Maryland Climate Bulletin
April 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 April 2023 was warmer and wetter than normal (i.e., 1991-2020 averages). Monthly mean temperatures were 49 to 61°F; maximum temperatures were between 63 to 74°F, and minimum temperatures were in the 35 to 49°F range. Monthly total precipitation was in the 2.6 to 5.9 inches range.

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

- Mean temperature was warmer than normal everywhere, notably in portions of southern Howard and northern Anne Arundel counties and Caroline, Dorchester, Wicomico, and Somerset counties (4.2°F and above).

- Maximum temperature was also warmer than normal everywhere, especially over Garrett and Allegany counties; Carroll, Baltimore, Montgomery, Howard, and Anne Arundel counties (5.0 to 5.6°F); and Dorchester and Wicomico counties (around 5.8°F).

- Minimum temperature was warmer than normal over most of the state, notably in portions of Montgomery, Baltimore, Howard, Anne Arundel counties, and smaller portions of Calvert, Saint Mary's, Talbot, Dorchester, Somerset, and Worcester counties (above 3.0°F). Large areas in Allegany and Garrett counties were colder than normal.

- Precipitation was below normal from Frederick to Garrett counties (–2 inches in western Garrett) and over Harford and Cecil counties (–1 in). Precipitation was above normal in the rest of the state, especially over the southern portions of Calvert and Saint Mary's counties, Dorchester, and portions of Caroline, Wicomico, Somerset, and Worcester counties, by 2 in and more.

- The extent of the surface in the state under drought conditions diminished from around 68% in March to 53% at the end of April. Since February, the continuous below-normal precipitation from Washington to Garrett counties has finally imposed abnormally dry conditions in this region. However, the above-normal precipitation over the eastern and western shores cleared most of the eastern shore's abnormally dry conditions observed in March; and it also reduced the large region affected by moderate drought conditions to only portions of Prince George's, Charles, Somerset, and Worcester counties.

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

- While, on average, the state was warmer and wetter than normal in April, Climate Divisions 6, 7, and 8 (North Central, Appalachian Mountains, and Allegheny Plateau) were warmer but drier than normal. Climate Divisions 1 and 2 (Southeastern Shore and Central Eastern Shore) had the largest precipitation and temperature anomalies (around 1.9 in and 4.5°F).

- Statewide temperature and precipitation anomalies have been changing considerably since February. Statewide warm anomalies in February (6.8°F) decreased in March

(1.8°F), and they increased in April (3.9°F). Statewide dry precipitation anomalies decreased from February (–0.81 in) to a minimum in March (–2.14 in) but changed to wet anomalies in April (0.45 in).

Historical Context (Figure 8, Tables A1 and A2)

- April's mean, maximum, and minimum statewide temperatures (58.1, 70.6, and 45.6°F) were above the long-term (1895-2022) average and within 25% of the highest values. April's precipitation (3.97 in) was above the long-term average.
- Statewide maximum temperature in April 2023 was the warmest on record for the month, and the mean temperature was the second warmest. While statewide precipitation in this month was not close to the records, counties like Dorchester, Somerset, Wicomico, and Worcester were within the ten wettest among the 129 Aprils in the 1895-2023 period. Most counties had (mean, maximum, and minimum) temperatures within the top five warmest Aprils on record.

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

- April statewide temperature showed a significant 2.8°F/century warming trend, and the heating degree-days a significant −84.21°F degree-days decreasing trend. On the other hand, statewide precipitation showed a non-significant trend (0.10 in/century).
- Regionally, April temperatures showed significant warming trends everywhere (above 1.5°F/century). Notably, the largest trend is over Baltimore City (3.9°F/century). However, large trends are also evident in portions of Baltimore, Carroll, Frederick, Montgomery, Howard, Prince George's, and Anne Arundel counties and over Caroline, Dorchester, Wicomico, Somerset, and Worcester counties (above 3°F/century).
- Regionally, April precipitation shows significant wet trends over Allegany and Garret counties (0.6 in/century).

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 April 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 5/10/2023.

- 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 5/10/2023.

