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Maryland Climate Bulletin
Summer 2024

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DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE
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Summary

Summer 2024 was warmer and drier than normal (i.e., 1991-2020 averages), starting with a warmer and drier June followed by a warmer and drier than normal July that changed to a warmer and wetter than normal August. Seasonal mean temperatures were between 68 and 80°F, maximum temperatures were in the 79−89°F range, and minimum temperatures were between 56 and 70°F. Seasonal accumulated total precipitation was in the 8−14 inches range.

Maryland Regional Features (Figures 1-5, C1, and E1)

- The mean temperature was warmer than normal everywhere in the state, particularly over parts of Baltimore, Carroll, Howard, Anne Arundel counties, Baltimore City, and western Charles County (2.2−2.4°F), Garrett County, and parts of Saint Mary's, Calvert, and Dorchester counties (around 2.0°F), and eastern Kent and Queen Anne's counties (around 1.8°F).

- The maximum temperature was also warmer than normal in the entire state, especially between Allegany and Washington counties (3.6−4.2°F), over Garrett County, portions of Carroll, Baltimore, Howard, Anne Arundel counties, and Baltimore City (2.7−3.0°), and the southern tip of Saint Mary's and Calvert counties (around 2.7°F).

- The minimum temperature was warmer than normal over most of the state, notably over Frederick and Washington counties and western Charles County (2.0−2.2°F), and Baltimore, Howard, Anne Arundel counties, Baltimore City, and Kent and Queen Anne's counties (1.8−2.0°). Slightly below normal temperatures appeared over Allegany and western Washington counties (around −0.4°F) and Wicomico, Somerset and Worcester counties.

- Precipitation was below normal over large areas in the state, particularly over southwestern Garrett County (more than 5 inches deficit), southern parts of Calvert, Saint Mary's, and Dorchester counties (4−5 inches deficit), and Kent and Queen Anne's counties (2−3 inches deficit). These regions had around 20−30% less rainfall than their climatological summer precipitation. The northern counties of Washington, Frederick, Carroll, and Baltimore had above-normal precipitation, around 5−15% more than their climatological precipitation.

- The partial water year 2024 (October 2023−August 2024) was above normal over large areas of the state, especially over Baltimore City, parts of Baltimore and Harford counties (5−5.5 in), portions of Frederick, Washington, and Cecil counties (4.5−5 in), and parts of Kent and Queen Anne's counties (4−4.5 in). These regions had around 9−13% more water than their climatological amounts at this time of the year. On the other hand, southwestern Garrett County and western Charles counties had around 5−13% less water than their climatological amounts.

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

- All eight climate divisions were warmer and drier than normal. Climate division 6, the North Central, had the largest mean temperature departure from normal (2.0°F), while climate division 1, the Southeastern Shore, had the smallest (0.6°F). Climate Division 8, Allegheny Plateau, had the largest deviation from normal maximum temperature (3.0°F), and Climate Division 5, Northeastern Shore, had the largest departure from normal minimum temperature (1.8°F). Climate Division 8 also had the largest departure from normal precipitation (−4.03 in), while Climate Division 6 had the smallest departure from normal (−0.34 in).

- Seasonally, statewide mean temperature anomalies (1.7°F) have remained warmer than normal since fall 2023, with the largest anomalies in winter 2023-24 (3.7°F). Statewide precipitation anomalies changed from above normal in winter 2023-24 (4.84 in) and spring (1.25 in) to below normal in summer (1.78 inches deficit).

Historical Context (Figure 8, Tables A1 and A2)

- Summer 2024's statewide mean, maximum, and minimum temperatures (76.2, 86.9, and 65.6°F) were above the long-term (1895-2023) averages and equal to or above the 5% of the highest recorded values for the season and close to the warmest records. The warmest records since 1895 in statewide mean, maximum, and minimum temperatures of 77.2, 87,9, and 66.6°F were reached in 2010. Statewide, the mean, maximum, and minimum temperatures in summer 2024 were the fourth, fifth, and seventh warmest since 1895. Summer's statewide precipitation (11.01 in) was below the long-term average but far from the driest summer of 1966 (5.29 in). Statewide precipitation in summer 2024 was the fortieth driest on record.
- Summer 2024's mean temperatures at the county level were among the five warmest summers for fifteen of the twenty-three counties: Baltimore, Frederick, Howard, Montgomery, and Washington counties had the second warmest summer; Carroll, Prince George's, and Saint Mary's had the third warmest; Anne Arundel, Calvert, Charles, Harford, and Kent had the fourth warmest; and Cecil and Queen Anne's got the fifth warmest.
- Summer 2024's maximum temperatures at the county level were among the five warmest for eight counties: Allegany, Baltimore, and Howard counties had the second warmest summer; Montgomery and Frederick counties had the third and fourth warmest summers; Carroll, Charles, and Saint Mary's got their fifth warmest summer on record.
- Summer 2024's minimum temperatures at the county level were among the five warmest for twelve counties: Queen Anne's had the third warmest summer; Frederick, Howard, Kent, and Montgomery counties had the fourth warmest summer; Baltimore, Cecil,

Charles, Harford, Prince George's, Talbot, and Washington counties got their fifth warmest summer on record.

- Summer 2024's precipitation at the county level only had Garrett County as the eleventh driest.

Century-Plus Trends, 1895-2024 (Figures 9, 10)

- Statewide mean temperature and cooling degree days in summer showed a significant warming trend (1.9°F/century) and an increasing cooling trend (186.3°FDD/century), respectively. On the other hand, statewide accumulated total precipitation displayed a non-significant drying trend (−0.22 in/century), while the partial water year presented a non-significant increasing trend (2.09 in/century).
- Regionally, summer mean temperatures showed significant warming trends over most of the state. The largest trends are found over the urban corridor from southern Montgomery and northern Prince George's counties to central Baltimore and southern Harford counties (larger than 2.4°F/century), with a maximum over Baltimore City (3.0°F/century). Significant, slightly smaller trends are also found over the Eastern Shore (around 2.4°F/century).
- Regionally, accumulated total precipitation in summer showed patches of drying and wetting trends. However, the only significant trends were drying trends (between −1.2 and −1.4 in/century) between western Frederick and eastern Washington 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. This is the seasonal version of the bulletin.

Maryland's geography is challenging, with the Allegheny and Blue Ridge mountains to the west, the 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 seasonal surface climate conditions, placing them in the context of regional and continental climate variability and change to help Marylanders interpret and understand recent climate conditions.

The seasonal surface climate conditions for summer 2024 are presented via maps of key variables, such as average surface air temperature, maximum surface air temperature, minimum surface air temperature, accumulated total precipitation, and their anomalies (i.e., departures from normal); they are complemented by partial water year conditions for the state (Section 3). Statewide and climate division averages for the season are compared against each other via scatter plots (Section 4). The seasonal 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, accumulated total precipitation, partial water year, and state maps of air temperature and accumulated total precipitation are presented in Section 6. Ancillary statewide, climate division, and county-level information are provided via tables and plots in Appendices A-B; climatology and variability maps are in Appendices C-E.

2. Data & Methods

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). It is available in a preliminary status at: https://www.ncei.noaa.gov/data/nclimgrid-monthly/access/
  Data was downloaded on 9/11/2024.

- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014). It is available in a preliminary status (v1.0.0) at: https://www.ncei.noaa.gov/pub/data/cirs/climdiv/
  Data was downloaded on 9/10/2024.

Some definitions:

About the seasons: Seasons are defined following the common three-month meteorological definitions. Spring includes March, April, and May; summer includes June, July, and August; fall includes September, October, and November; and winter includes December, January, and February. Seasonal temperatures are obtained as the mean of the temperatures in the three months, while seasonal precipitation and degree days are obtained as the sum of their values in the three months (which in turn were obtained as the sum of their daily values).

