Maryland Climate Bulletin
May 2023

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DEPARTMENT OF
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State
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Summary

Statewide averages show that May 2023 was colder and dryer than normal (i.e., 1991-2020 averages). Monthly mean temperatures were in the range of 53 to 64°F; maximum temperatures were between 65 to 75°F, and minimum temperatures were in the 40 to 54°F range. Monthly total precipitation was in the 0.4 to 4.8 inches range. In general, a colder and drier than normal May.

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

- Mean temperature was colder than normal everywhere, notably in Washington and Allegany counties (above 3°F).

- Maximum temperature was also colder than normal everywhere, especially over portions of Allegany County and portions of Charles, Calvert, and Saint Mary's counties (above 2.1°F).

- Minimum temperature was colder than normal everywhere, notably in the northern portions of Harford, Baltimore, Carroll, and Frederick counties, in the totality of Washington, and Allegany counties, and portions of Garrett County (above 4.0°F).

- Precipitation was below normal everywhere, especially over the Piedmont Province over portions of Montgomery, Frederick, Carroll, Harford, and Cecil counties, in the totality of Baltimore and Howard counties, and Baltimore City; and northern parts of Anne Arundel and Prince George's counties (above 3 inches).

- The extent of the surface in the state under drought conditions increased from around 53% at the beginning of May, to around 66% at the end of the month. Around 45% of the state is under abnormally dry conditions (especially over the north-central counties and northern counties around the Chesapeake Bay), and around 20% is under moderate drought. The much below-normal precipitation over the counties in the Piedmont Province has imposed moderate drought conditions in this region.   The return to below-normal precipitation over Charles and Prince George's counties has also led to moderate drought conditions in these counties.

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

- All eight climate divisions were colder and drier than normal. Climate divisions 1, 2, and 8, which were not under dry conditions on the drought monitor, were less dry than the others. Climate divisions 4 and 6, which were under moderate drought conditions, were the driest among all the divisions.

- Statewide temperature and precipitation anomalies have been zigzagging considerably since March. From warm and dry anomalies (1.6°F, −2.11 in) in March, to warmer and wet anomalies (3.9°F, 0.36 in) in April to cold and dry anomalies (−2.2°F, −2.31 in) in May.

Historical Context (Figure 8, Tables A1 and A2)

- May's mean, maximum, and minimum statewide temperatures (61.2, 72.8, and 49.7°F) were below the long-term (1895-2022) average and far from any records. May's precipitation (1.72 in) was below the long-term average and within 25% of the smallest values.
- Statewide precipitation in May 2023 was ranked eighth among the driest Mays on record. Baltimore City, Baltimore, and Howard counties experienced the driest May on record. Carroll, Harford, and Cecil counties had the third driest May; Anne Arundel, Frederick, and Kent counties had the fourth driest May; and Montgomery County had the fifth driest May on record.

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

- May statewide temperature, heating, and cooling degree days showed significant trends: a warming trend (1.0°F/century), a decreasing trend (−18.42°F degree-days), and an increasing trend (15.92°FDD), respectively. Statewide precipitation also had a significant increasing trend (0.77 in/century).
- Regionally, May temperatures showed significant warming trends almost everywhere. Notably, the largest trend is in Baltimore City (2.0°F/century), as in April. However, trends above 1.0°F/century are also evident in Baltimore and Howard counties, and portions of Harford, Carroll, Montgomery, Prince George's, and Anne Arundel counties; similar trends are also found in Caroline, Queen Anne's, Talbot, Dorchester, Wicomico, Somerset, and Worcester counties, and portions of Cecil and Kent counties.
- Regionally, May precipitation shows significant wet trends over the northern counties west of the Bay and the southeastern shore. The largest trends (above 1.0 in/century) are in Allegany and Garrett counties, and in the Piedmont Province, over Frederick, Montgomery, Howard, Carroll, Baltimore counties, and Baltimore City.

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 May 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, 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 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 6/10/2023.

- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20230606) at: https://www.ncei.noaa.gov/pub/data/cirs/climdiv/ Data was downloaded on 6/10/2023.