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

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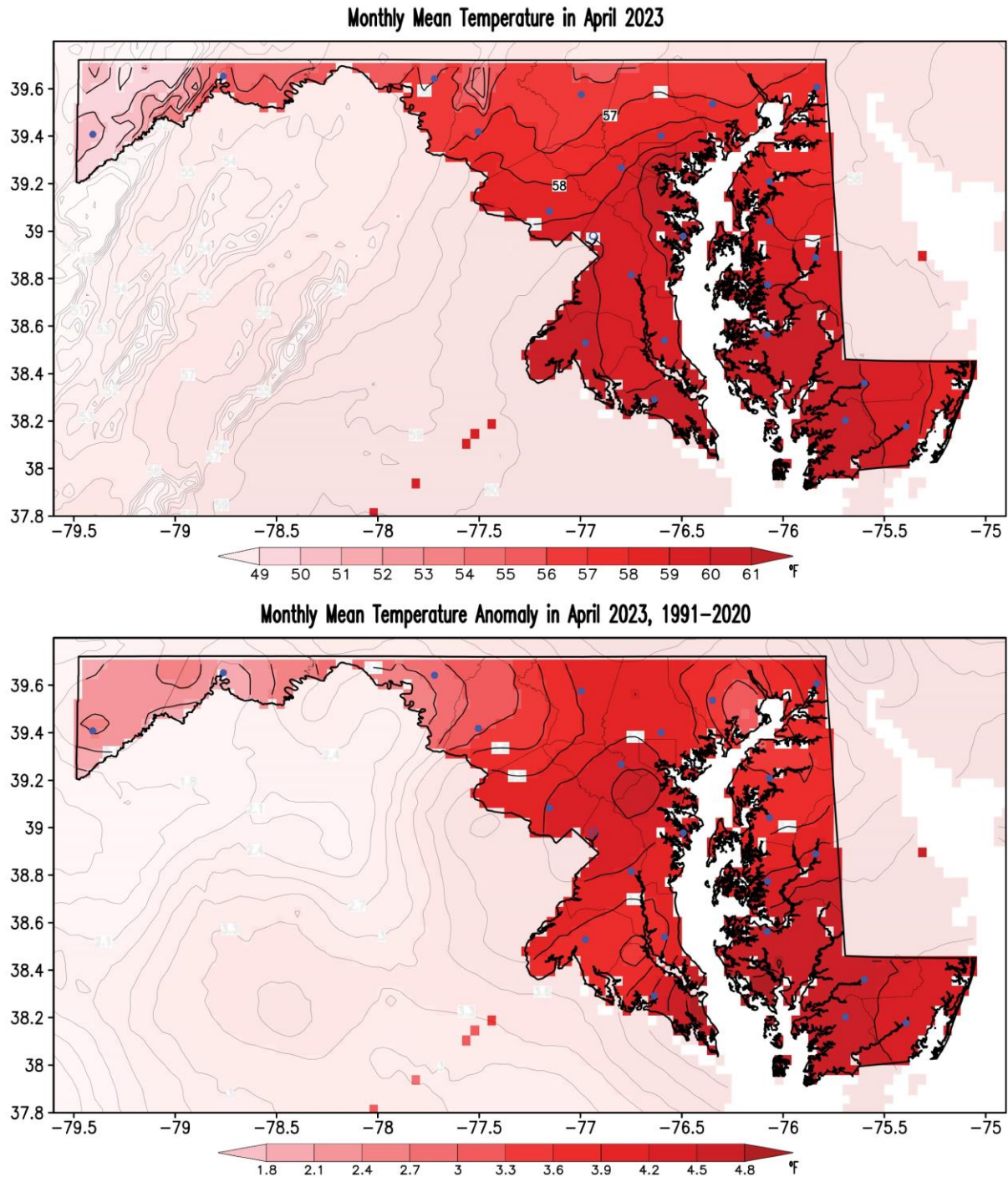
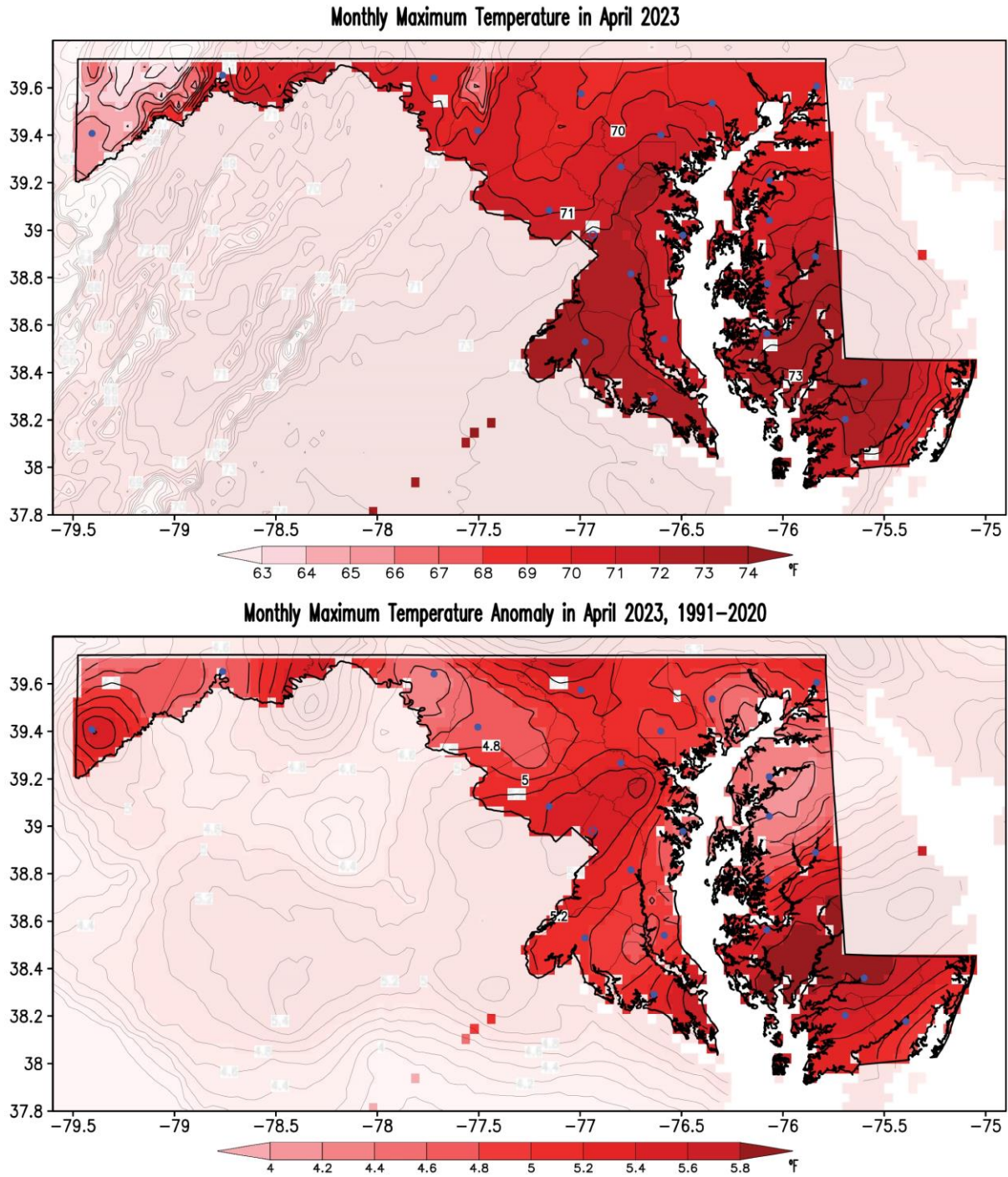**Figure 1.** Monthly mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for April 2023. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has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

B.   Maximum Temperatures

Monthly Maximum Temperature in April 2023

Monthly Maximum Temperature Anomaly in April 2023, 1991−2020

Figure 2. Monthly maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for April 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.
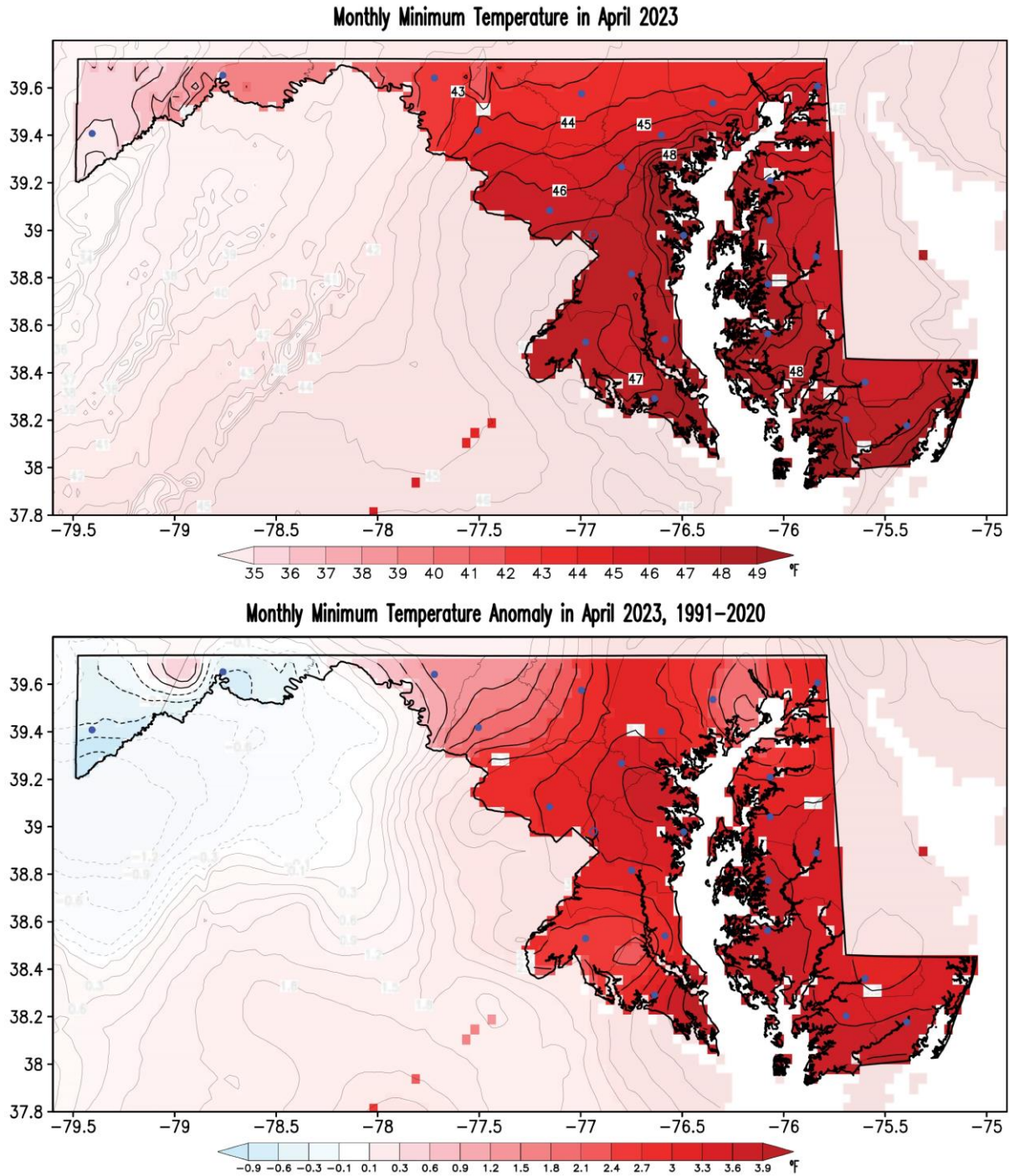
C.   Minimum Temperatures