About climate and climatology. Weather and climate are closely related, but they are not the same. Weather represents the state of the atmosphere (temperature, precipitation, 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). The current climate normal, or just the climatology, is defined for 1991–2020.

About the anomalies: Anomalies for a given season (e.g., summer 2024) are the departures of the seasonal value from the corresponding climatology; in this case, the 1991-2020 climatology. When the observed seasonal 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 variability. The monthly standard deviation of a climate variable measures its dispersion relative to its monthly mean and assesses its 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.

About degree days. Degree days are the difference between the daily mean temperature (high temperature plus low temperature divided by two) and a predefined base temperature; because energy demand is cumulative, degree-day totals are usually calculated on a daily, monthly, seasonal, and annual basis.

- *Heating and cooling degree days*. These are used to get a general idea of how much energy is required to warm or cool buildings. The base temperature used for this purpose is 65°F, considered tolerable for human comfort (CPC, 2023).

About the water year. The water year is the sum of total precipitation from the 1st of October to the 30th of September of the next year and is labeled by the year in which the measurements end; so, the water year 2024 started in October 2023 and will end in September 2024. Total precipitation in the complete water year reflects winter snow accumulation and summer rainfall. Precipitation that falls during a water year reflects how much water will contribute to actual stream flow and groundwater inputs for that year. This issue presents only the partial water year from October to August from the total monthly precipitation data.

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. Summer 2024 Maps

A. Mean Temperatures

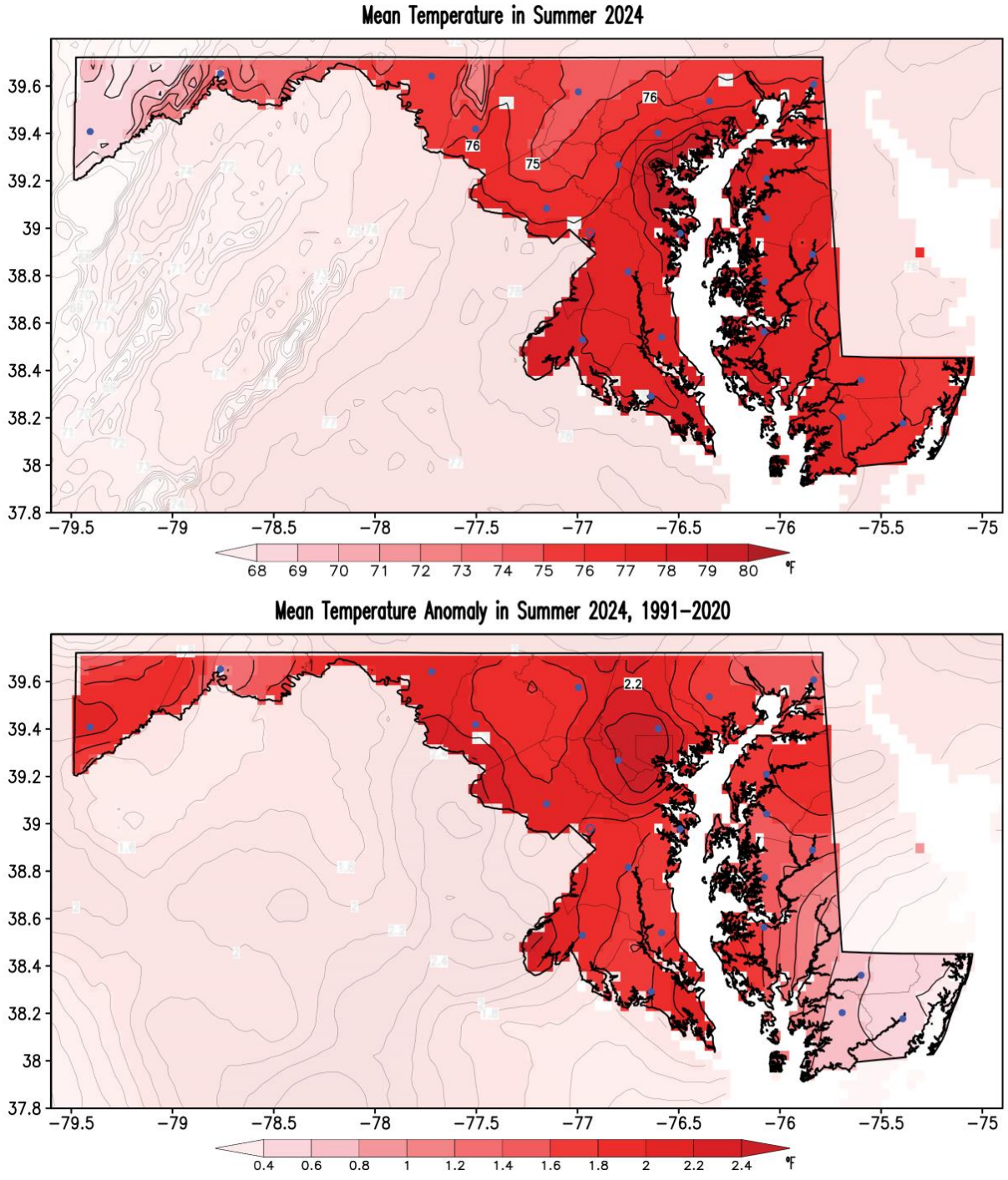

Figure 1. Seasonal mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for summer 2024. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

