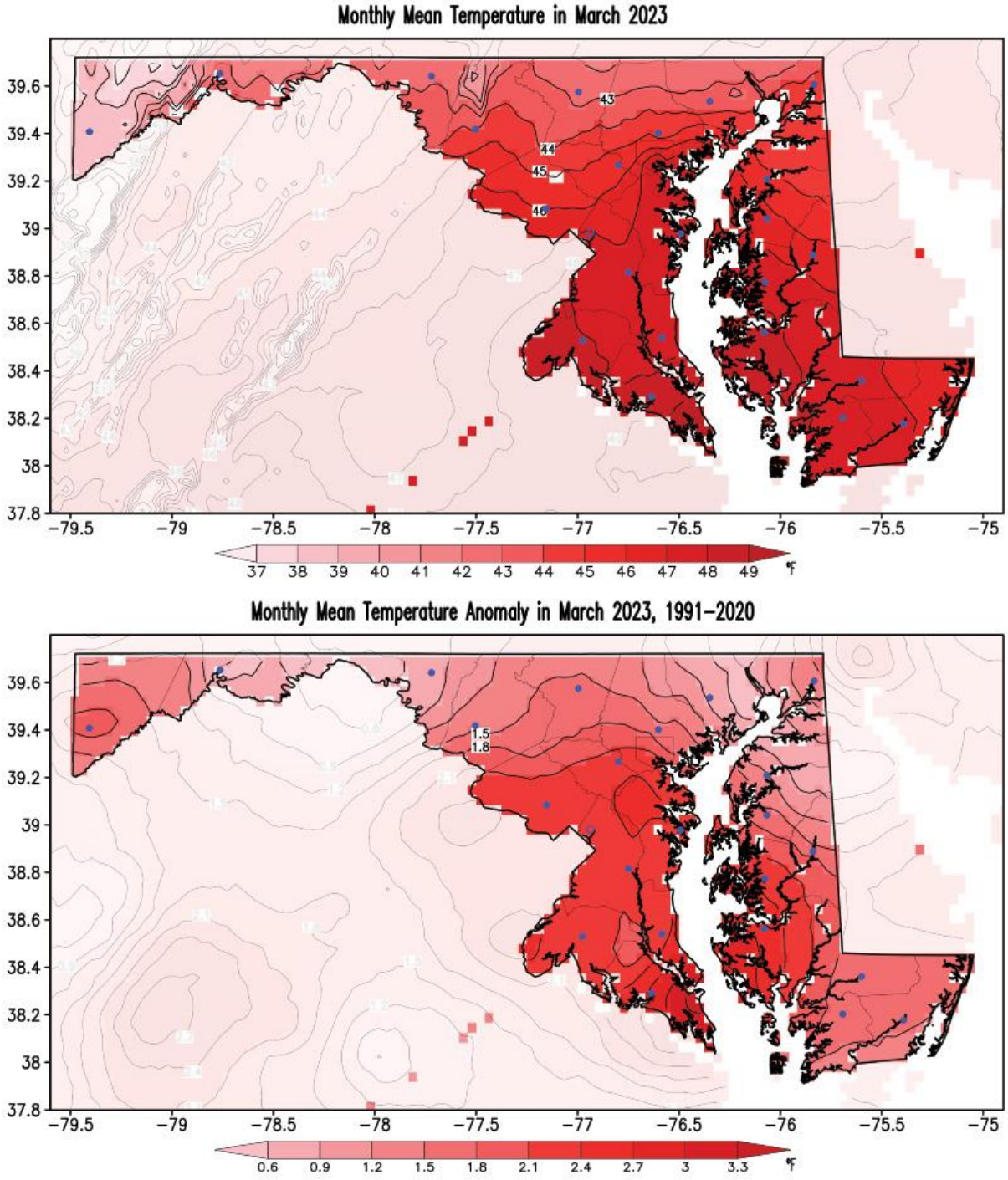

Figure 1. Monthly mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for March 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been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

B. Maximum Temperatures

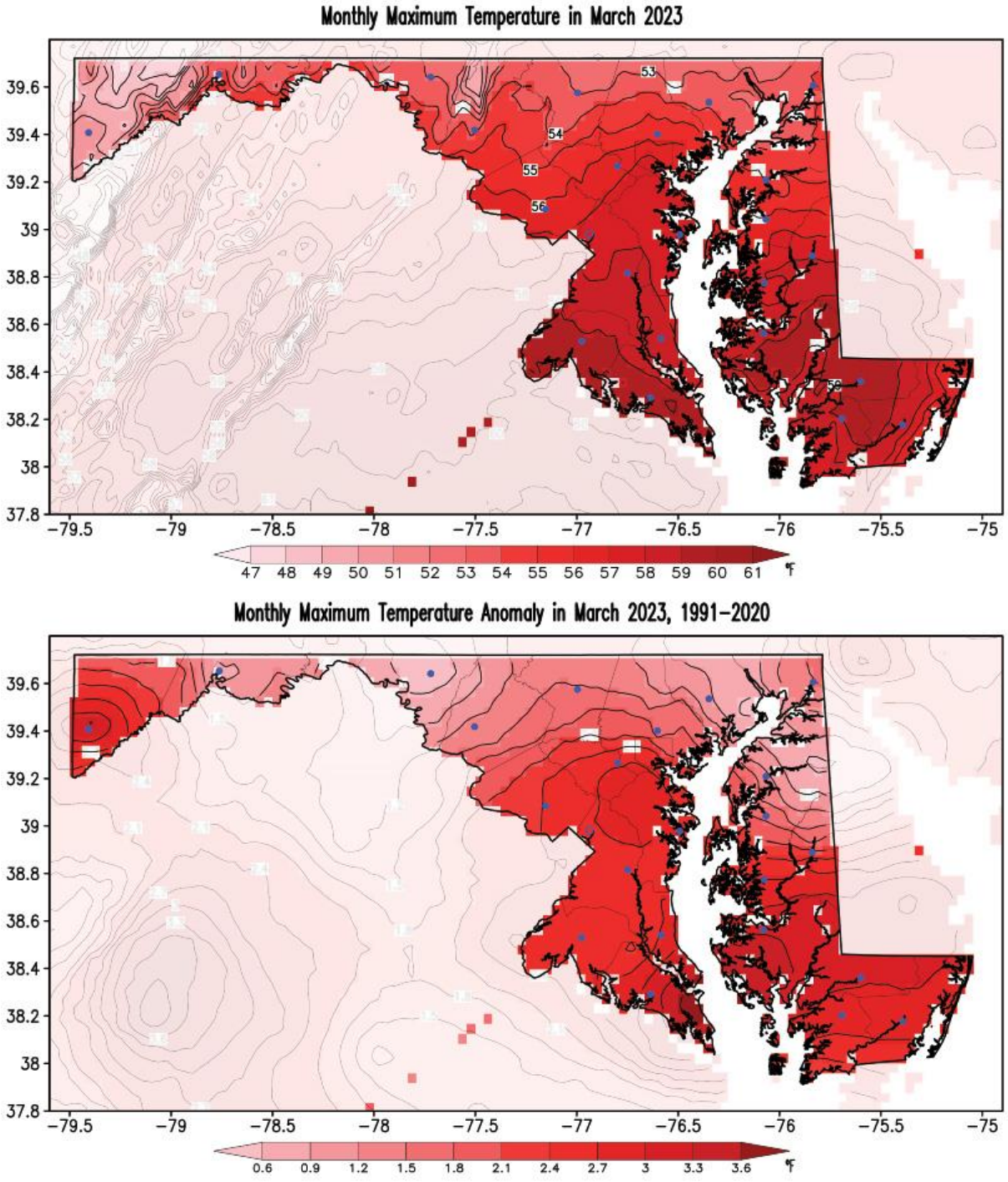

Figure 2. Monthly maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for March 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has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