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

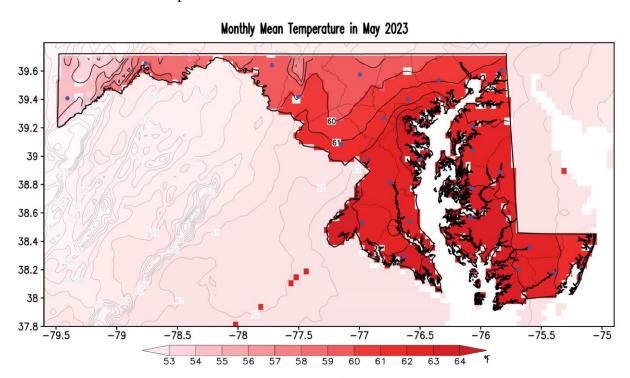The eight climate divisions in Maryland are:

- 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.   May 2023 Maps
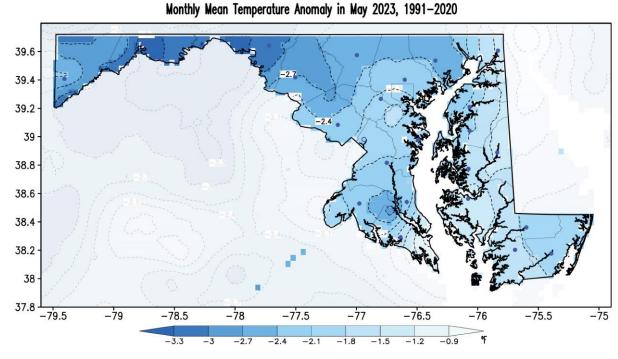
A.   Mean Temperatures

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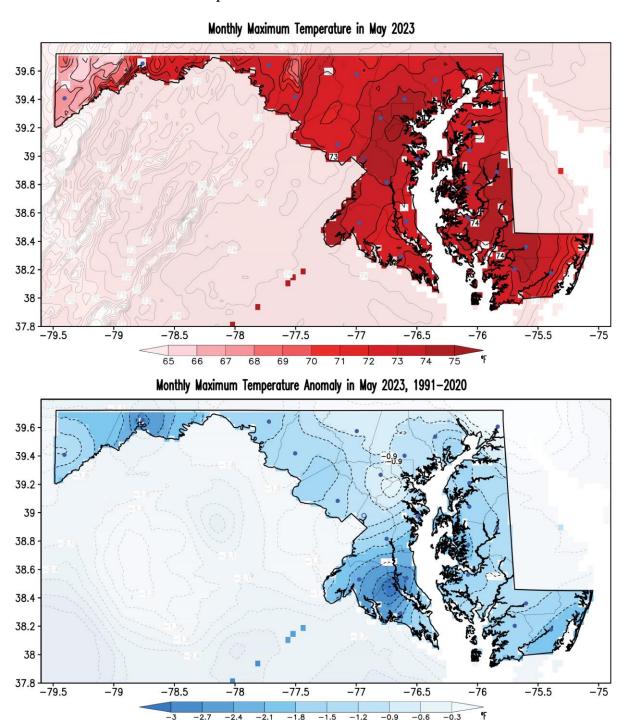
B.   Maximum Temperatures

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

Monthly Minimum Temperature in May 2023

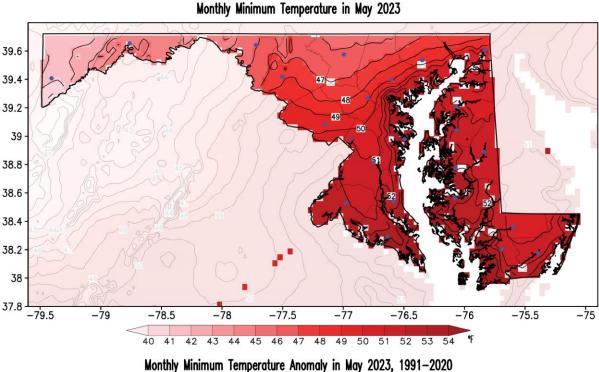### Monthly Minimum Temperature Anomaly in May 2023, 1991−2020
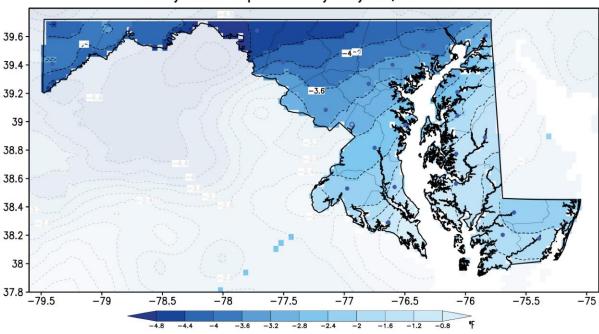
Figure 3. Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for May 2023. Temperatures are in °F following the color bar. Blue shading in the anomaly map marks colder than normal conditions. Note shading outside the state has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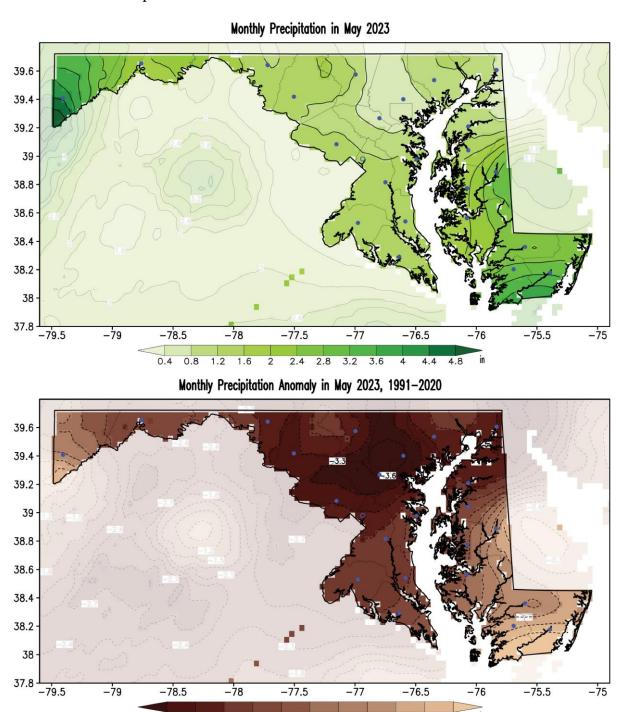
D.   Precipitation