B. Maximum Temperatures

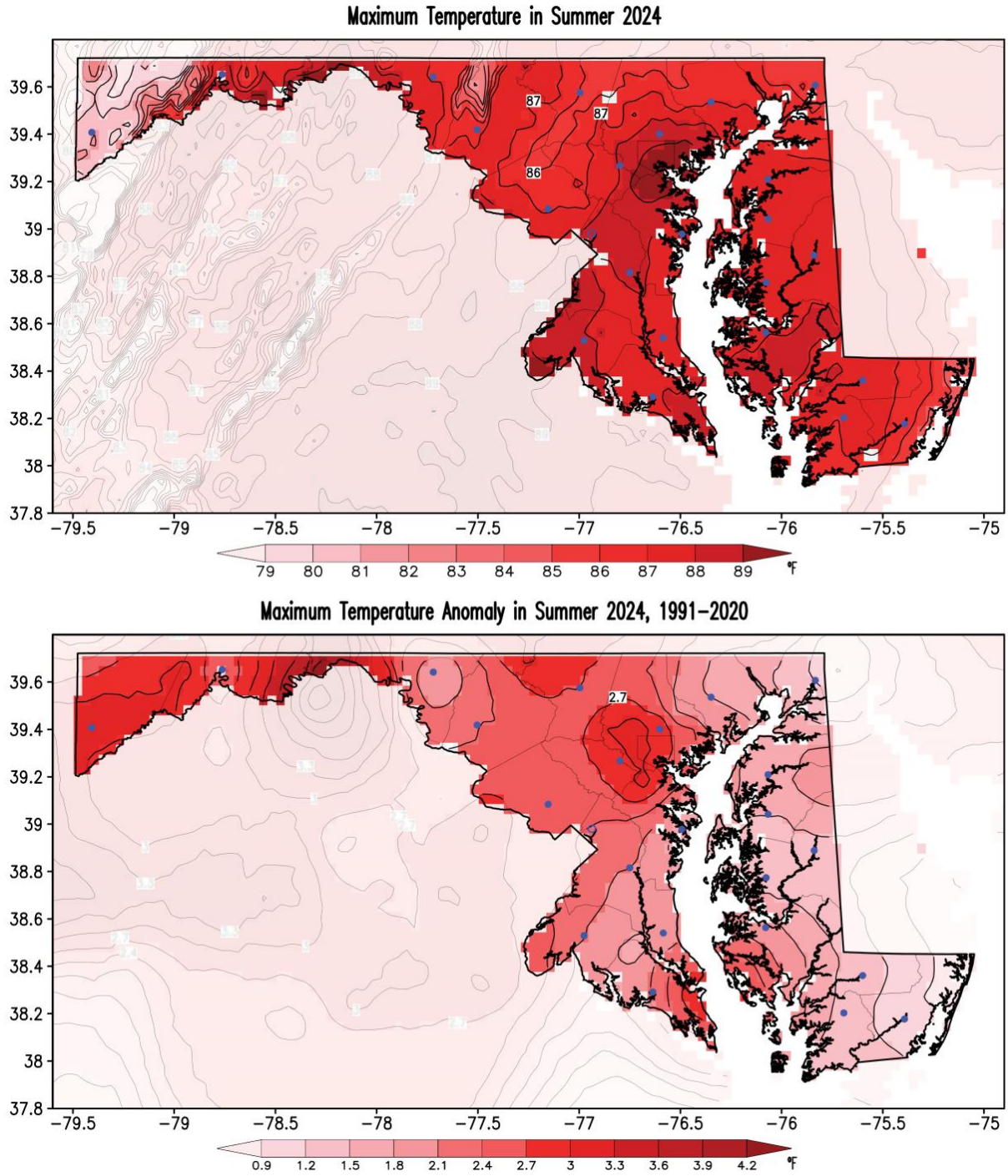

Figure 2. Seasonal maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for summer 2024. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

C. Minimum Temperatures

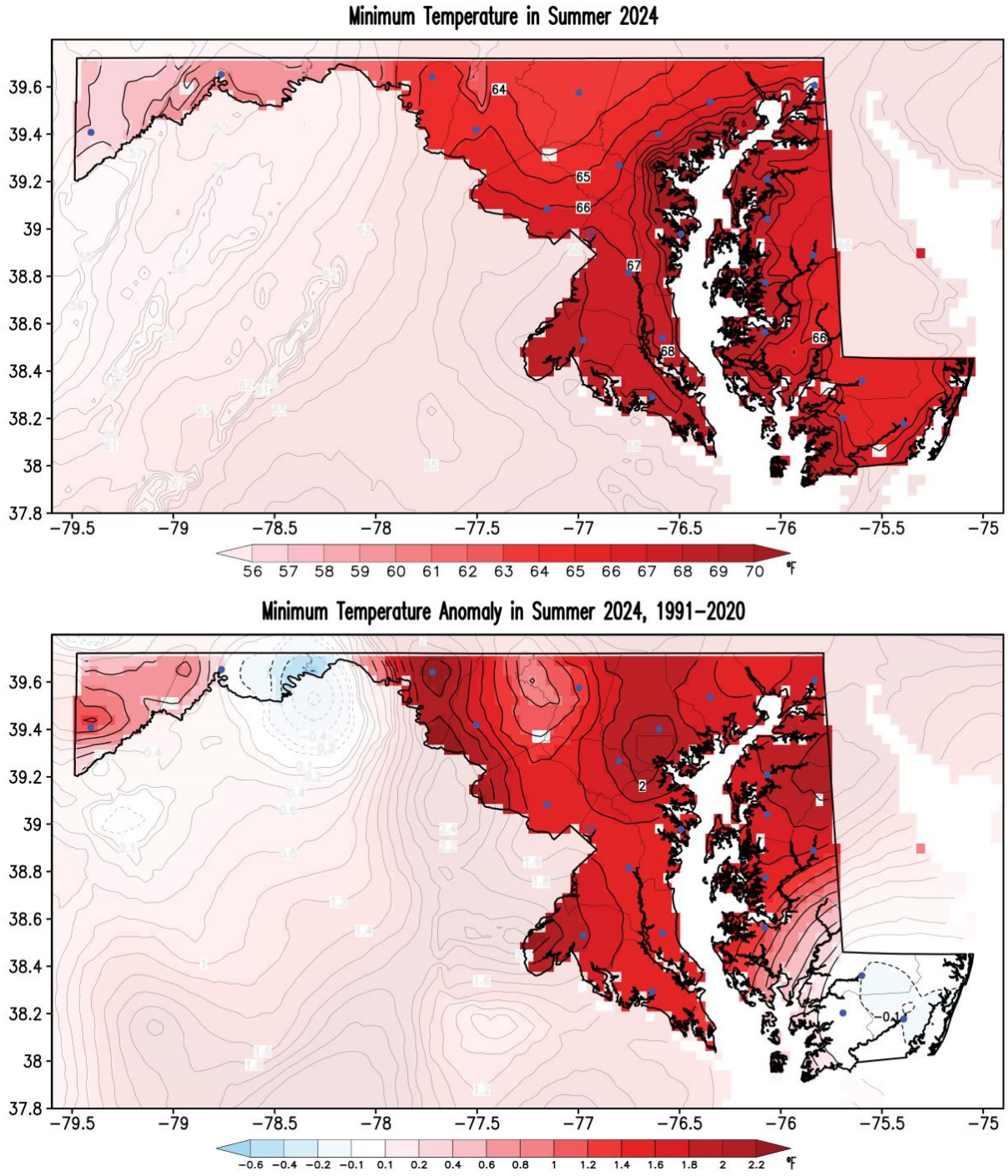

Figure 3. Seasonal minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for summer 2024. Temperatures are in °F following the color bar. Blue/red shading in the anomaly map marks colder/warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