C. Minimum Temperatures

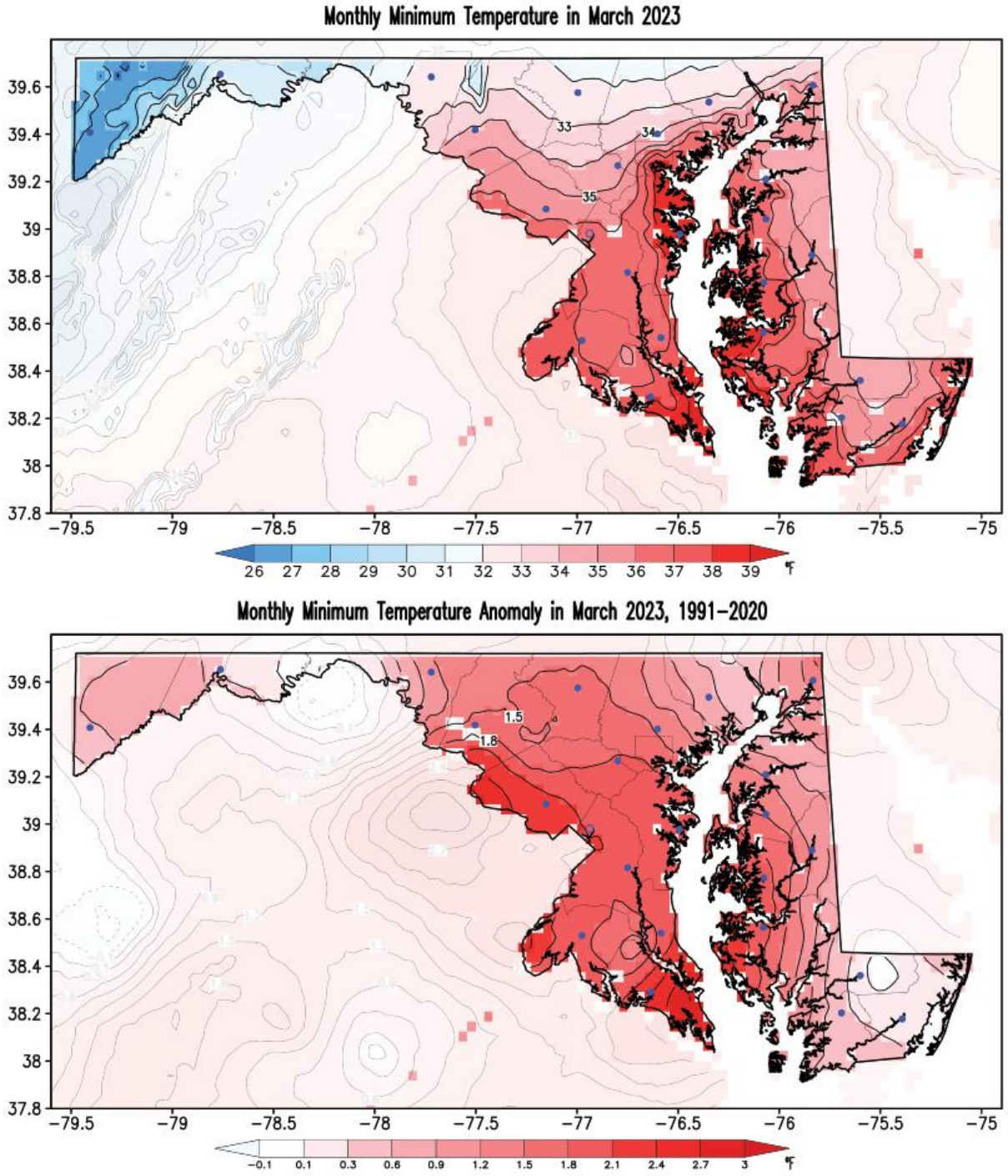

Figure 3. Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for March 2023. Temperatures are in °F following the color bar. Blue/red shading in the temperature map shows temperatures below/above 32°F, while red shading in the 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

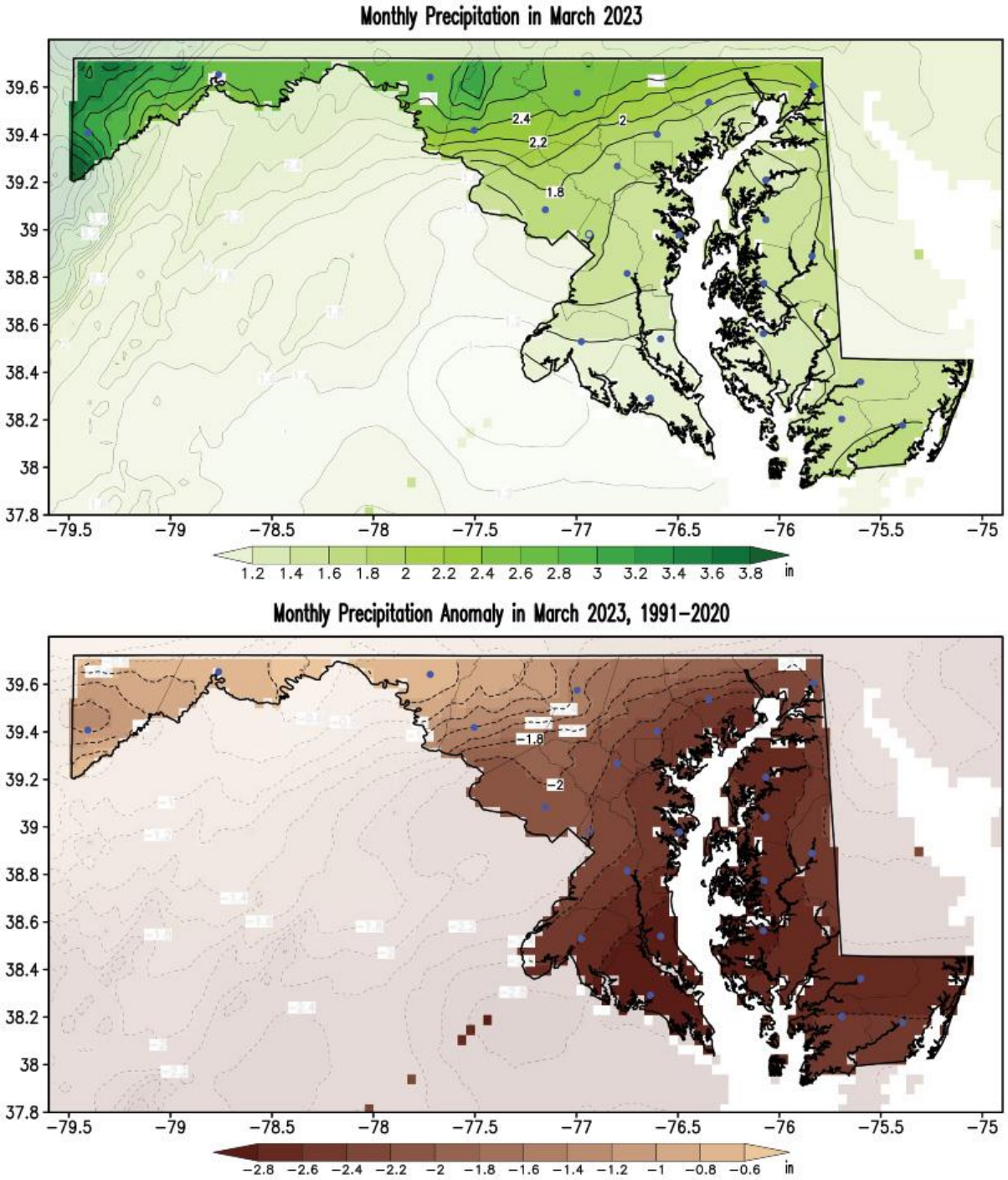

Figure 4. Monthly total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for March 2023. Precipitation is in inches following the color bar. Brown shading in the anomaly map marks drie than normal conditions. Note shading outside the state has been washed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