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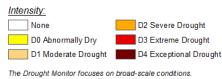
E.   Drought

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on May 30, 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. May and MAM 2023 Climate Divisions Averages

A. May 2023 Scatter Plots

Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for May 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 (3.61 inches in CD8, top panel) and by the maximum precipitation anomaly (|-3.12| inches in CD6, 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.
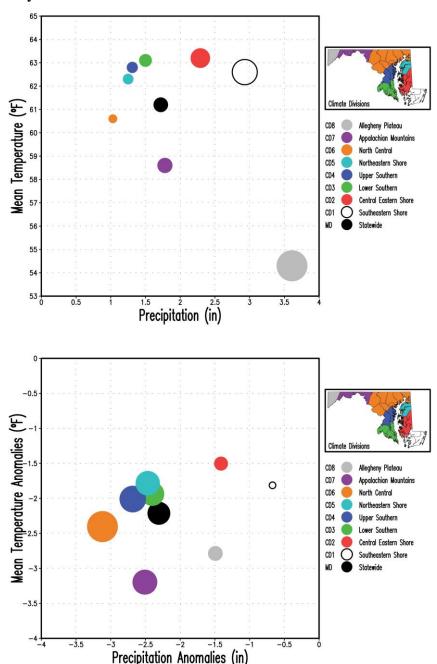
B.   March-May 2023 Scatter Plots

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for March, April, and May 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 (4.98 inches in CD2 in April, top panel) and by the maximum precipitation anomaly (|-3.12| inches in CD6 in May, bottom panel) among the nine regions and three months. May is displayed with filled circles only, while April and March are displayed with superposed multiplication and addition signs, respectively.

5.   May 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 May for the period 1895-2022. The label and asterisk in purple represent conditions for May 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.

6. 1895-2023 May Trends

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

Figure 9. Maryland (statewide) mean surface air temperature, heating degree-days, cooling degree-days, and precipitation in May for the period 1895-2023. Temperature is in °F, heating/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 (62.6°F, 122.32°FDD, 55.64°FDD, and 3.82 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (2.6°F, 47.74°FDD, 33.85°FDD, and 1.52 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 and 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 (1.0°F/century), the decreasing heating degree-days trend (−18.42°FDD/century), the increasing cooling degree-days trend (15.92°FDD/century), and the increasing precipitation trend (0.77 in/century) are statistically significant at the 95% level (*Student's t-test* −Santer et al. 2000).