D. Precipitation

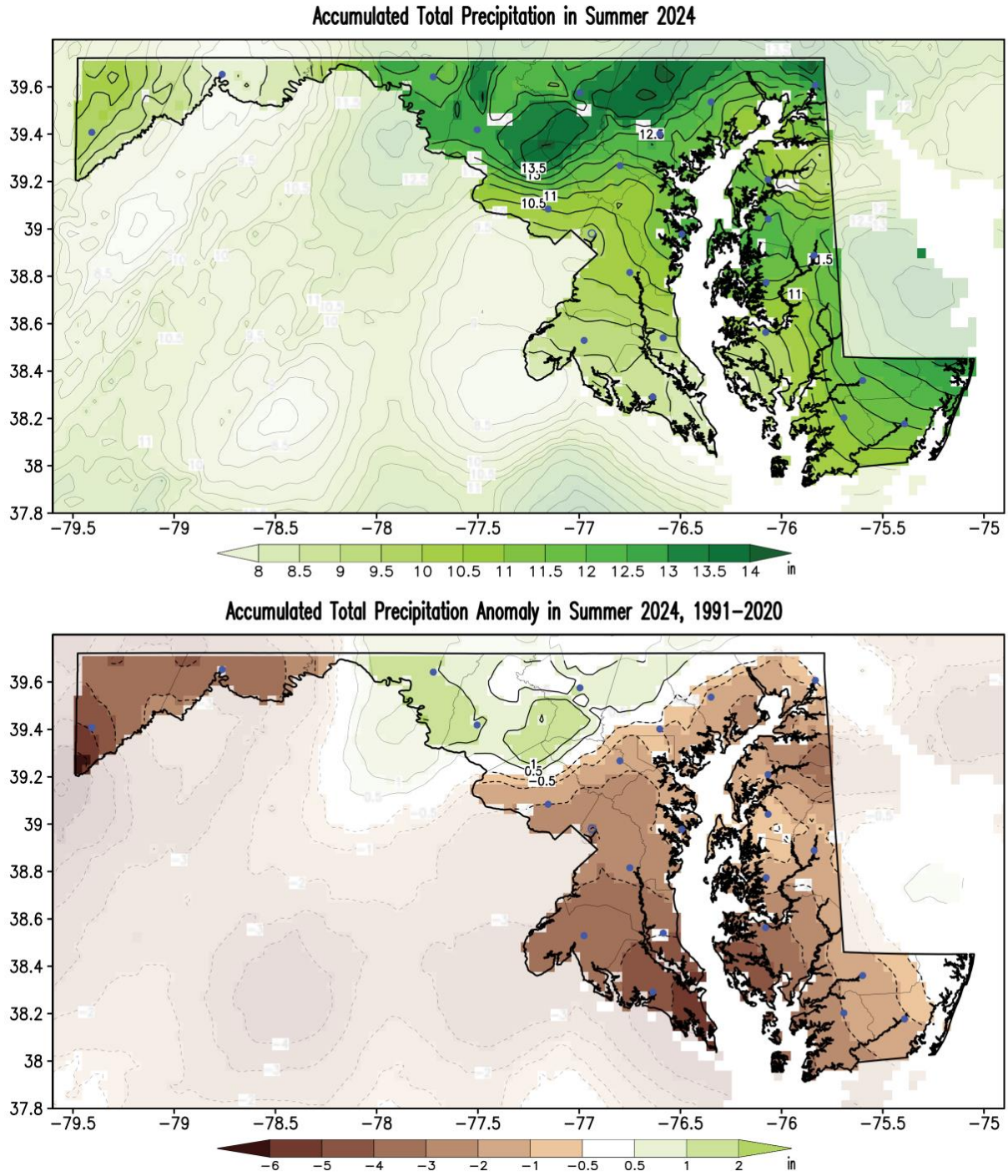

Figure 4. Seasonal accumulated total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for summer 2024. Precipitation is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

E. Partial Water Year (October 2023 – August 2024)

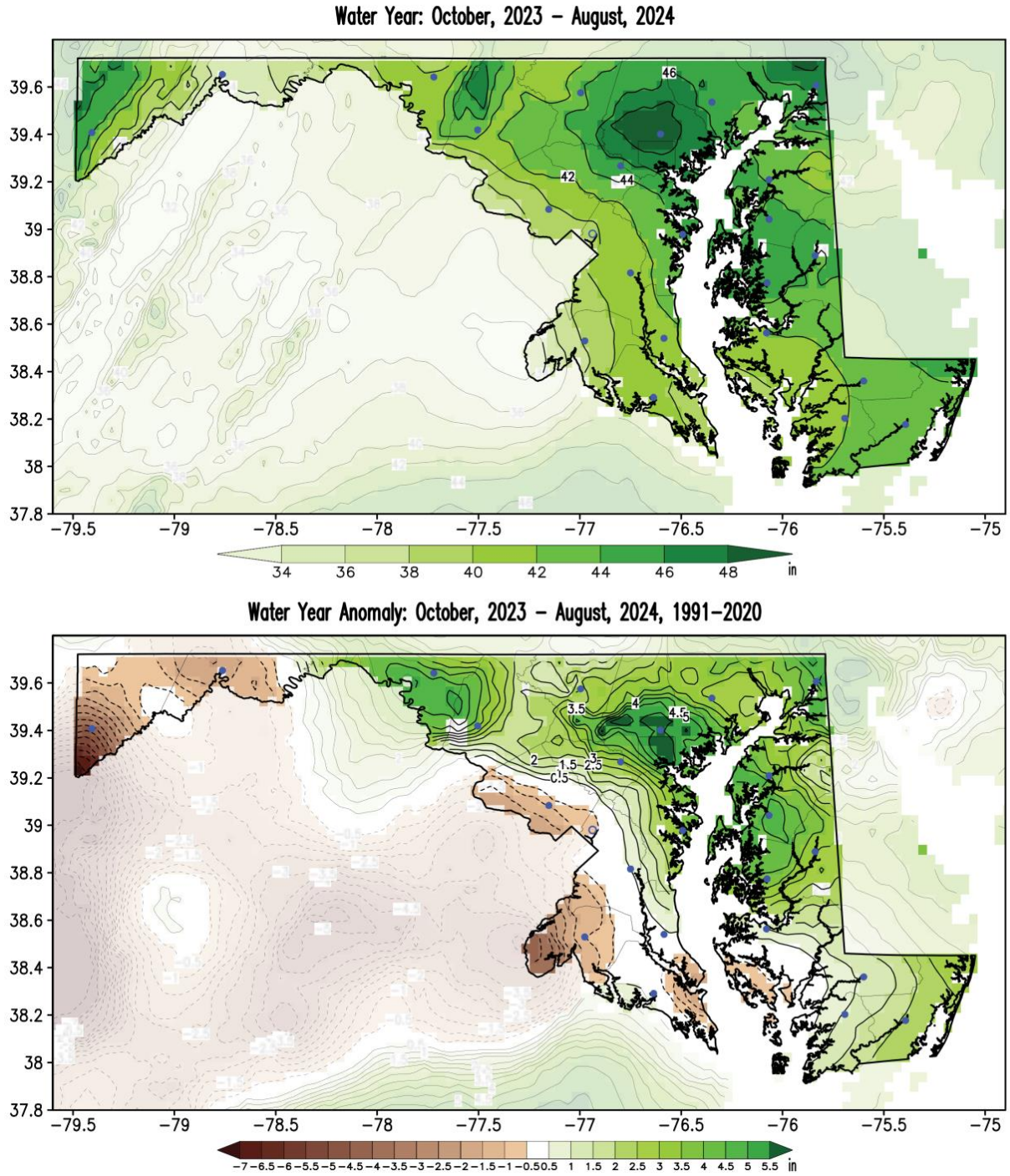

Figure 5. Partial water year until August 2024 (top panel), and its anomaly with respect to the 1991-2020 climatology (bottom panel). Water year is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. The current maps display the partial conditions from October 2023 to August 2024. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