Figure 3. Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for April 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 April 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.
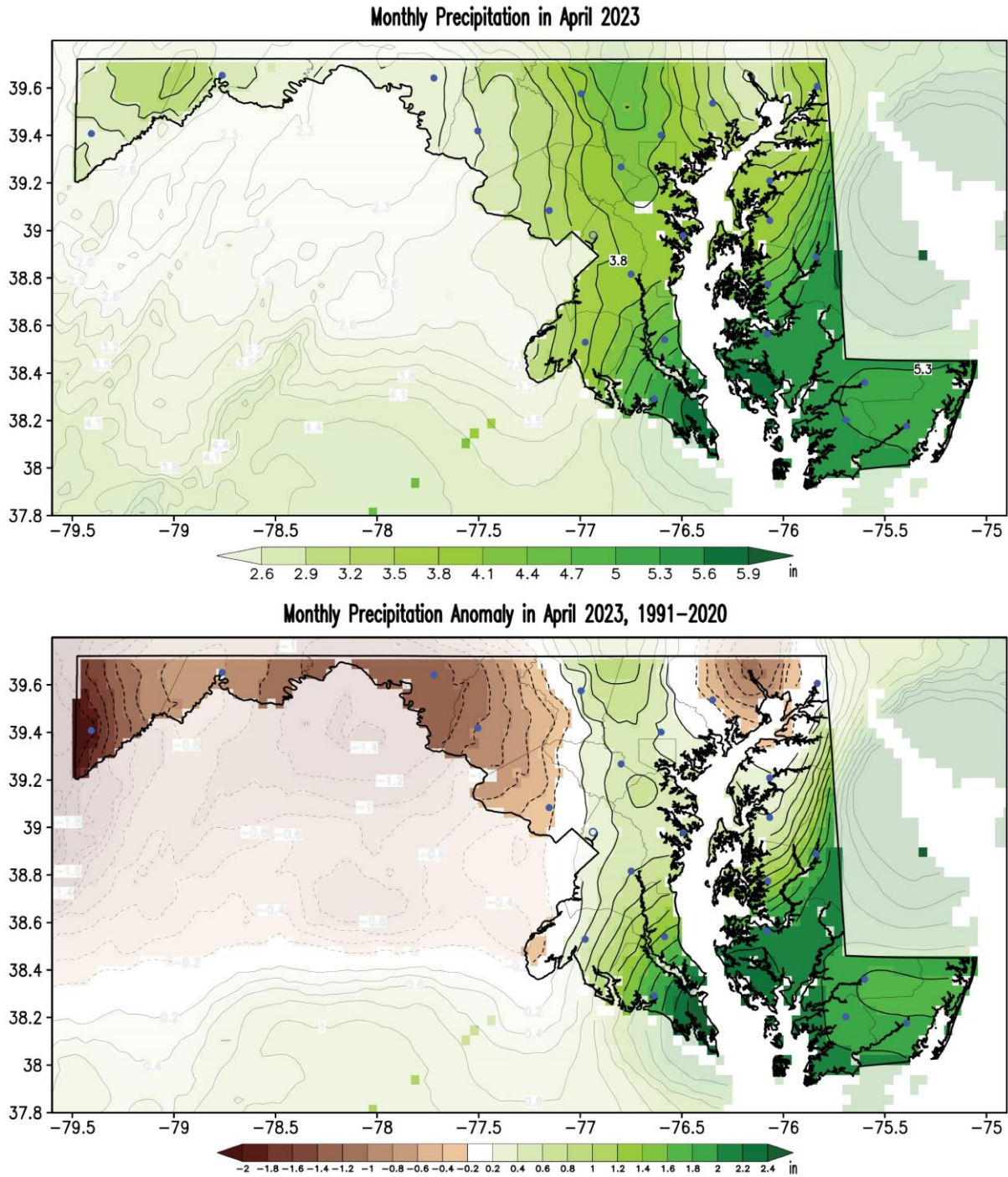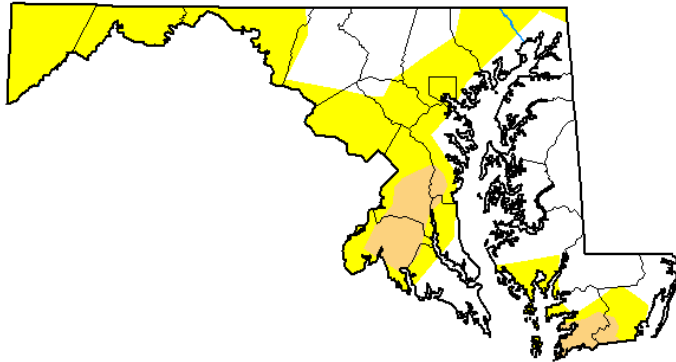
E.   Drought

U.S. Drought Monitor
Maryland

May 2, 2023
(Released Thursday, May. 4, 2023)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	46.56	53.44	7.86	0.00	0.00	0.00
Last Week 04-25-2023	3.00	97.00	62.98	0.00	0.00	0.00
3 Months Ago 01-31-2023	94.45	5.55	0.00	0.00	0.00	0.00
Start of Calendar Year 01-03-2023	100.00	0.00	0.00	0.00	0.00	0.00
Start of Water Year 09-27-2022	65.82	34.18	6.75	0.00	0.00	0.00
One Year Ago 05-03-2022	39.09	60.91	2.78	0.00	0.00	0.00

Intensity:

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

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

Author:
Brad Pugh
CPC/NOAA

droughtmonitor.unl.edu

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on May 2, 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. Numbers in the table indicate the percentage of the state covered under the combined drought conditions at the cited time in the left column.