E. Drought

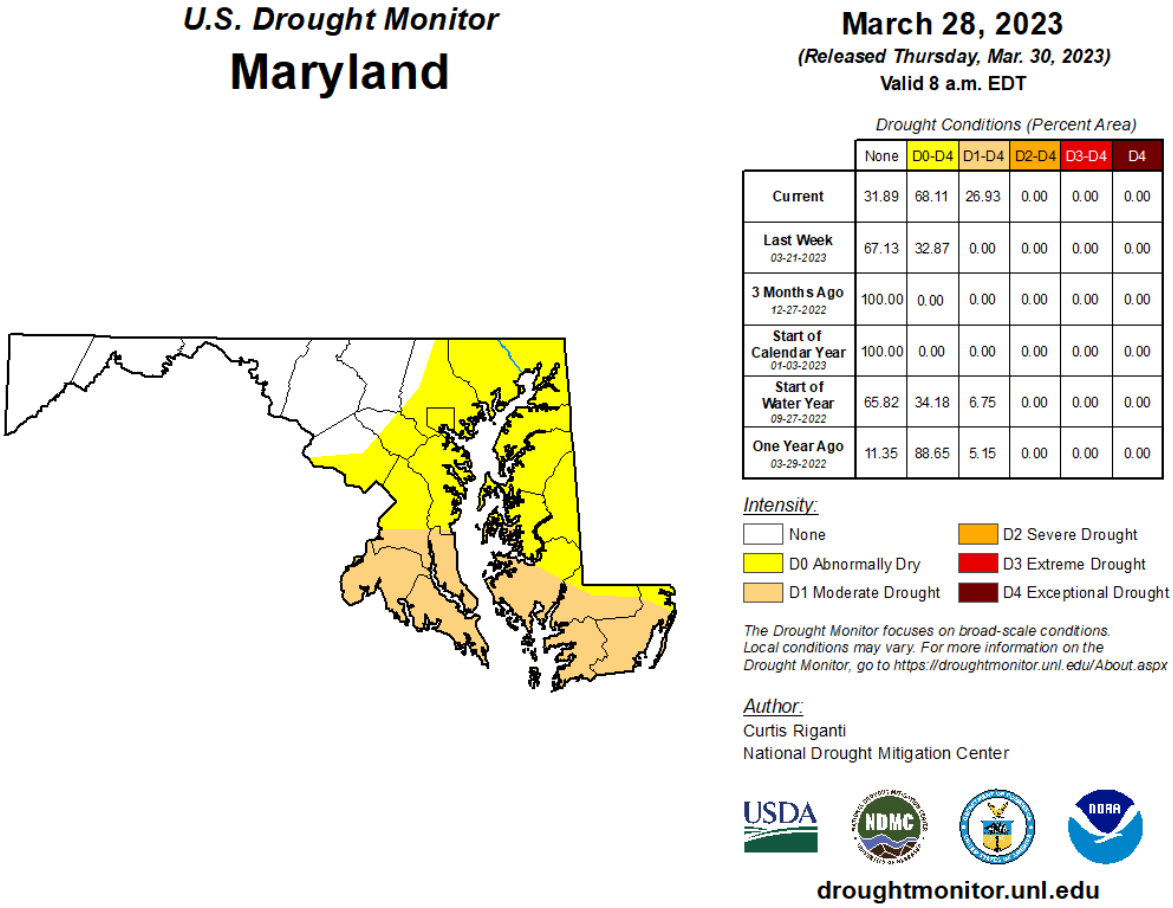

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on March 28, 2023. Yellow shading indicates regions that are abnormally dry while regions with light orange shading shows regions than are under a moderate drought according to the inset of drought intensity. The numbers in the table shows the percentage of the state covered under the combined drought conditions at the cited time.