4. Summer and Winter 2023-24–Summer 2024 Climate Divisions Averages

A. Summer 2024 Scatter Plots

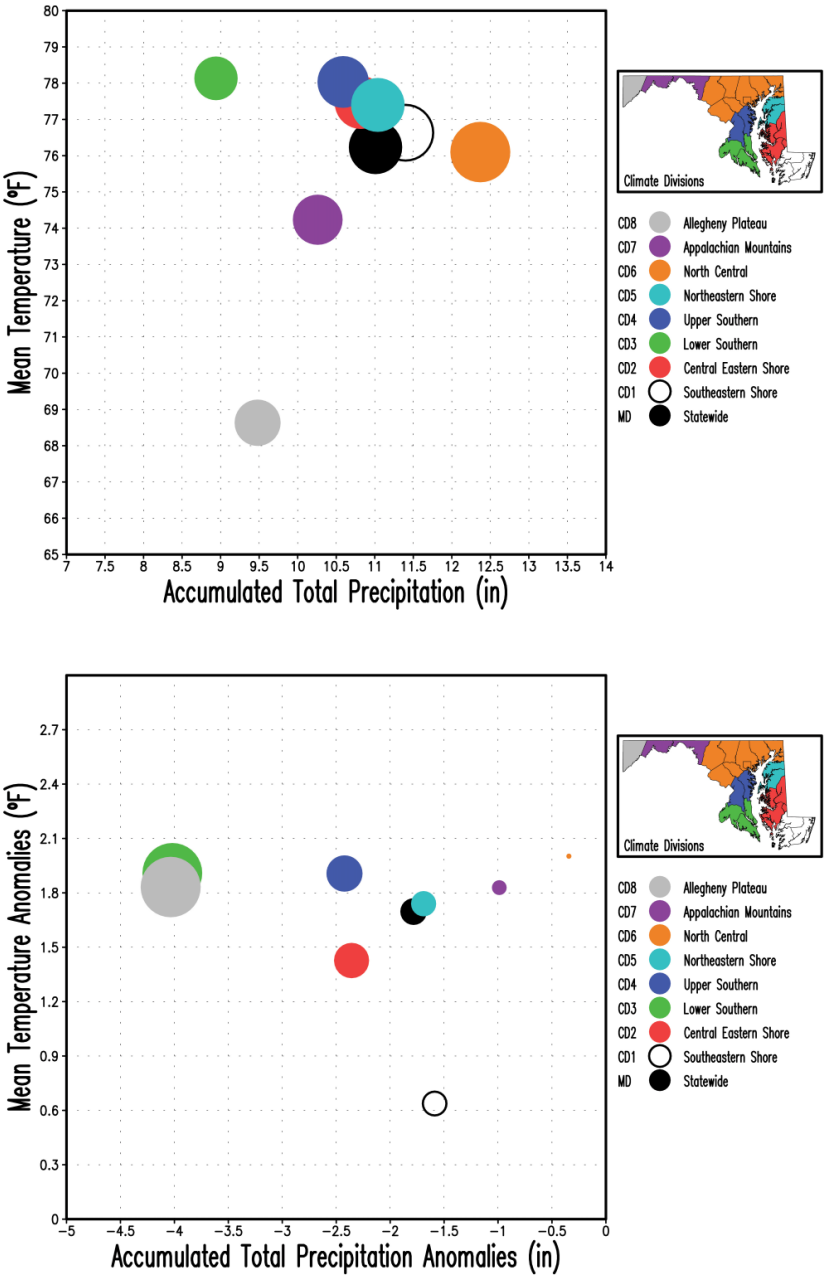

Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) seasonal mean surface air temperature vs. accumulated total precipitation for summer 2024. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 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 (12.37 inches in CD6, top panel) and by the maximum precipitation anomaly (|−4.03| inches in CD8, 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. Winter 2023-24, Spring, Summer 2024 Scatter Plots

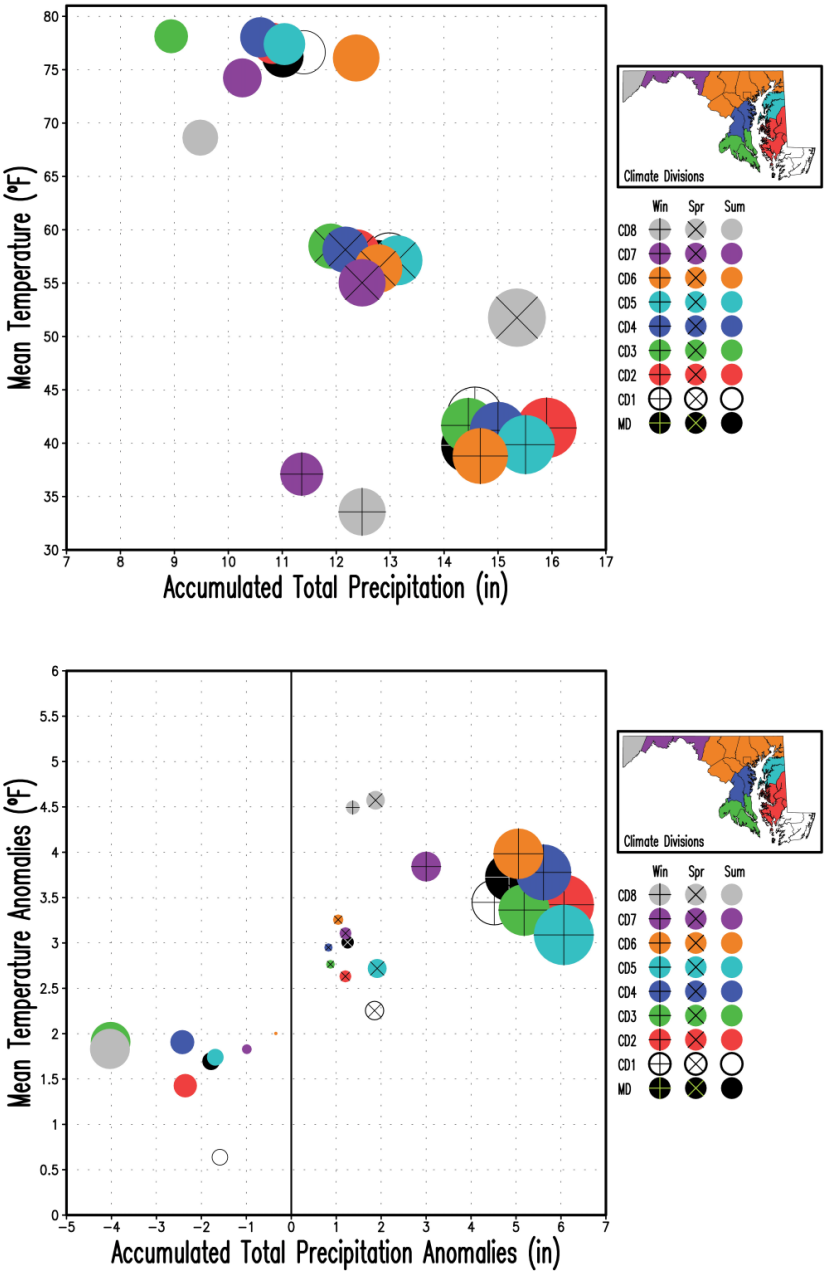

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) seasonal mean surface air temperature vs. accumulated total precipitation for winter 2023-24, spring, and summer 2024. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies 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 (15.90 inches in CD2 in winter, top panel) and by the maximum precipitation anomaly (6.07 inches in CD2 in winter, bottom panel) among the nine regions and three months. Summer is displayed with filled circles only, while spring and winter are displayed with superposed multiplication and addition signs, respectively.