4. April and FMA 2023 Climate Divisions Averages

A. April 2023 Scatter Plots
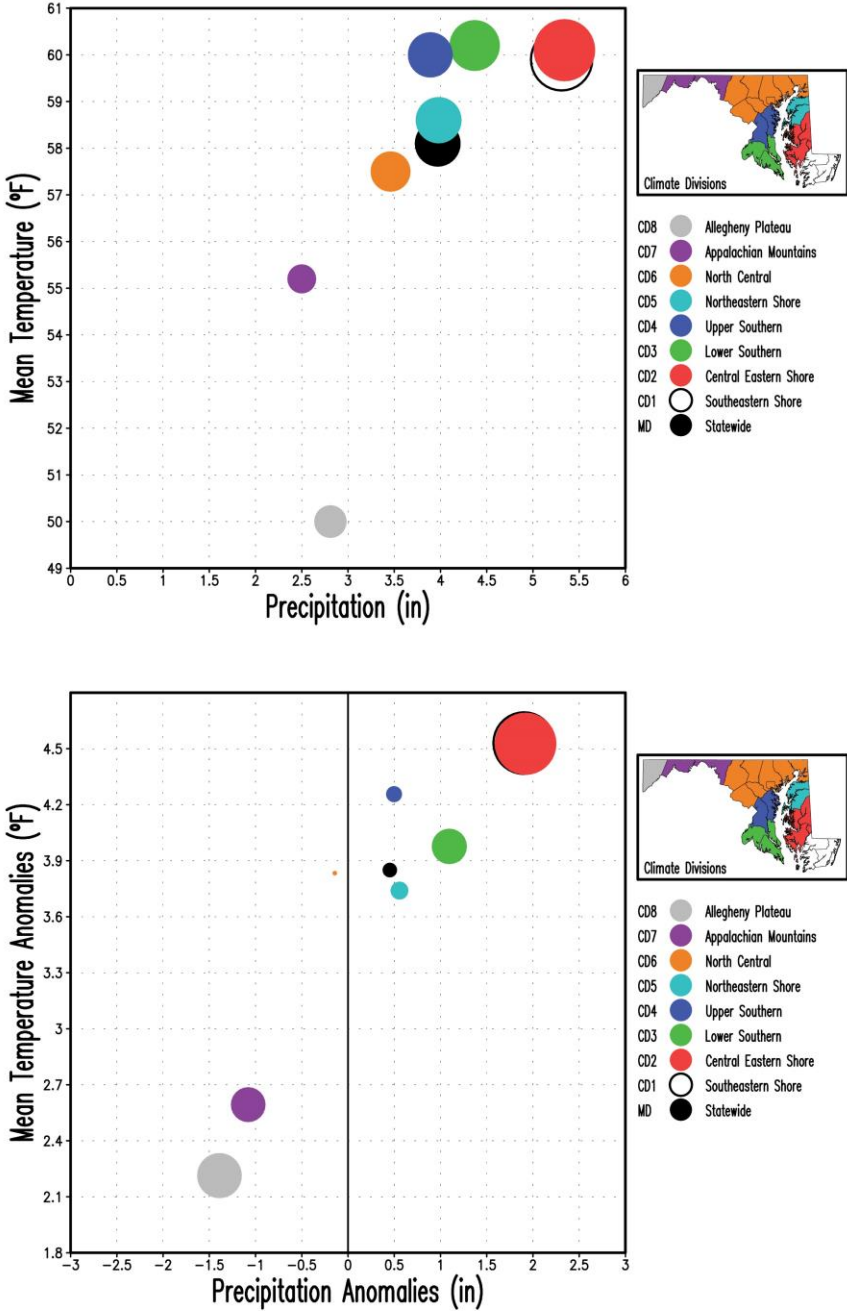
Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for April 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. Temperatures are in °F and precipitation is in inches. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (5.34 inches in CD2, top panel) and by the maximum precipitation anomaly (1.92 inches in CD2, 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.
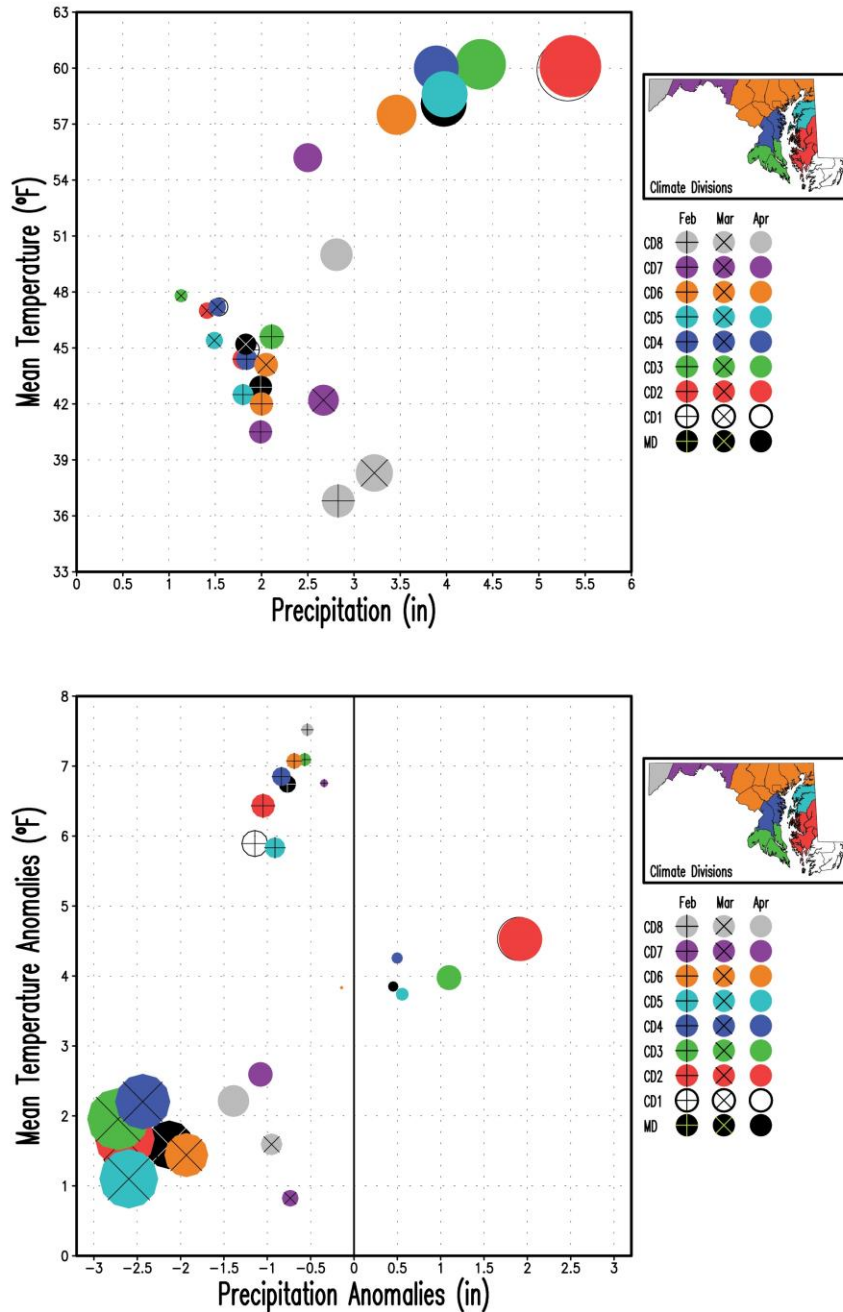
B.   February-April 2023 Scatter Plots

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for February, March, and April 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. Temperatures are in °F, and precipitation is in inches. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (5.34 inches in CD2 in April, top panel) and by the maximum precipitation anomaly (|-2.72| inches in CD3 in March, bottom panel) among the nine regions and three months. April is displayed with filled circles only, while March and February are displayed with superposed multiplication and addition signs, respectively.