B.   Temperature and Precipitation Maps

Linear Trends in Monthly Mean Temperature in May, 1895−2023

Linear Trends in Monthly Total Precipitation in May, 1895−2023

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

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)	Region	Total Precipitation (in)	Rank (#)
Statewide	61.2	44	Statewide	1.72	8
Climate Division 1	62.6	54	Climate Division 1	2.93	54
Climate Division 2	63.2	57	Climate Division 2	2.29	31
Climate Division 3	63.1	47	Climate Division 3	1.50	10
Climate Division 4	62.8	45	Climate Division 4	1.31	6
Climate Division 5	62.3	50	Climate Division 5	1.25	6
Climate Division 6	60.6	39	Climate Division 6	1.03	3
Climate Division 7	58.6	19	Climate Division 7	1.78	14
Climate Division 8	54.3	31	Climate Division 8	3.61	50
Allegany	58.1	23	Allegany	2.13	23
Anne Arundel	63.1	48	Anne Arundel	1.17	4
Baltimore	61.0	45	Baltimore	0.69	1
Baltimore City	63.0	54	Baltimore City	0.63	1
Calvert	62.7	45	Calvert	1.50	10
Caroline	62.8	58	Caroline	2.59	41
Carroll	59.5	37	Carroll	1.07	3
Cecil	61.3	52	Cecil	0.90	3
Charles	63.0	43	Charles	1.45	8
Dorchester	63.5	57	Dorchester	2.14	28
Fredrick	59.8	29	Fredrick	1.35	4
Garrett	54.3	31	Garrett	3.60	49
Harford	60.8	36	Harford	1.02	3
Howard	60.9	45	Howard	0.84	1
Kent	62.1	49	Kent	0.95	4
Montgomery	61.0	39	Montgomery	1.21	5
Prince George's	62.5	44	Prince George's	1.35	8
Queen Anne's	62.5	53	Queen Anne's	1.39	7
Saint Mary's	63.3	52	Saint Mary's	1.57	11
Somerset	63.4	58	Somerset	3.13	65
Talbot	63.1	54	Talbot	1.94	17
Washington	59.2	25	Washington	1.45	6
Wicomico	62.7	55	Wicomico	2.56	39
Worcester	62.0	50	Worcester	3.06	64

Table A1. Monthly mean surface air temperature (left) and total precipitation (right) at Maryland (statewide), climate division, and county levels for May 2023. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for May 2023 occupies among the 129 Mays 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	72.8	51	Statewide	49.7	31
Climate Division 1	73.0	57	Climate Division 1	52.3	53
Climate Division 2	73.9	53	Climate Division 2	52.5	68
Climate Division 3	73.2	35	Climate Division 3	53.0	61
Climate Division 4	73.9	49	Climate Division 4	51.7	37
Climate Division 5	73.2	52	Climate Division 5	51.4	55
Climate Division 6	73.0	56	Climate Division 6	48.3	25
Climate Division 7	72.2	42	Climate Division 7	45.1	13
Climate Division 8	66.8	36	Climate Division 8	41.7	25
Allegany	71.6	37	Allegany	44.5	17
Anne Arundel	74.0	52	Anne Arundel	52.2	38
Baltimore	73.6	61	Baltimore	48.4	25
Baltimore City	74.8	67	Baltimore City	51.3	35
Calvert	72.4	34	Calvert	53.0	57
Caroline	74.3	57	Caroline	51.3	66
Carroll	72.5	57	Carroll	46.4	20
Cecil	73.0	62	Cecil	49.5	26
Charles	73.6	36	Charles	52.4	49
Dorchester	74.0	55	Dorchester	53.1	69
Fredrick	72.4	53	Fredrick	47.3	15
Garrett	66.9	36	Garrett	41.7	25
Harford	72.9	52	Harford	48.7	20
Howard	73.5	60	Howard	48.3	26
Kent	72.9	52	Kent	51.4	45
Montgomery	72.8	52	Montgomery	49.3	29
Prince George's	73.9	48	Prince George's	51.1	37
Queen Anne's	73.3	50	Queen Anne's	51.6	56
Saint Mary's	72.9	37	Saint Mary's	53.7	68
Somerset	73.3	54	Somerset	53.4	58
Talbot	73.3	46	Talbot	52.9	65
Washington	72.7	46	Washington	45.7	12
Wicomico	74.0	59	Wicomico	51.5	52
Worcester	72.0	55	Worcester	52.0	46