4. March and JFM 2023 Climate Divisions Averages

A. March 2023 Scatter Plots

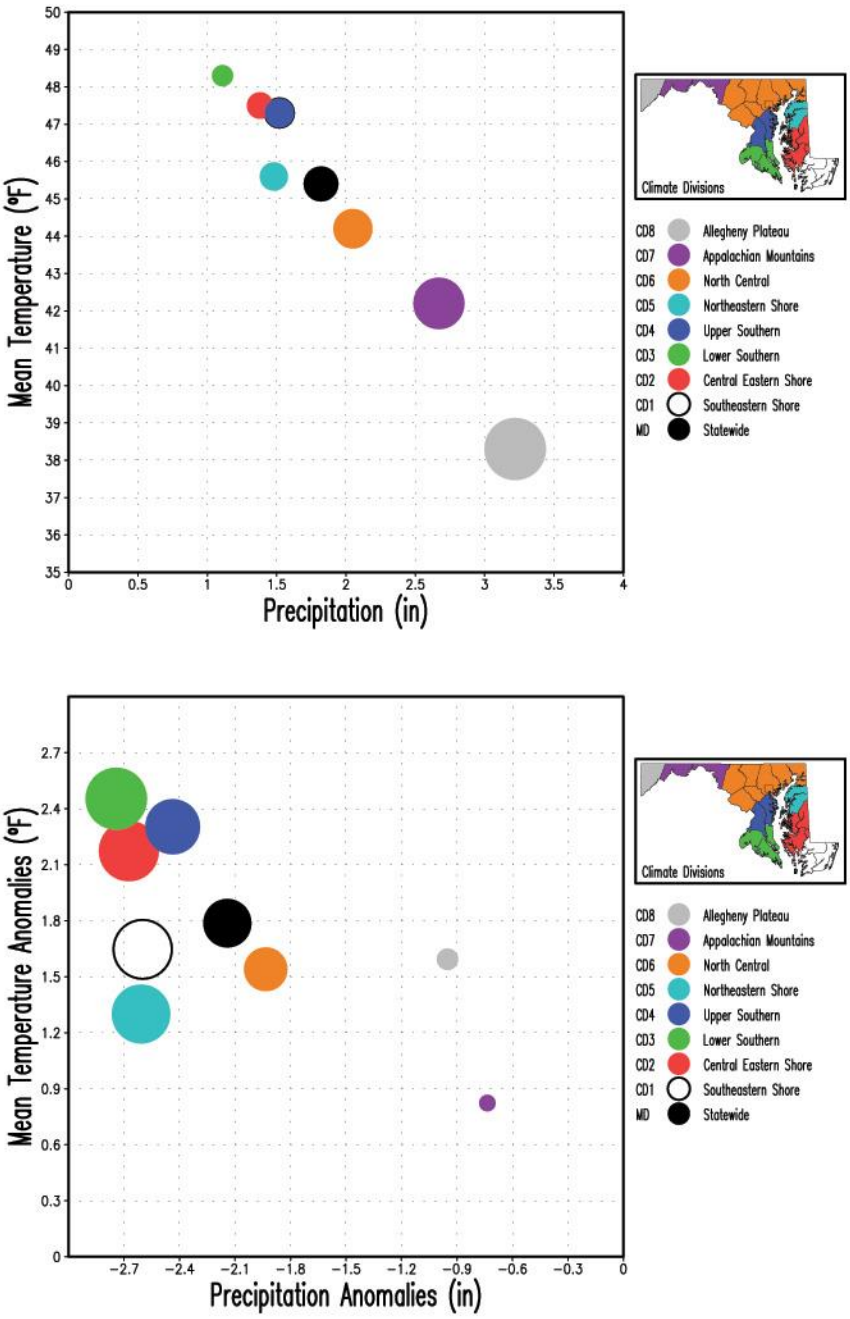

Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for March 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. 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 (3.22 inches in CD8, top panel) and by the maximum precipitation anomaly (|-2.74| inches 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.

B. January-March, 2023 Scatter Plots

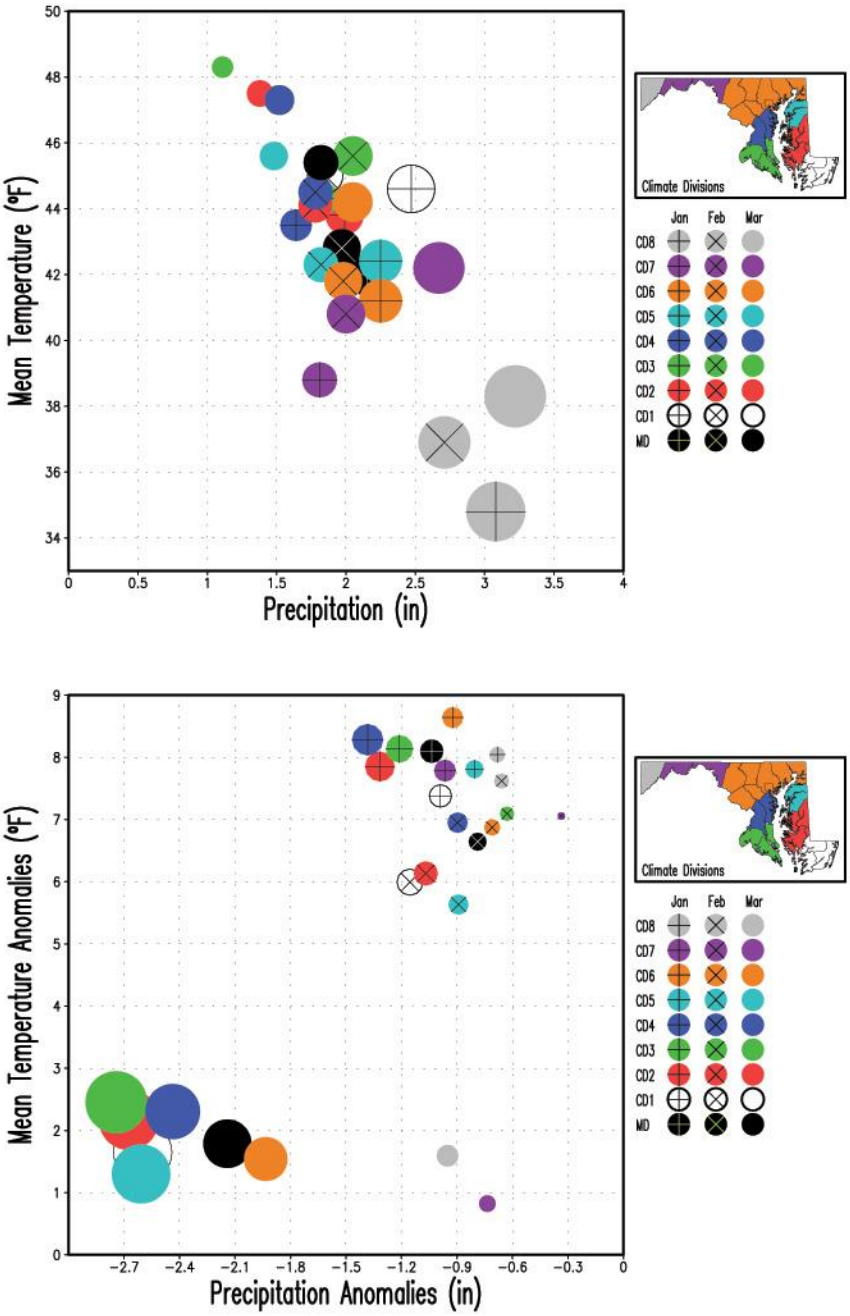

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for January, February and March 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect 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 (3.2 inches in CD8 in March, top panel) and by the maximum precipitation anomaly (|-2.74| inches in CD3 in March, bottom panel) among the nine regions and three months. March is displayed with filled circles only, while February and January are displayed with superposed multiplication and addition signs, respectively.