5. April 2023 Statewide Averages in the Historical Record

A. Box and Whisker Plots
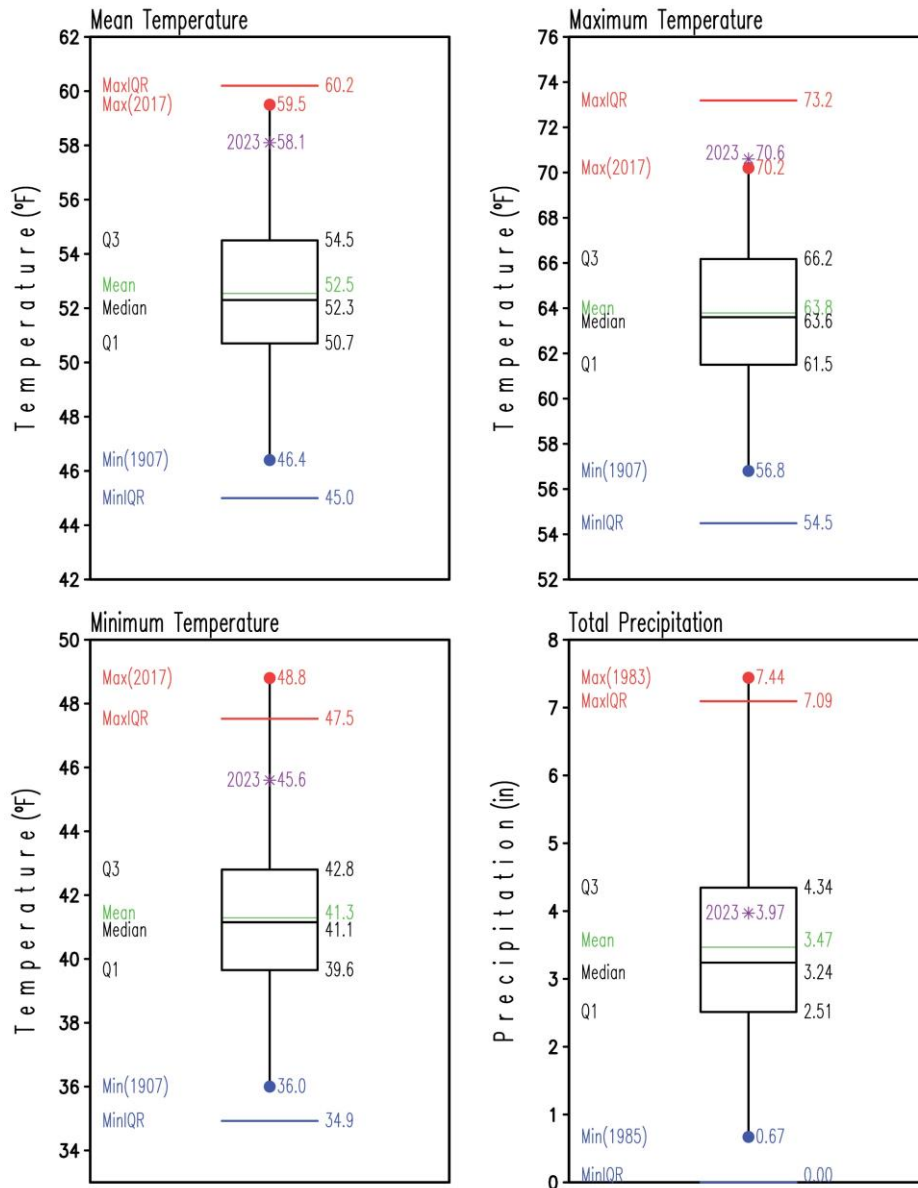

Figure 8. Box and Whisker plots of Maryland (statewide) monthly mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and total precipitation (lower right) for April for the period 1895-2022. The label and asterisk in purple represent conditions for April 2023. Statistics 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.
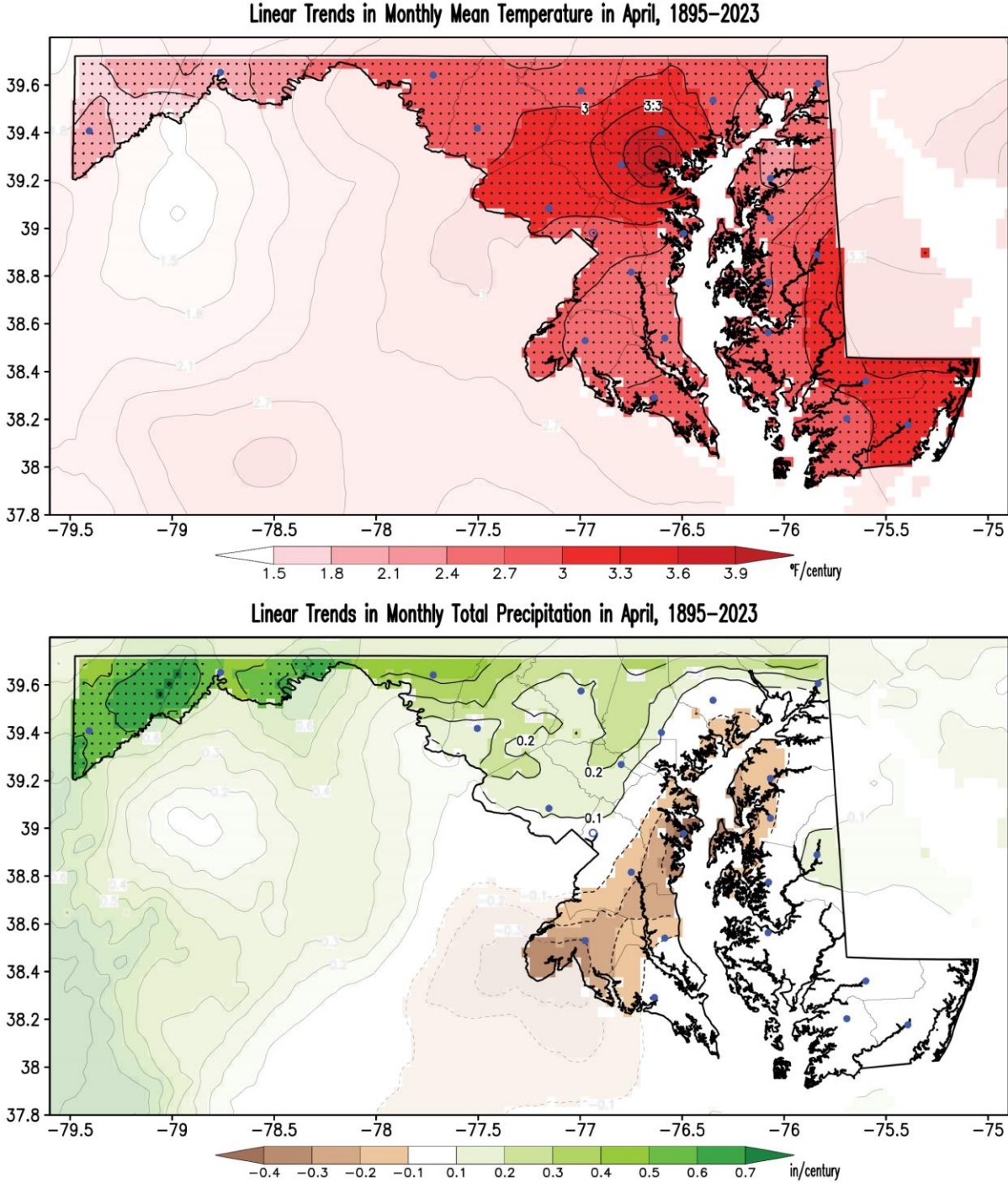
6. 1895-2023 April Trends