5. Summer 2024 Statewide Averages in the Historical Record

A. Box and Whisker Plots

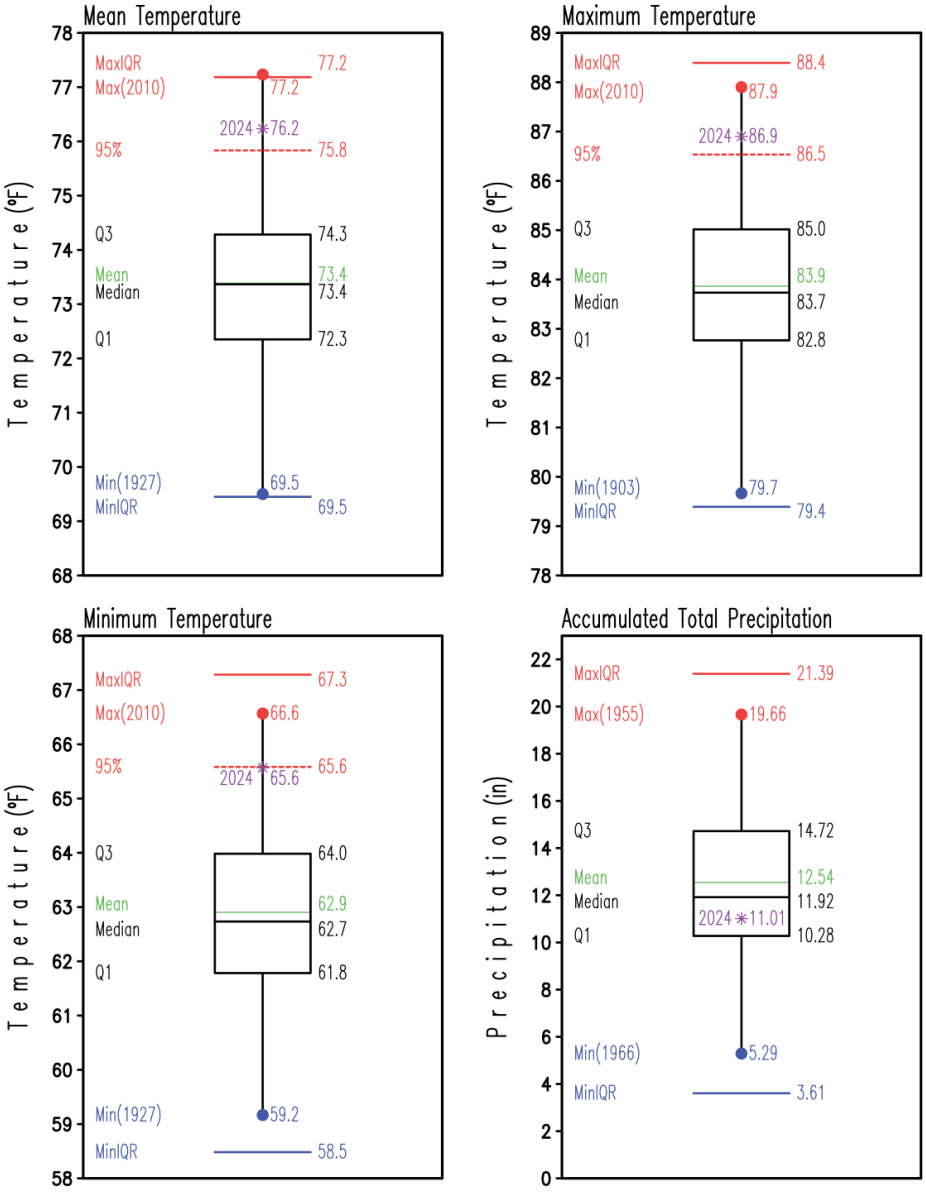

Figure 8. Box and Whisker plots of Maryland (statewide) seasonal mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and accumulated total precipitation (lower right) for summer for the period 1895-2023. The label and asterisk in purple represent conditions for summer 2024. Statistics for the period 1895-2023 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 threshold indicating the upper 5% values is marked by the dashed red line. 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. 1895-2024 Trends

A. Statewide Mean Temperature, Cooling Degree-Days, Accumulated Total Precipitation, and Partial (October-August) Water Year

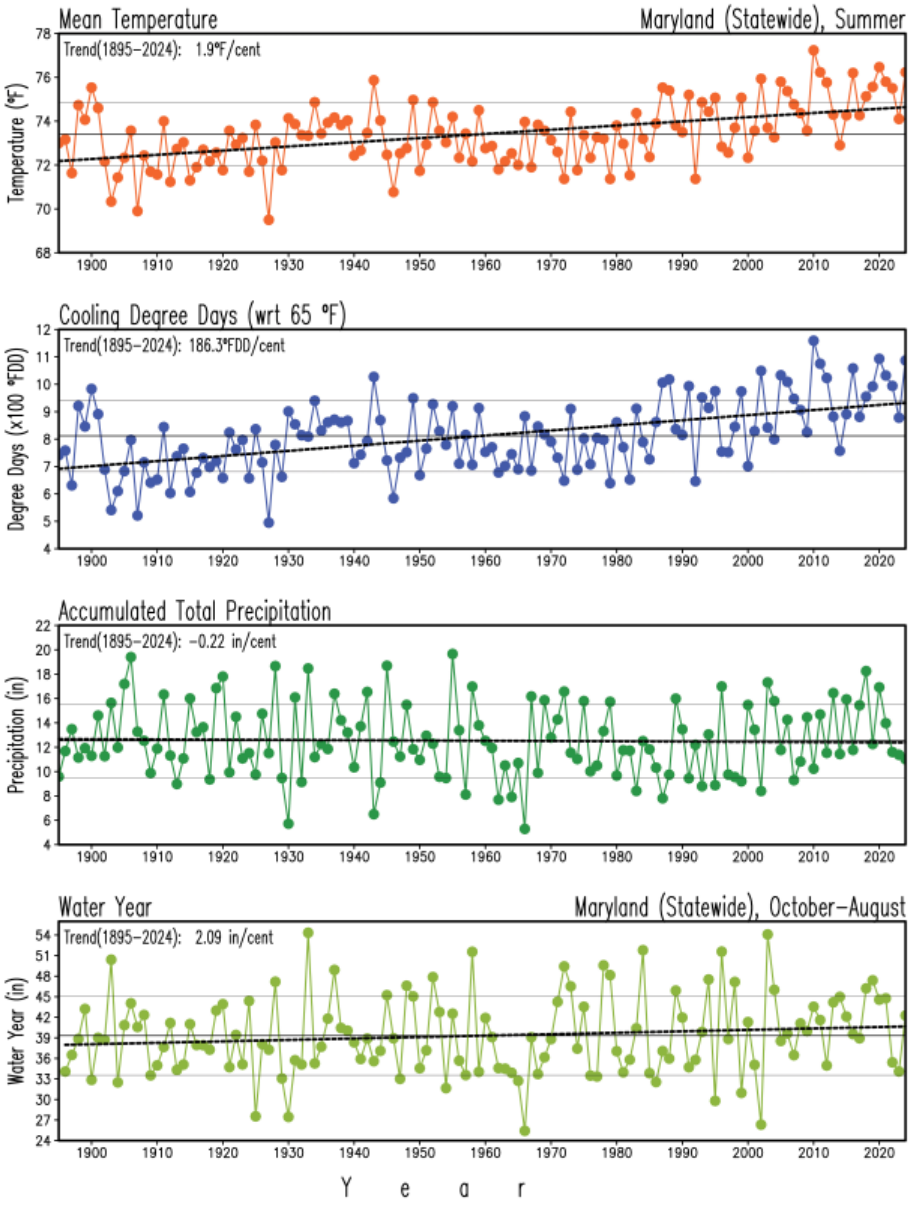

Figure 9. Maryland (statewide) mean surface air temperature, cooling degree-days, accumulated total precipitation in summer, and partial (October-August) water year for the period 1895-2024. Temperature is in °F, cooling degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (73.4°F, 811.9°FDD, 12.53 in, and 39.32 in, 1895-2024), and the double thin, continuous gray lines indicate the standard deviation (1.4°F, 131.1°FDD, 3.01 in, and 5.77 in) above/below the long-term mean. The thick dashed black lines show the long-term linear trend. The warming temperature trend (1.9°F/century), and the increasing cooling degree-days trend (186.3°FDD/century) are statistically significant at the 95% level (*Student's t-test* –Santer et al. 2000), but not the decreasing precipitation trend (–0.22 in/century) or the increasing water year trend (2.09 in/century).