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

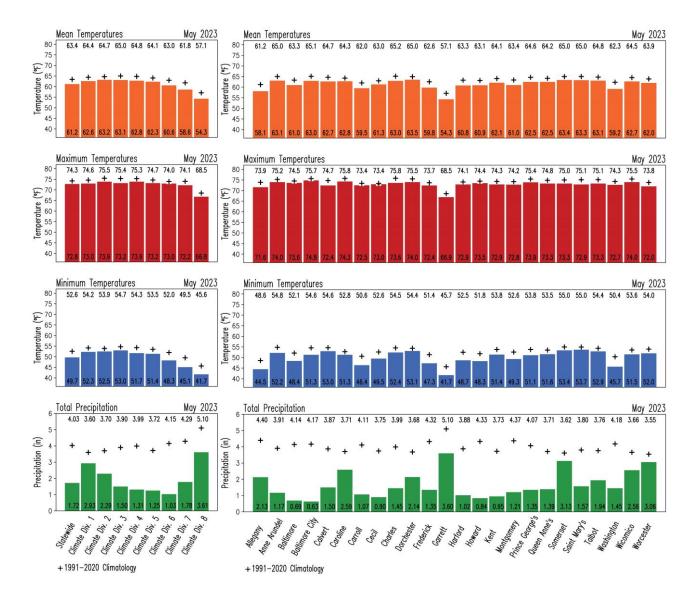## A. Temperatures and Precipitation

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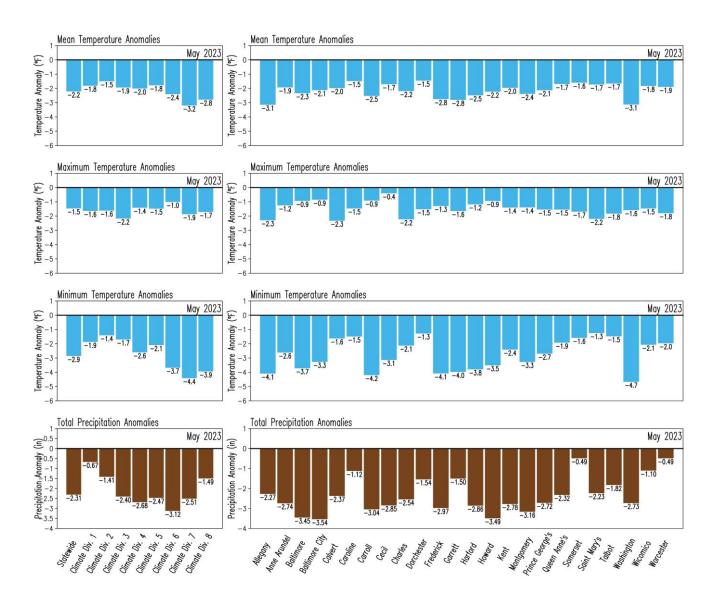
B.   Temperature and Precipitation Anomalies

Figure B2. Anomalies of the monthly surface variables in Maryland for May 2023. Anomalies are with respect to the 1991-2020 climatology. Blue color represents 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 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 May 2023.
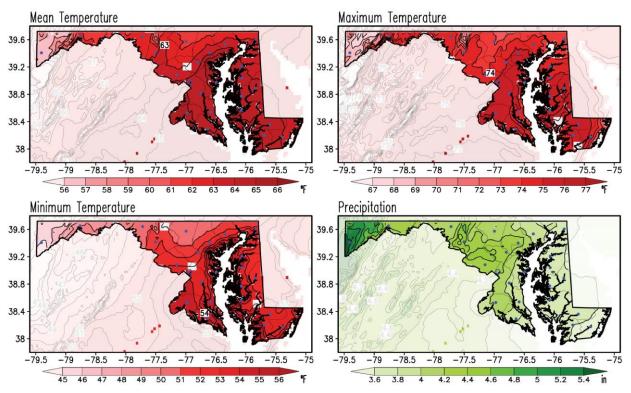
Appendix C. May 1991-2020 Climatology Maps

Figure C1. May 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 May 2023 conditions are compared to obtain the May 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. May Standard Deviation and May 2023 Standardized Anomalies Maps
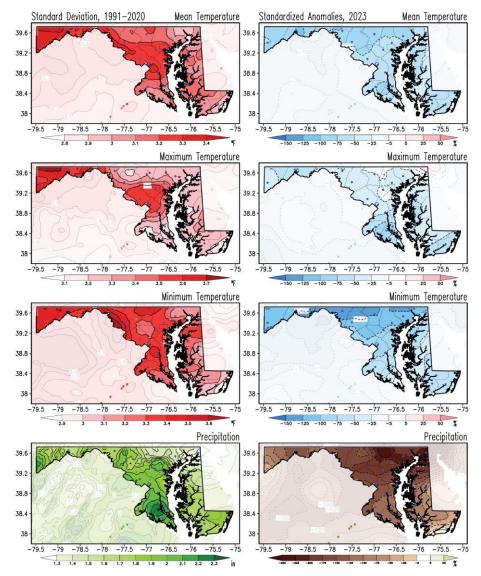

Figure D1. Standard deviation for May and standardized anomalies of temperatures and precipitation for May 2023. Standard deviations for monthly mean, maximum, and minimum surface air temperatures and total precipitation were obtained for the 1991-2020 period (left column). Anomalies for May 2023 (right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

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