5. March 2023 Statewide Averages in the Historical Record

A. Box and Whisker Plots

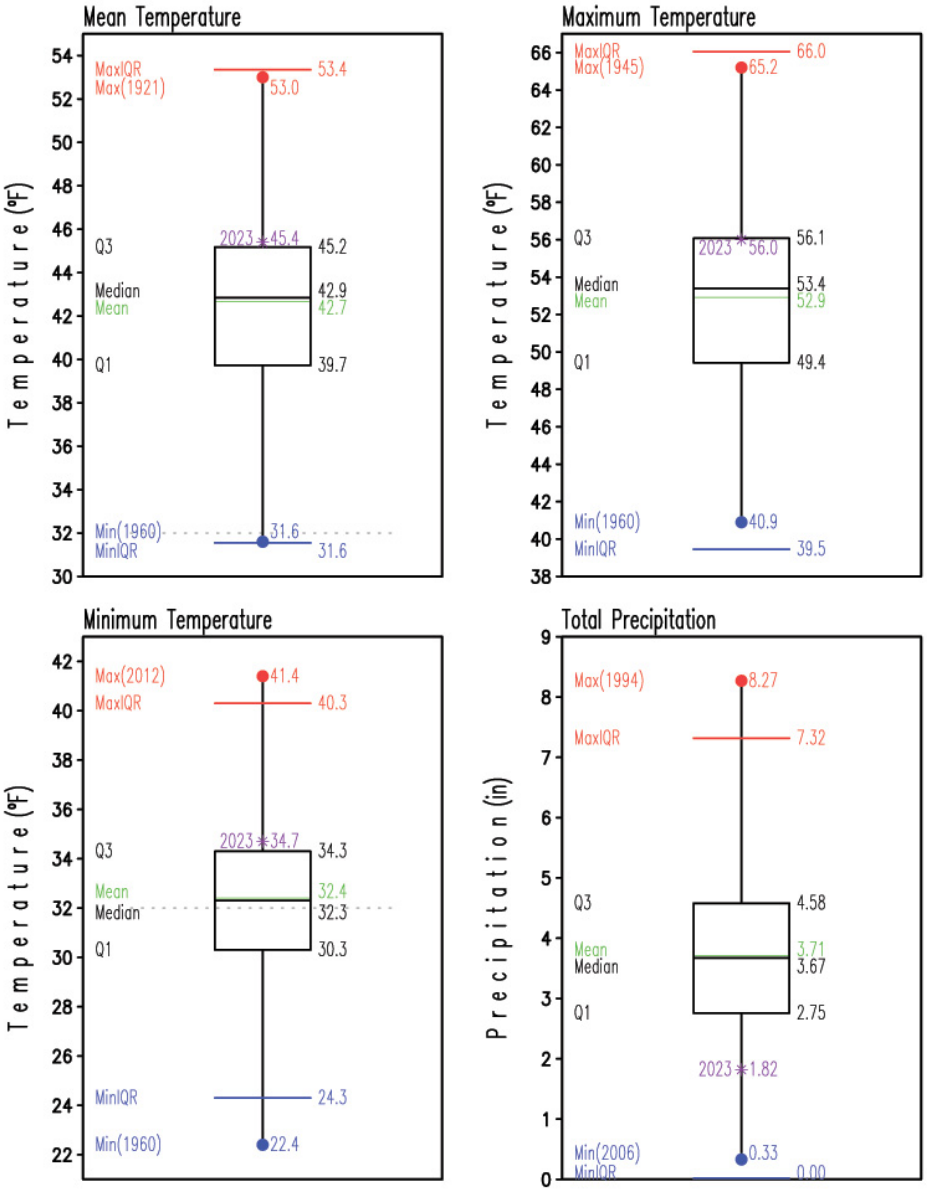

Figure 8. Box and Whisker plots of Maryland (statewide) monthly mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and total precipitation (lower right) for March for the period 1895-2022. The label and asterisk in purple represent conditions for March 2023. Statistics 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 smaller and larger 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. For reference, the 32° F temperature is displayed with a horizontal dotted line.

6. 1895-2023 Trends

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

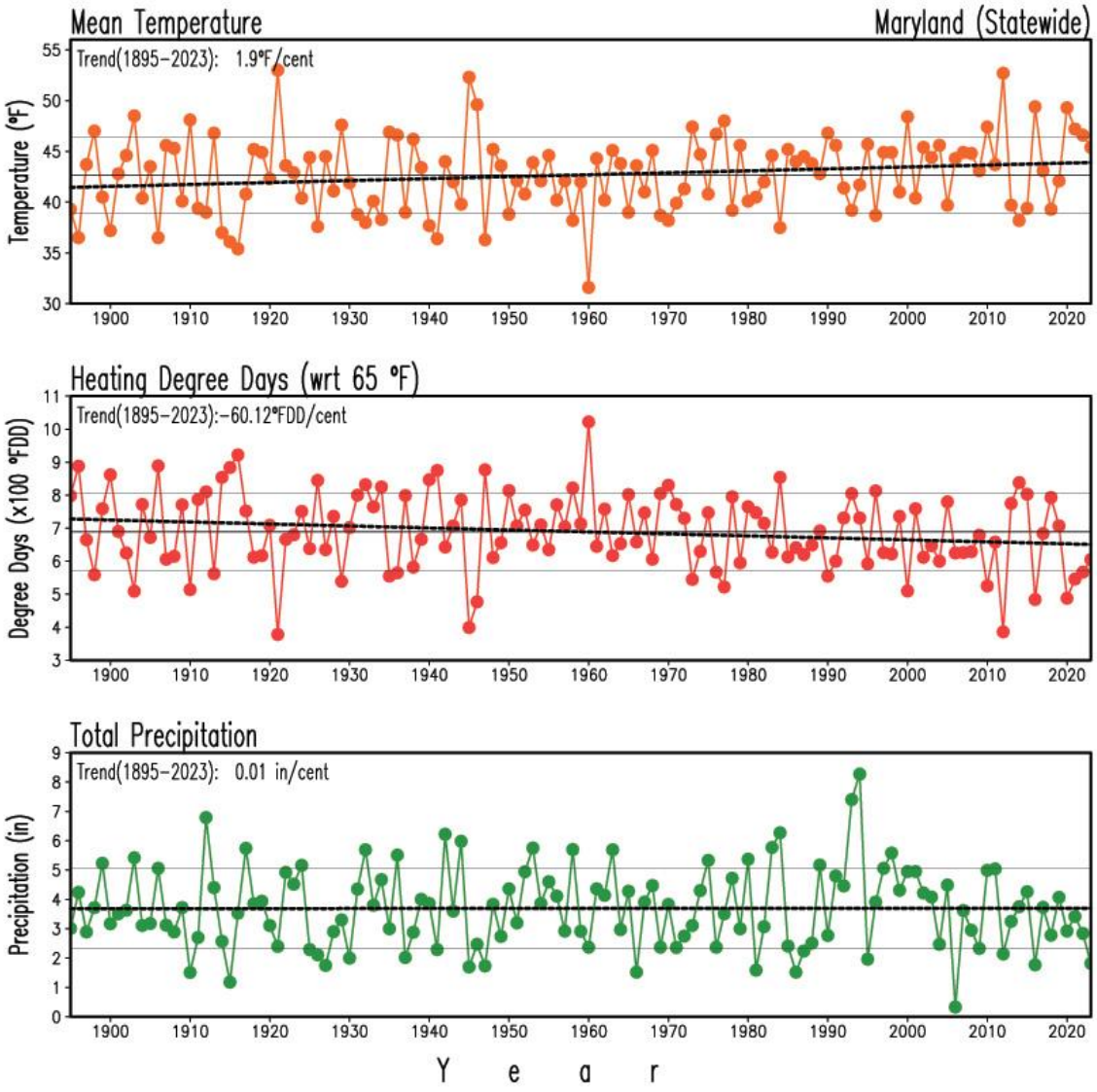

Figure 9. Maryland (statewide) mean surface air temperature, heating degree-days, and precipitation in March for the period 1895-2023. Temperature is in °F, heating degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (42.7°F, 689.35°FDD, and 3.69 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (3.8°F, 116.85°FDD, and 1.37 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 heat 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 (1.9°F/century) and the decreasing heating degree-days (−60.12°FDD/century) trend are statistically significant at the 95% level (*Student's t-test* −Santer et al. 2000), but not the precipitation trend (0.01 in/century) that is nonexistent.