A. Statewide Mean Temperature, Heating Degree-Days, and Precipitation
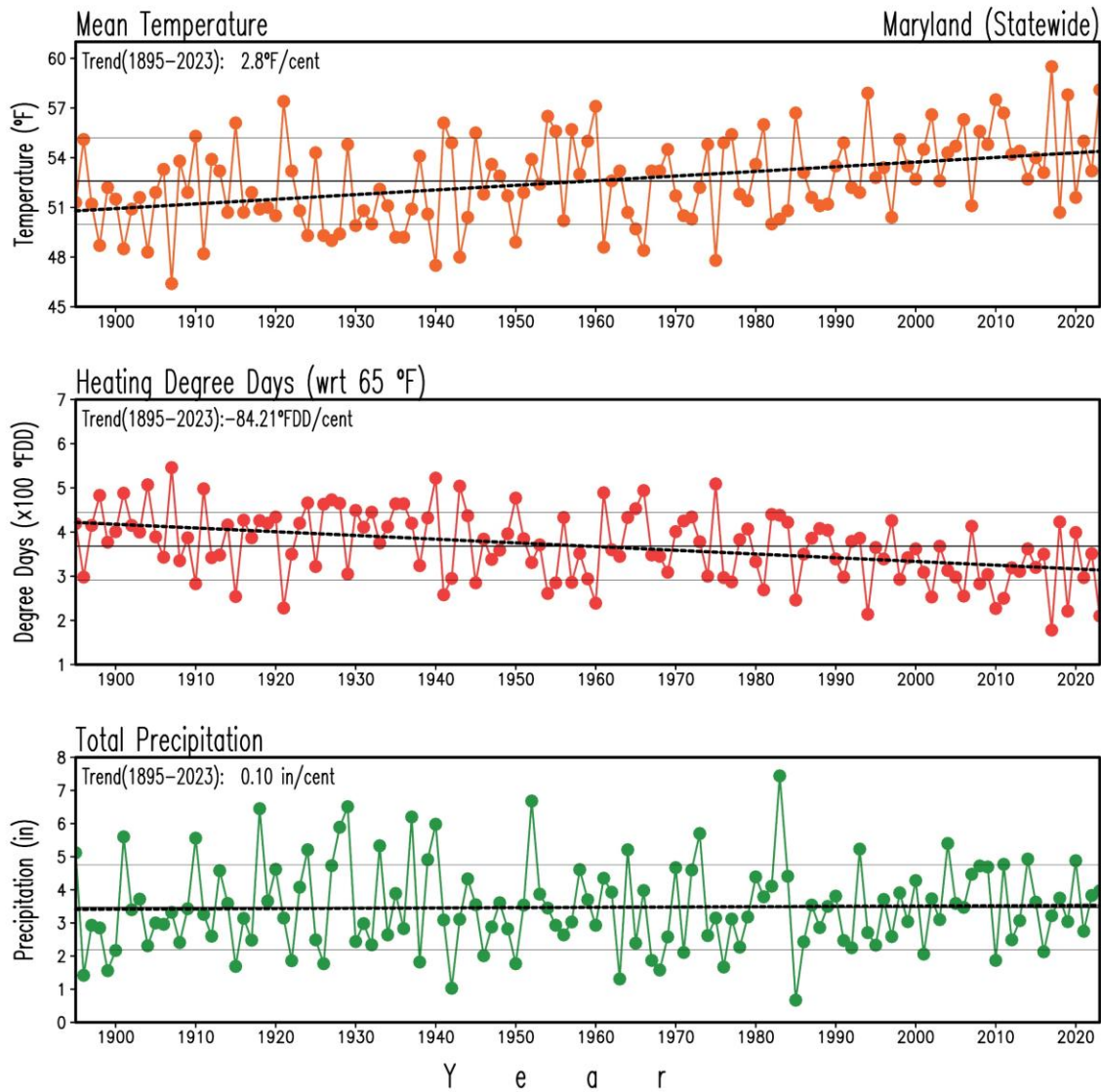
Figure 9. Maryland (statewide) mean surface air temperature, heating degree-days, and precipitation in April for the period 1895-2023. Temperature is in °F, heating degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (52.6°F, 367.97°FDD, and 3.47 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (2.6°F, 76.82°FDD, and 1.28 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 (2.8°F/century) and the decreasing heating degree-days (−84.21°FDD/century) trend are statistically significant at the 95% level (*Student's t-test* −Santer et al. 2000), but not the low precipitation trend (0.10 in/century).

B. Temperature and Precipitation Maps

Linear Trends in Monthly Mean Temperature in April, 1895–2023

Linear Trends in Monthly Total Precipitation in April, 1895–2023

Figure 10. Linear trends in surface air mean temperature and precipitation in April 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. April 2023 Tables: Statewide, Climate Divisions, and Counties

A.   Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)	Region	Total Precipitation (in)	Rank (#)
Statewide	58.1	128	Statewide	3.97	92
Climate Division 1	59.9	128	Climate Division 1	5.31	123
Climate Division 2	60.1	128	Climate Division 2	5.34	120
Climate Division 3	60.2	128	Climate Division 3	4.37	106
Climate Division 4	60.0	128	Climate Division 4	3.89	87
Climate Division 5	58.6	127	Climate Division 5	3.98	89
Climate Division 6	57.5	127	Climate Division 6	3.46	70
Climate Division 7	55.2	121	Climate Division 7	2.50	40
Climate Division 8	50.0	113	Climate Division 8	2.81	32
Allegany	54.4	116	Allegany	2.72	54
Anne Arundel	60.2	128	Anne Arundel	3.99	90
Baltimore	57.9	127	Baltimore	4.18	88
Baltimore City	59.9	127	Baltimore City	4.07	89
Calvert	59.8	128	Calvert	4.82	114
Caroline	59.4	128	Caroline	5.24	116
Carroll	56.5	128	Carroll	3.83	83
Cecil	57.4	127	Cecil	3.38	66
Charles	60.3	126	Charles	3.63	79
Dorchester	60.5	128	Dorchester	5.52	121
Fredrick	56.7	125	Fredrick	2.81	44
Garrett	50.0	113	Garrett	2.81	32
Harford	57.2	126	Harford	3.20	57
Howard	58.2	128	Howard	3.87	84
Kent	58.4	127	Kent	3.72	80
Montgomery	58.5	128	Montgomery	3.15	66
Prince George's	59.8	128	Prince George's	3.85	88
Queen Anne's	58.8	127	Queen Anne's	4.08	92
Saint Mary's	60.4	128	Saint Mary's	5.14	118
Somerset	60.5	128	Somerset	5.41	123
Talbot	60.0	128	Talbot	4.73	108
Washington	55.9	123	Washington	2.29	32
Wicomico	60.0	127	Wicomico	5.31	120
Worcester	59.3	127	Worcester	5.24	122

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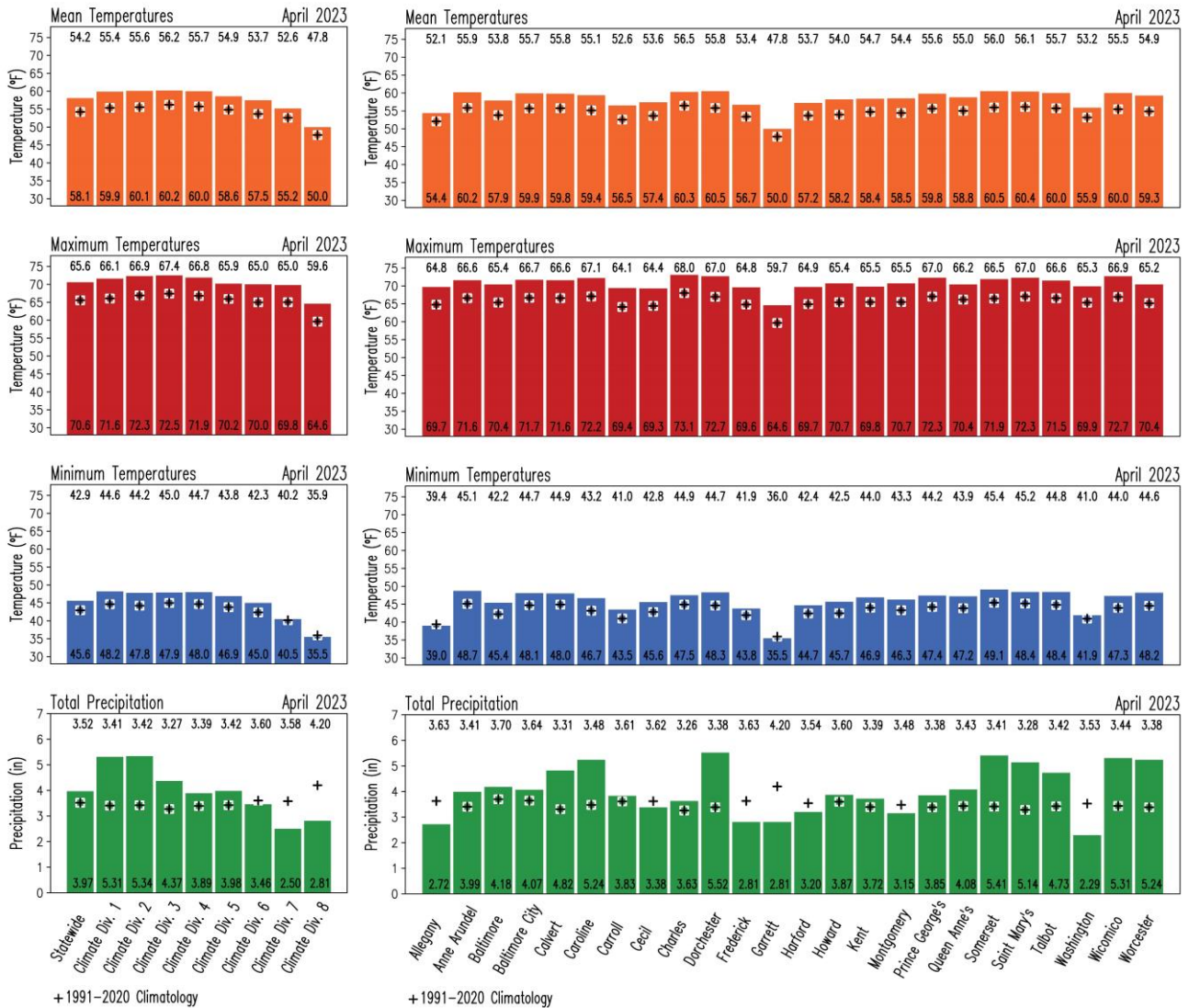
B.   Maximum and Minimum Temperatures