B. Temperature and Precipitation Maps

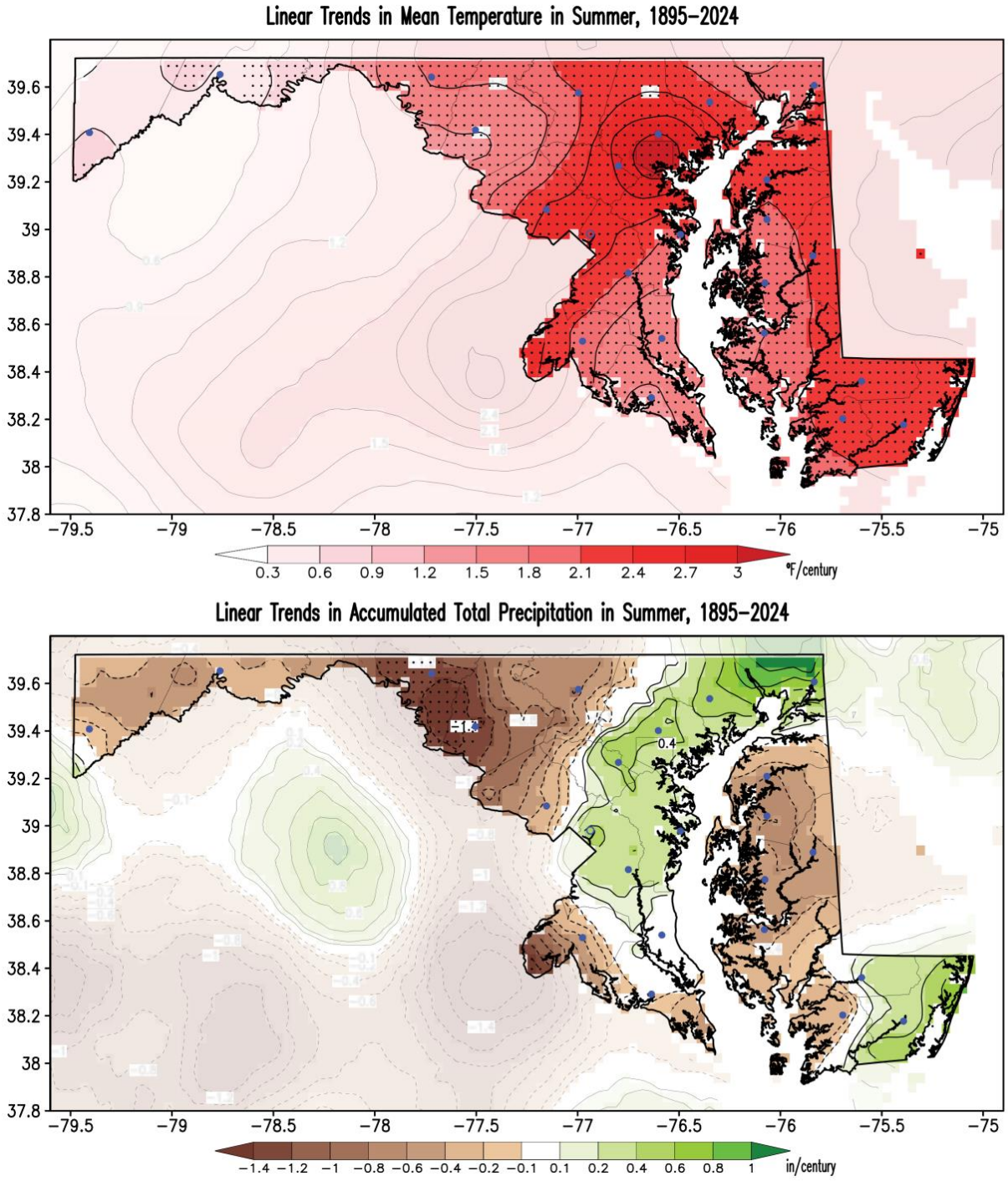

Figure 10. Linear trends in summer surface air mean temperature and accumulated total precipitation for the period 1895-2024. Temperatures are in °F/century, and precipitation is in inches/century following the color bars. Red shading in the temperature map marks warming trends. Brown/green shading in 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. Summer 2024 Tables: Statewide, Climate Divisions, and Counties

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)
Statewide	76.2	127
Climate Division 1	76.6	117
Climate Division 2	77.5	123
Climate Division 3	78.1	129
Climate Division 4	78.0	128
Climate Division 5	77.4	126
Climate Division 6	76.1	129
Climate Division 7	74.2	127
Climate Division 8	68.6	124
Allegany	73.1	119
Anne Arundel	78.4	127
Baltimore	76.7	129
Baltimore City	79.0	129
Calvert	77.8	127
Caroline	77.0	124
Carroll	74.9	128
Cecil	76.3	126
Charles	78.3	127
Dorchester	77.7	122
Fredrick	75.4	129
Garrett	68.7	123
Harford	76.5	127
Howard	76.2	129
Kent	77.6	127
Montgomery	76.4	129
Prince George's	77.7	128
Queen Anne's	77.4	126
Saint Mary's	78.1	128
Somerset	77.3	117
Talbot	77.7	123
Washington	75.3	129
Wicomico	76.6	116
Worcester	76.1	115

Region	Acc. Total Precipitation (in)	Rank (#)
Statewide	3.67	40
Climate Division 1	3.80	58
Climate Division 2	3.61	40
Climate Division 3	2.98	19
Climate Division 4	3.53	40
Climate Division 5	3.68	51
Climate Division 6	4.12	68
Climate Division 7	3.42	42
Climate Division 8	3.16	11
Allegany	2.73	21
Anne Arundel	3.68	52
Baltimore	4.28	74
Baltimore City	4.04	62
Calvert	3.09	22
Caroline	3.87	54
Carroll	4.34	84
Cecil	4.06	59
Charles	3.02	21
Dorchester	3.33	27
Fredrick	4.27	83
Garrett	3.15	11
Harford	4.07	61
Howard	3.98	59
Kent	3.60	49
Montgomery	3.72	55
Prince George's	3.36	38
Queen Anne's	3.75	57
Saint Mary's	2.89	22
Somerset	3.52	40
Talbot	3.79	51
Washington	4.07	86
Wicomico	3.90	58
Worcester	3.95	65

Table A1. Seasonal mean surface air temperature (left) and accumulated total precipitation (right) at Maryland (statewide), climate division, and county levels for summer 2024. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for summer 2024 occupies among the 130 summers since 1895 after the 130 values have been arranged from the lowest to the highest in the *standard competition ranking method*. The closer to 130 the rank, the larger (i.e., 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	86.9	126
Climate Division 1	86.8	120
Climate Division 2	87.9	123
Climate Division 3	88.1	126
Climate Division 4	88.1	125
Climate Division 5	87.4	123
Climate Division 6	86.9	127
Climate Division 7	87.0	126
Climate Division 8	80.4	123
Allegany	86.8	129
Anne Arundel	88.2	125
Baltimore	87.5	129
Baltimore City	89.4	129
Calvert	87.5	123
Caroline	87.8	120
Carroll	86.4	126
Cecil	86.1	122
Charles	88.4	126
Dorchester	88.2	124
Fredrick	86.6	127
Garrett	80.4	123
Harford	86.8	125
Howard	87.3	129
Kent	87.3	123
Montgomery	87.1	128
Prince George's	88.1	125
Queen Anne's	87.4	122
Saint Mary's	87.9	126
Somerset	87.2	123
Talbot	87.4	121
Washington	87.2	125
Wicomico	87.5	121
Worcester	86.0	119

Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	65.6	124
Climate Division 1	66.5	106
Climate Division 2	67.0	121
Climate Division 3	68.2	125
Climate Division 4	67.9	127
Climate Division 5	67.4	128
Climate Division 6	65.3	127
Climate Division 7	61.5	119
Climate Division 8	56.9	114
Allegany	59.5	101
Anne Arundel	68.5	125
Baltimore	65.8	126
Baltimore City	68.6	127
Calvert	68.0	124
Caroline	66.2	123
Carroll	63.4	125
Cecil	66.6	126
Charles	68.2	126
Dorchester	67.2	117
Fredrick	64.2	127
Garrett	56.9	114
Harford	66.2	126
Howard	65.1	127
Kent	67.9	127
Montgomery	65.8	127
Prince George's	67.2	126
Queen Anne's	67.4	128
Saint Mary's	68.2	123
Somerset	67.4	106
Talbot	68.0	126
Washington	63.4	126
Wicomico	65.7	107
Worcester	66.3	105

Table A2. Seasonal maximum (left) and minimum (right) surface air temperatures at Maryland (statewide), climate division, and county levels for summer 2024. Temperatures are in °F. The rank is the order that the variable for summer 2024 occupies among the 130 summers since 1895 after the 130 values have been arranged from the lowest to the highest using the *standard competition ranking method*. The closer to 130 the rank, 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. Summer 2024 Bar Graphs: Statewide, Climate Divisions, and Counties