B. Temperature and Precipitation Maps

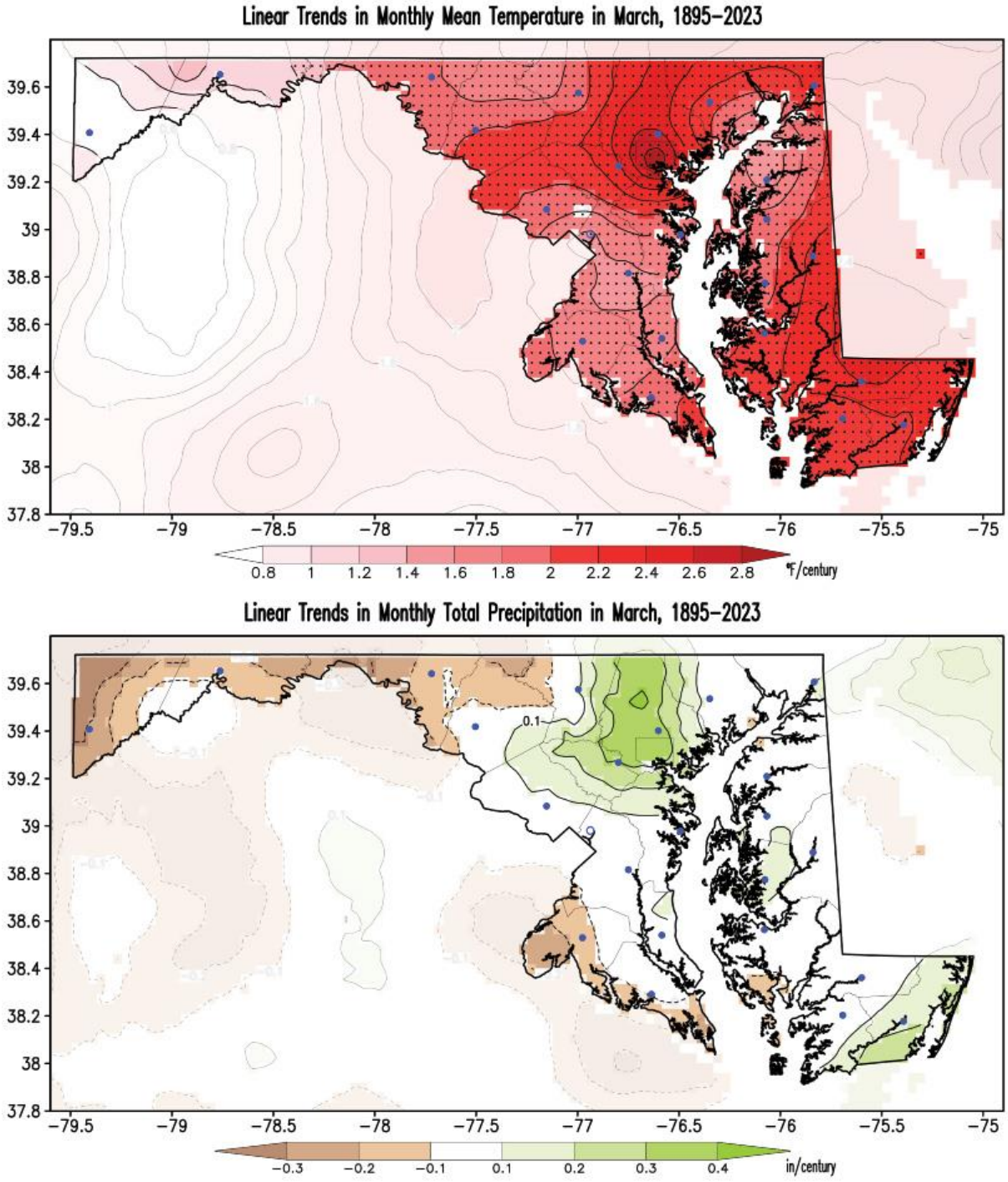

Figure 10. Linear trends in surface air mean temperature and precipitation for the period 1895-2023. Temperatures are in °F/century, and precipitation is in inches/century following the color bars. Red shading in the temperature map marks warming trends. Brown/green shading in the precipitation map shows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

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)
Statewide	45.4	101
Climate Division 1	47.3	103
Climate Division 2	47.5	108
Climate Division 3	48.3	107
Climate Division 4	47.3	106
Climate Division 5	45.6	95
Climate Division 6	44.2	98
Climate Division 7	42.2	84
Climate Division 8	38.3	84
Allegany	41.6	79
Anne Arundel	47.4	106
Baltimore	44.3	101
Baltimore City	46.6	105
Calvert	47.8	107
Caroline	46.5	102
Carroll	43.0	94
Cecil	43.9	94
Charles	48.3	106
Dorchester	48.1	109
Fredrick	43.7	94
Garrett	38.3	84
Harford	43.4	82
Howard	45.2	107
Kent	45.2	92
Montgomery	45.8	106
Prince George's	47.2	105
Queen Anne's	45.9	95
Saint Mary's	48.6	107
Somerset	47.7	102
Talbot	47.6	108
Washington	42.8	87
Wicomico	47.3	103
Worcester	47.0	102

Region	Total Precipitation (in)	Rank (#)
Statewide	1.82	11
Climate Division 1	1.52	5
Climate Division 2	1.38	4
Climate Division 3	1.11	7
Climate Division 4	1.52	9
Climate Division 5	1.48	6
Climate Division 6	2.05	18
Climate Division 7	2.67	51
Climate Division 8	3.22	48
Allegany	2.69	55
Anne Arundel	1.53	8
Baltimore	1.98	14
Baltimore City	1.69	10
Calvert	1.17	7
Caroline	1.55	5
Carroll	2.42	34
Cecil	1.95	17
Charles	1.14	5
Dorchester	1.26	4
Fredrick	2.43	32
Garrett	3.22	48
Harford	1.91	13
Howard	1.79	12
Kent	1.46	6
Montgomery	1.71	13
Prince George's	1.51	9
Queen Anne's	1.48	7
Saint Mary's	1.04	7
Somerset	1.50	5
Talbot	1.40	6
Washington	2.65	45
Wicomico	1.43	5
Worcester	1.59	5

Table A1. Monthly mean surface air temperature (left) and total precipitation (right) at Maryland (statewide), climate division, and county levels for March 2023. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for March 2023 occupies among the 129 Marches 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	56.0	96
Climate Division 1	58.4	111
Climate Division 2	58.4	106
Climate Division 3	59.2	103
Climate Division 4	57.8	99
Climate Division 5	55.5	82
Climate Division 6	54.5	91
Climate Division 7	53.2	78
Climate Division 8	49.4	83
Allegany	53.0	76
Anne Arundel	57.6	100
Baltimore	54.8	92
Baltimore City	56.7	103
Calvert	58.4	105
Caroline	57.8	101
Carroll	53.6	88
Cecil	53.5	81
Charles	59.4	102
Dorchester	59.1	115
Fredrick	53.9	91
Garrett	49.5	85
Harford	53.4	78
Howard	56.0	101
Kent	54.8	78
Montgomery	56.1	97
Prince George's	58.0	98
Queen Anne's	56.0	87
Saint Mary's	59.4	108
Somerset	58.4	108
Talbot	57.8	104
Washington	53.4	80
Wicomico	59.1	116
Worcester	57.8	110

Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	34.7	102
Climate Division 1	36.2	85
Climate Division 2	36.5	100
Climate Division 3	37.4	105
Climate Division 4	36.8	107
Climate Division 5	35.6	99
Climate Division 6	33.9	103
Climate Division 7	31.2	85
Climate Division 8	27.1	89
Allegany	30.2	83
Anne Arundel	37.2	107
Baltimore	33.8	102
Baltimore City	36.4	103
Calvert	37.2	105
Caroline	35.2	99
Carroll	32.5	102
Cecil	34.2	98
Charles	37.2	105
Dorchester	37.1	102
Fredrick	33.6	100
Garrett	27.1	89
Harford	33.5	98
Howard	34.3	104
Kent	35.6	97
Montgomery	35.5	108
Prince George's	36.4	107
Queen Anne's	35.8	99
Saint Mary's	37.8	107
Somerset	37.0	92
Talbot	37.4	104
Washington	32.1	91
Wicomico	35.5	88
Worcester	36.2	84