Region	Maximum Air Temperature (°F)	Rank (#)	Region	Minimum Air Temperature (F)	Rank (#)
Statewide	70.6	129	Statewide	45.6	124
Climate Division 1	71.6	129	Climate Division 1	48.2	127
Climate Division 2	72.3	129	Climate Division 2	47.8	127
Climate Division 3	72.5	129	Climate Division 3	47.9	124
Climate Division 4	71.9	129	Climate Division 4	48.0	125
Climate Division 5	70.2	126	Climate Division 5	46.9	125
Climate Division 6	70.0	129	Climate Division 6	45.0	124
Climate Division 7	69.8	124	Climate Division 7	40.5	97
Climate Division 8	64.6	124	Climate Division 8	35.5	80
Allegany	69.7	125	Allegany	39.0	77
Anne Arundel	71.6	129	Anne Arundel	48.7	127
Baltimore	70.4	128	Baltimore	45.4	126
Baltimore City	71.7	128	Baltimore City	48.1	126
Calvert	71.6	127	Calvert	48.0	125
Caroline	72.2	129	Caroline	46.7	127
Carroll	69.4	129	Carroll	43.5	124
Cecil	69.3	129	Cecil	45.6	126
Charles	73.1	129	Charles	47.5	124
Dorchester	72.7	129	Dorchester	48.3	127
Fredrick	69.6	125	Fredrick	43.8	122
Garrett	64.6	124	Garrett	35.5	80
Harford	69.7	128	Harford	44.7	124
Howard	70.7	128	Howard	45.7	126
Kent	69.8	125	Kent	46.9	125
Montgomery	70.7	126	Montgomery	46.3	125
Prince George's	72.3	129	Prince George's	47.4	125
Queen Anne's	70.4	126	Queen Anne's	47.2	127
Saint Mary's	72.3	129	Saint Mary's	48.4	125
Somerset	71.9	129	Somerset	49.1	127
Talbot	71.5	128	Talbot	48.4	128
Washington	69.9	125	Washington	41.9	112
Wicomico	72.7	129	Wicomico	47.3	126
Worcester	70.4	129	Worcester	48.2	127