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

A. Temperatures and Precipitation

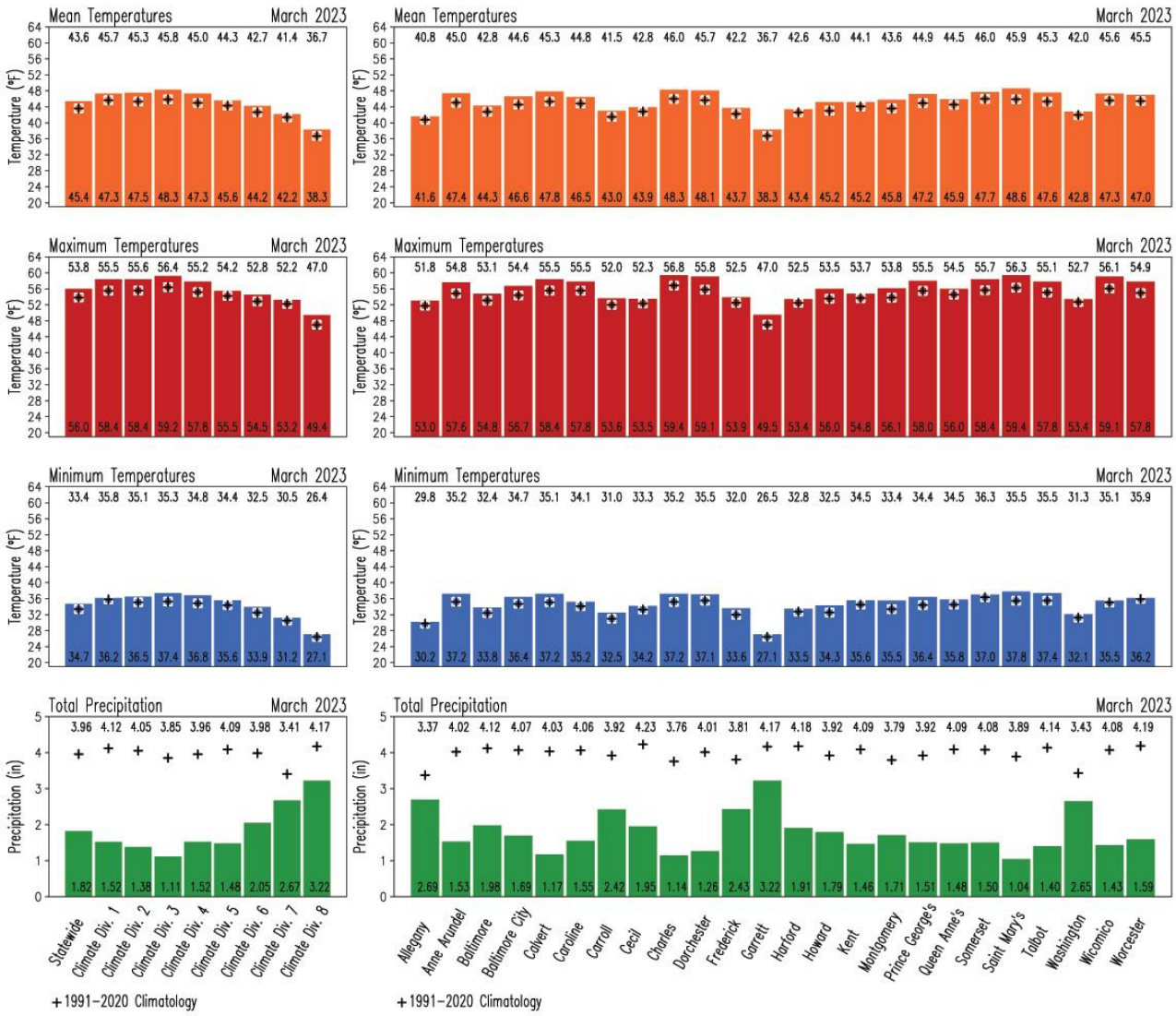

Figure B1. Monthly surface variables in Maryland for March 2023. Color bars represent the variables as follows: mean surface air temperature (orange), maximum surface air temperature (red), minimum surface air temperature (blue) and total precipitation (green) at statewide and climate division (left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

B. Temperature and Precipitation Anomalies

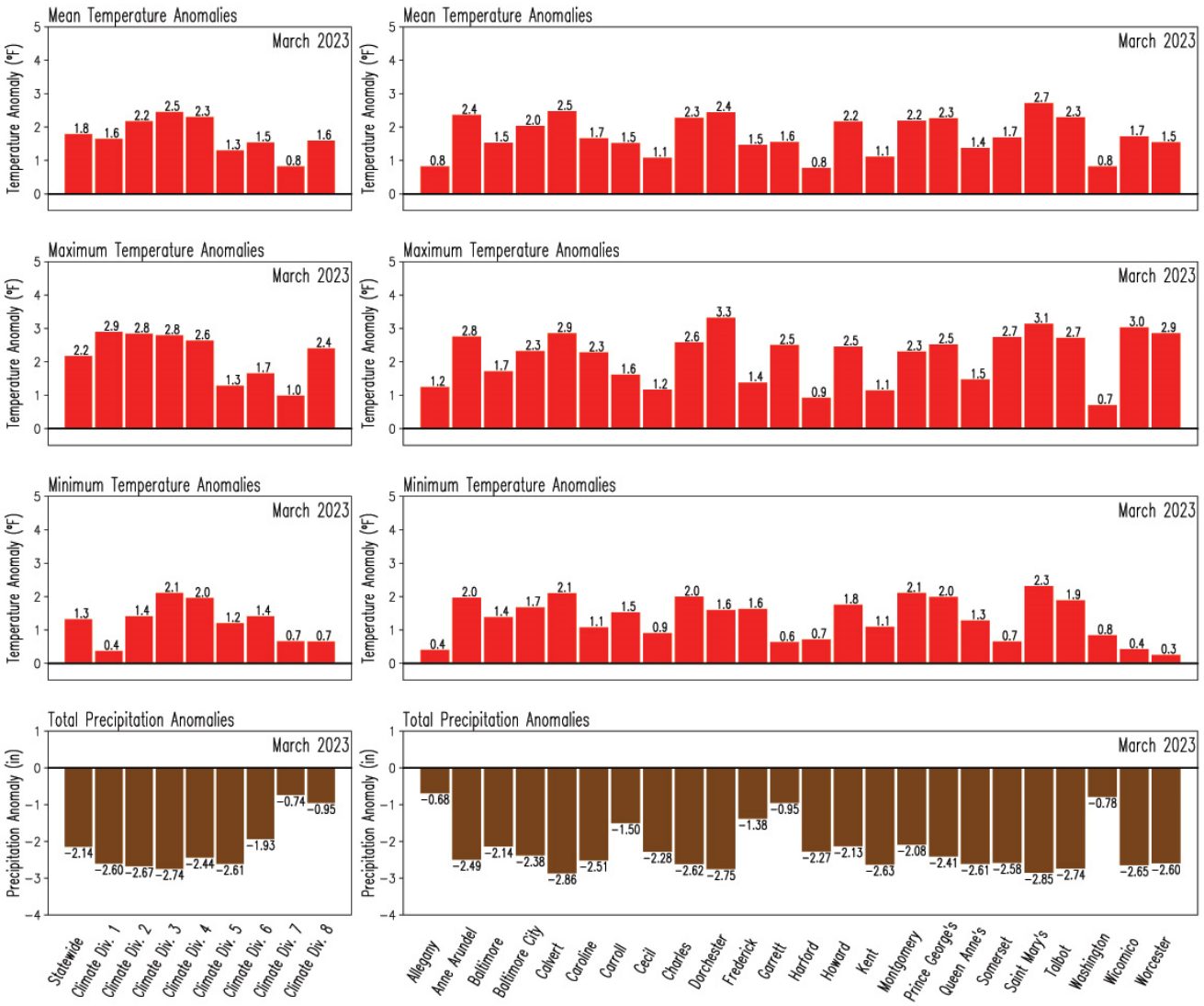

Figure B2. Anomalies of the monthly surface variables in Maryland for March 2023. Anomalies are with respect to the 1991-2020 climatology. Red color represents positive anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air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