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

A. Temperatures and Precipitation

Figure B1. Monthly surface variables in Maryland for April 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 April 2023. For comparison, the corresponding 1991-2020 climatological values for April are displayed as black addition signs, and their magnitude are shown at the top of the panels.
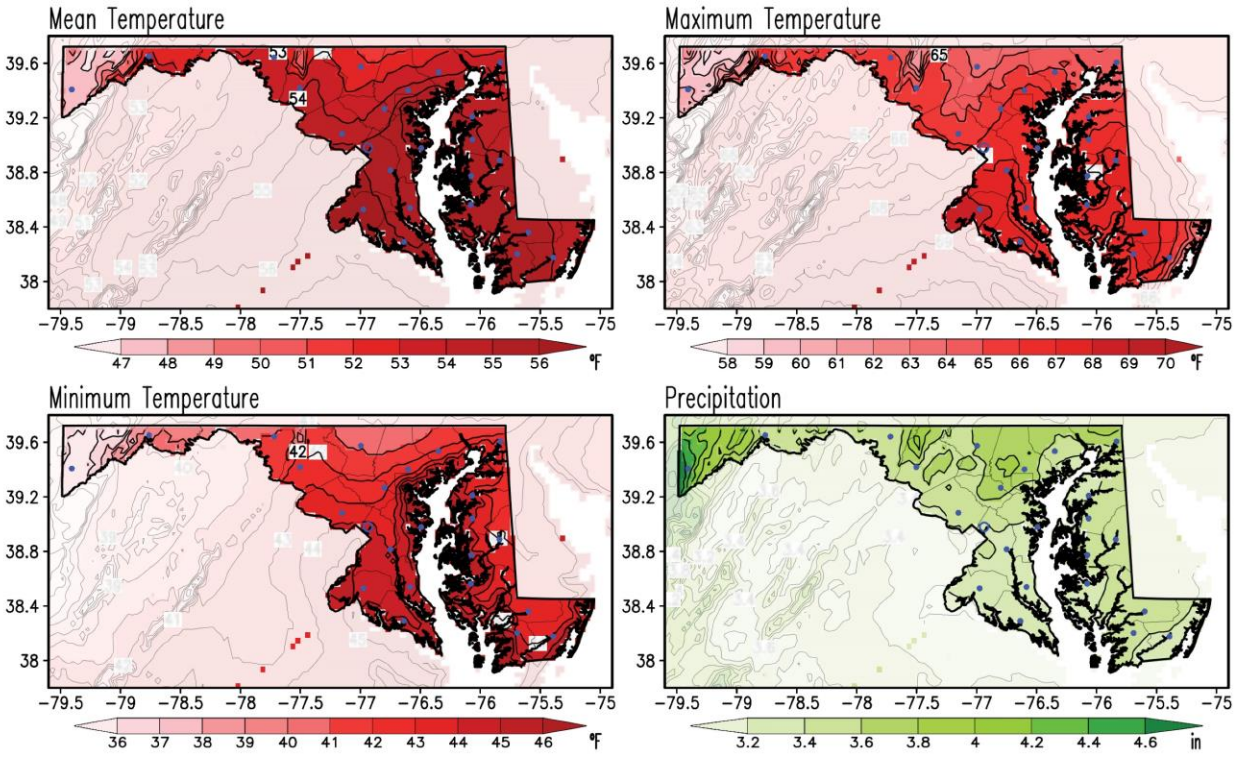
B.   Temperature and Precipitation Anomalies
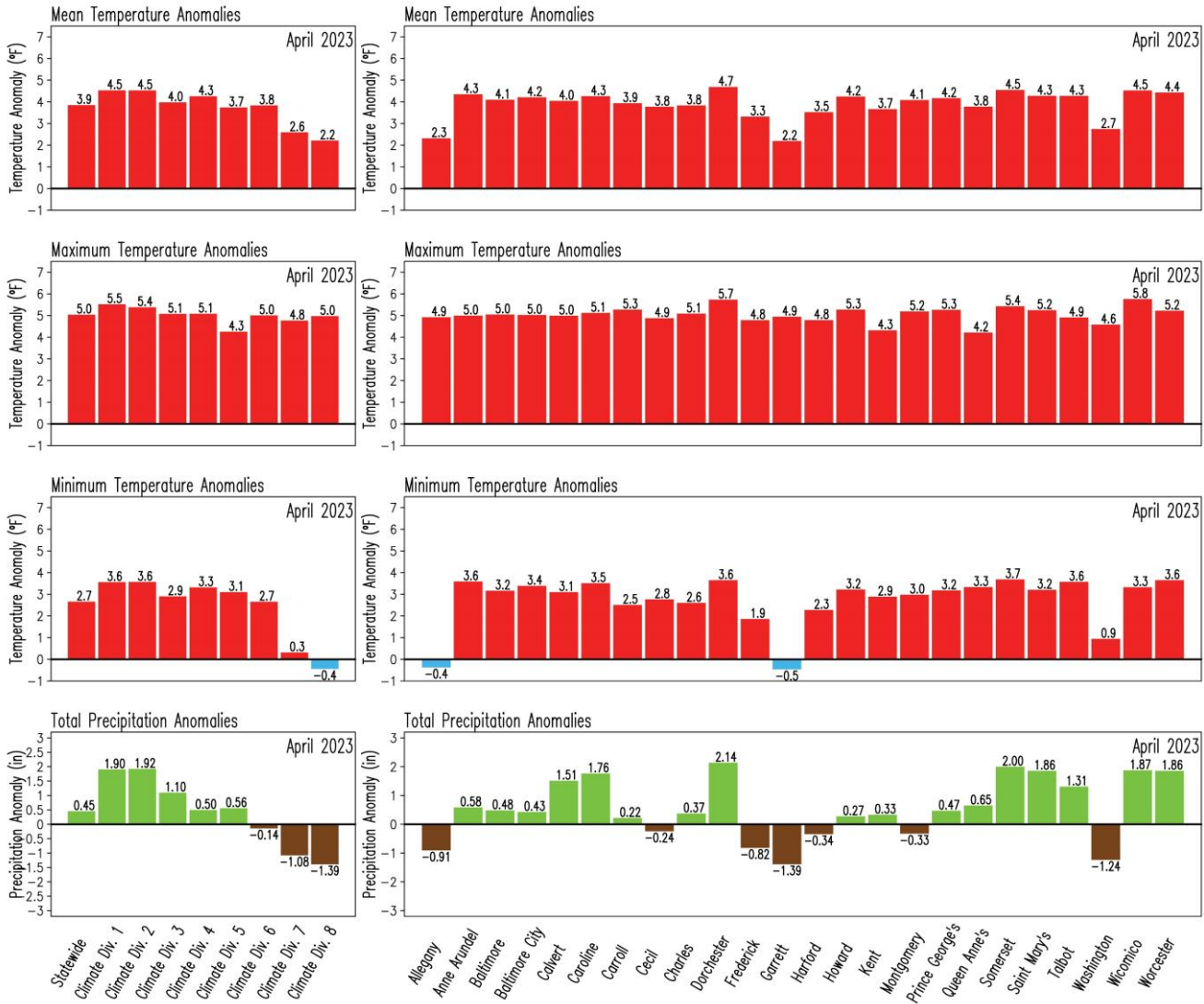
Figure B2. Anomalies of the monthly surface variables in Maryland for April 2023. Anomalies are with respect to the 1991-2020 climatology. Red/blue color represents warm/cold anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top) while green/brown color indicates wet/dry 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 April 2023.

Appendix C. April 1991-2020 Climatology Maps

Figure C1. April 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 April 2023 conditions are compared to obtain the April 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. April Standard Deviation and April 2023 Standardized Anomalies Maps
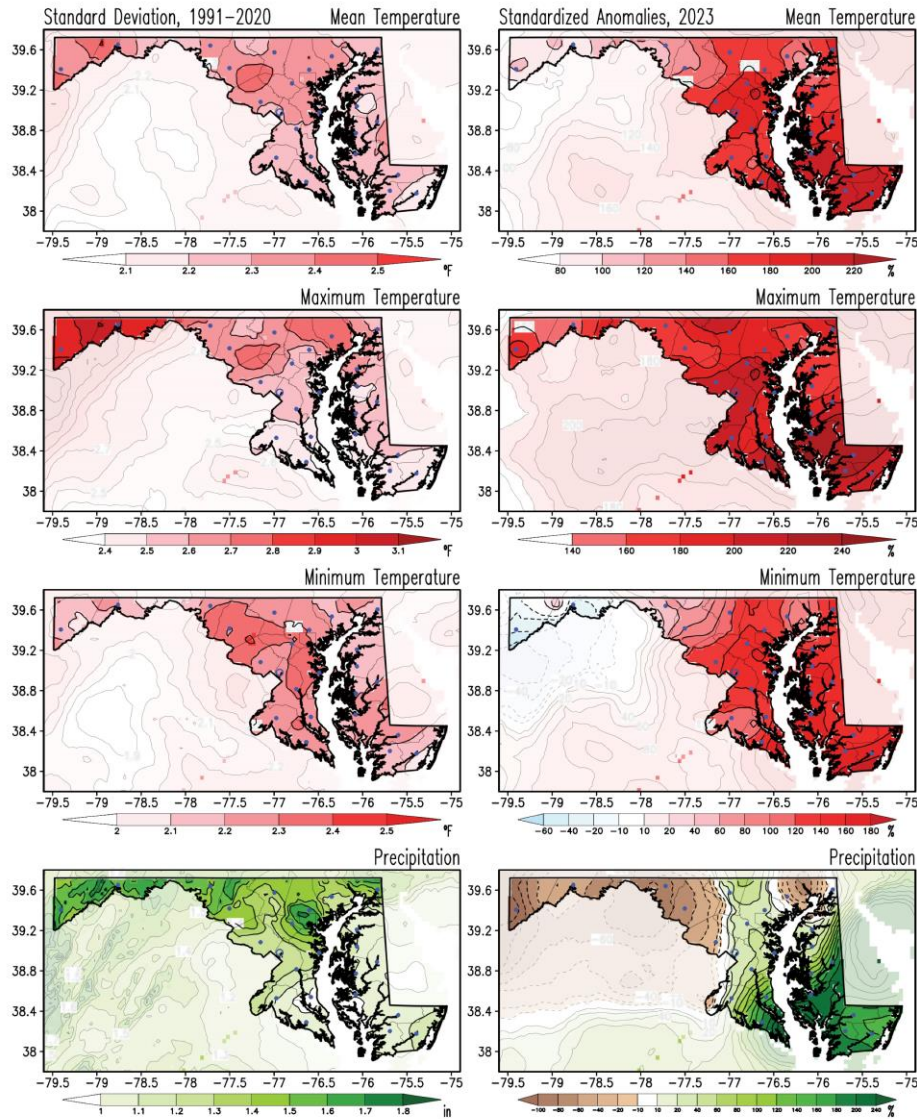
Figure D1. Standard deviation for April and standardized anomalies of temperatures and precipitation for April 2023. Standard deviations for monthly mean, maximum, and minimum surface air temperatures and total precipitation were obtained for the 1991-2020 period (left column). Anomalies for April 2023 (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.