Appendix C. March 1991-2020 Climatology Maps

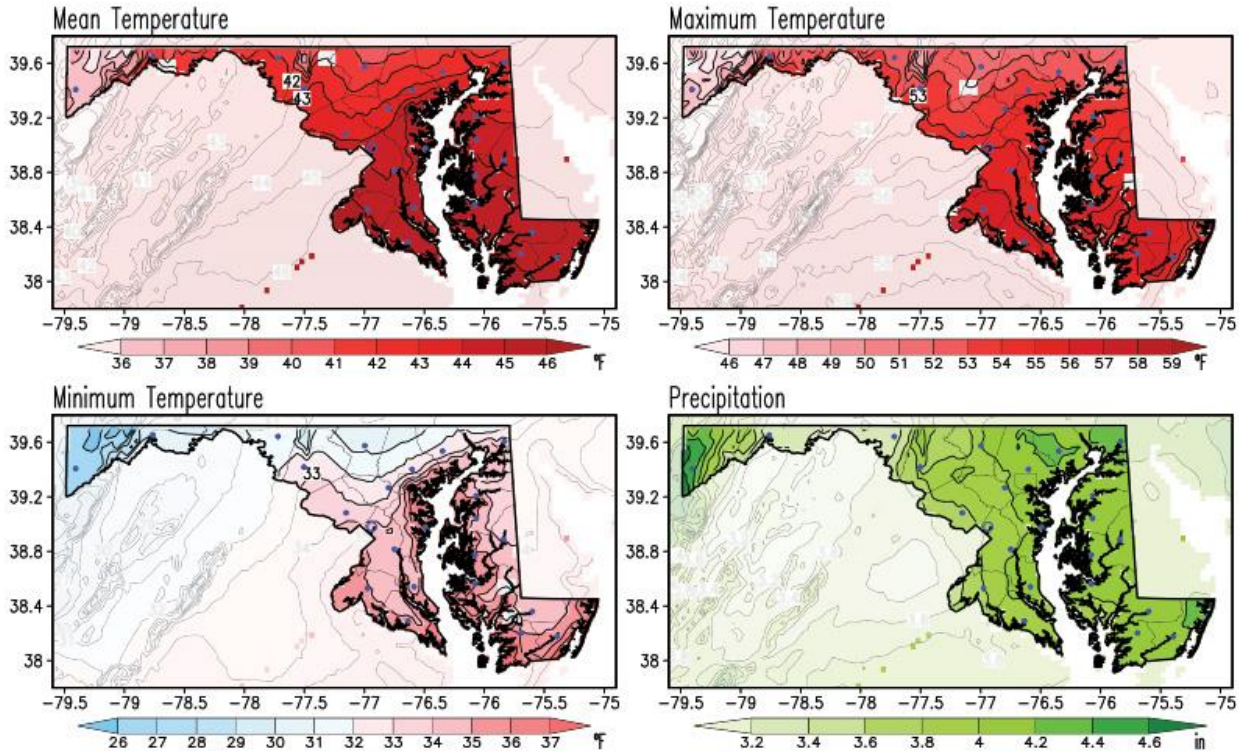

Figure C1. March climatology of the monthly mean, maximum and minimum surface air temperatures, and total precipitation for the period 1991-2020. Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the March 2023 conditions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

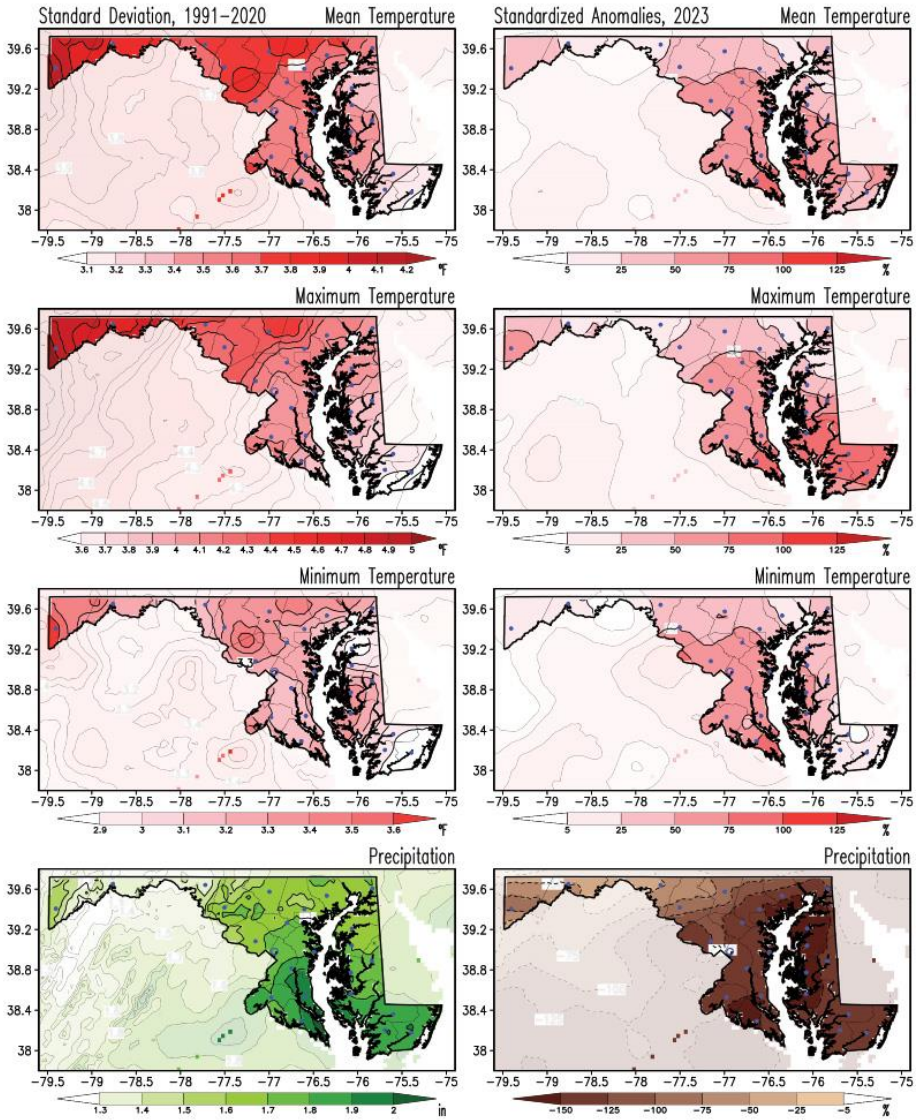

Figure D1. Standard deviation for March and standardized anomalies of temperatures and precipitation for March 2023. Standard deviations for monthly mean, maximum, and minimum surface air temperatures and total precipitation were obtained for the 1991-2020 period (left column). Anomalies for March 2023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