A. Temperatures and Precipitation

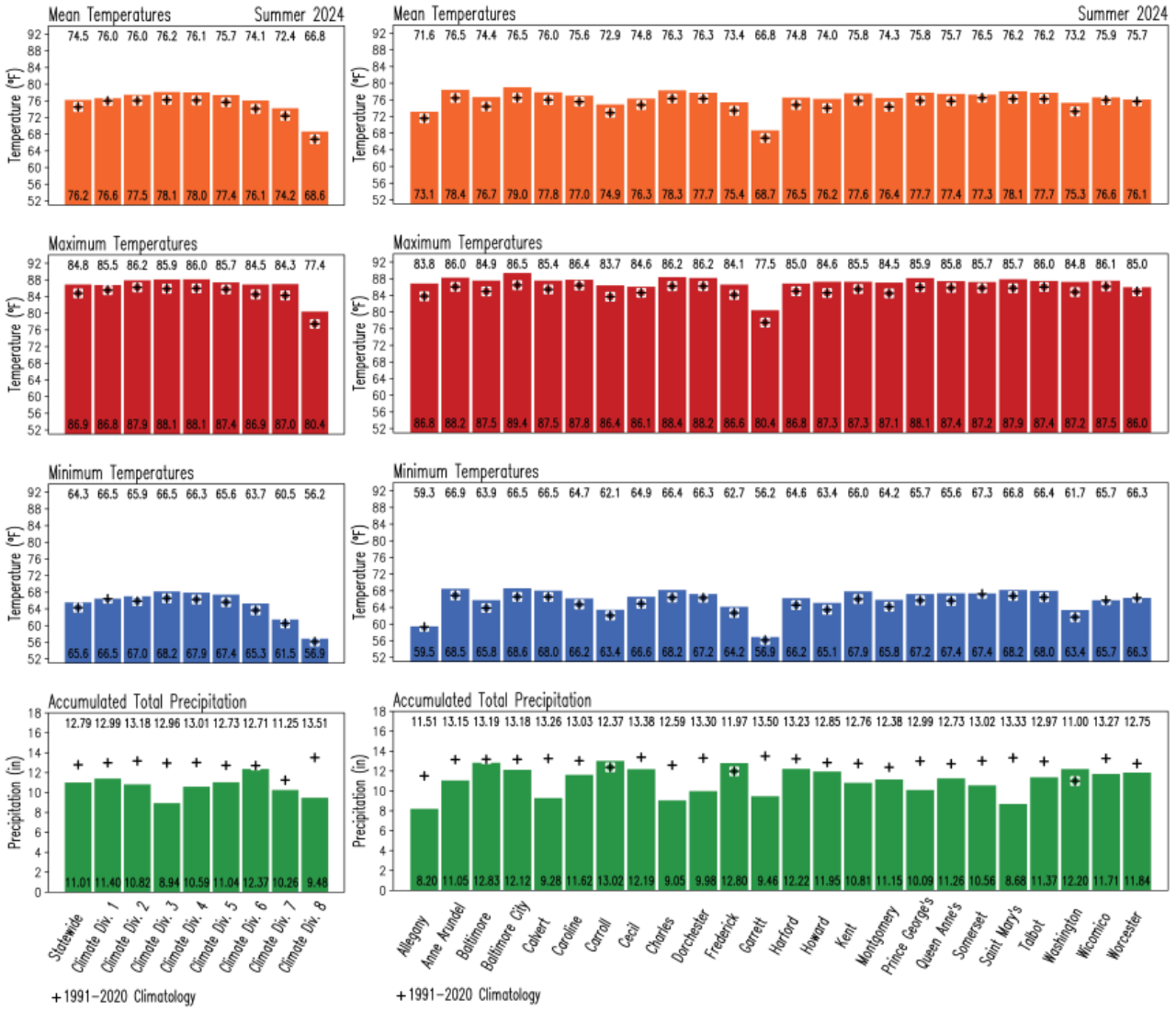

Figure B1. Seasonal surface variables in Maryland for summer 2024. Color bars represent the variables as follows: mean surface air temperature (orange), maximum surface air temperature (red), minimum surface air temperature (blue) and accumulated total precipitation (green) at statewide and climate division (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 summer 2024. For comparison, the corresponding 1991-2020 climatological values for summer are displayed as black addition signs, and their magnitudes are shown at the top of the panels.

B. Temperature and Precipitation Anomalies

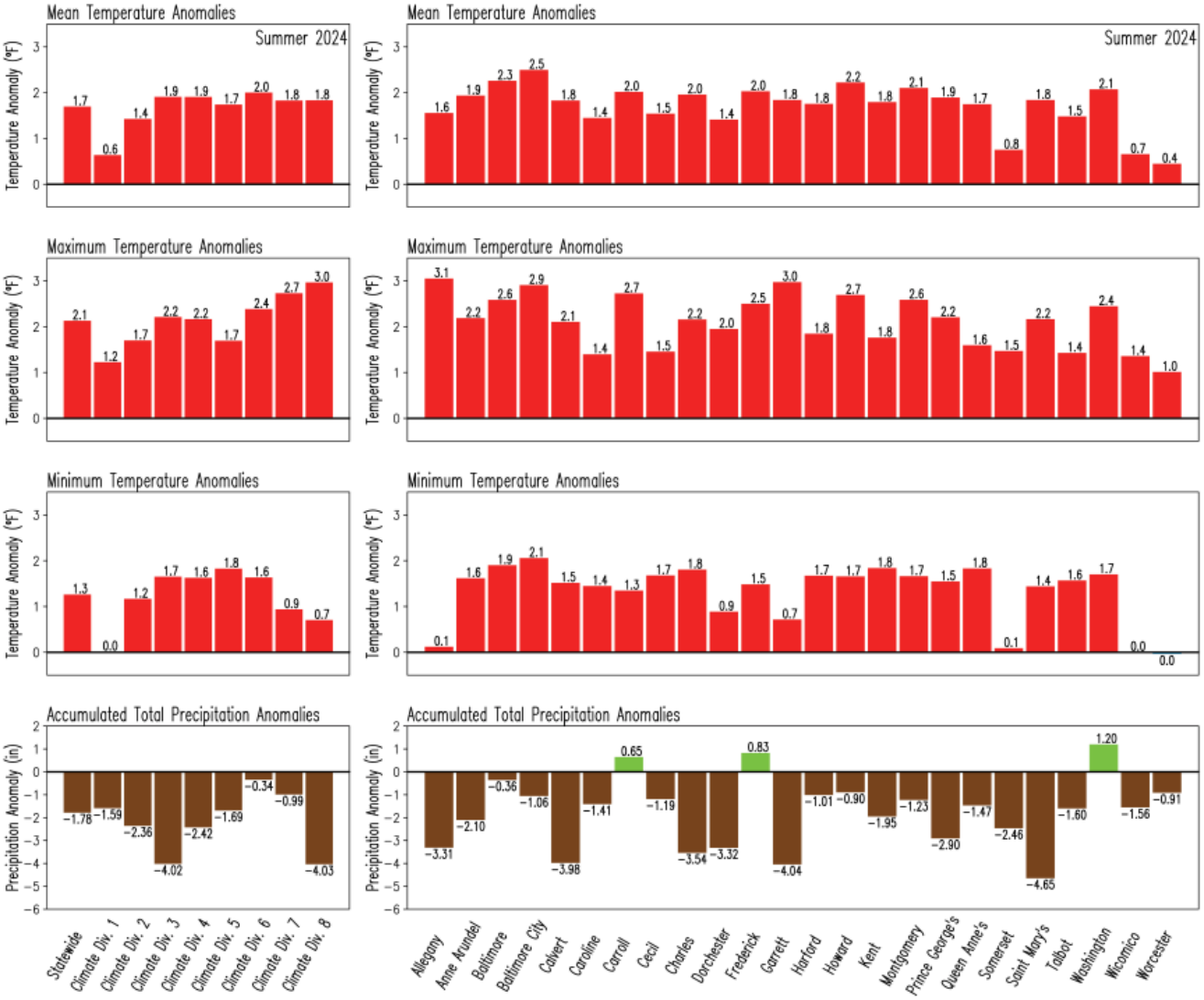

Figure B2. Anomalies of the seasonal surface variables in Maryland for summer 2024. Anomalies are with respect to the 1991-2020 climatology. The red color represents positive anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top), while the green/brown color indicates negative/positive anomalies in accumulated 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 the bars indicate the magnitude of the anomaly for summer 2024.

Appendix C. Summer 1991-2020 Climatology Maps and Summer 2024 Precipitation as Percentage of Climatology

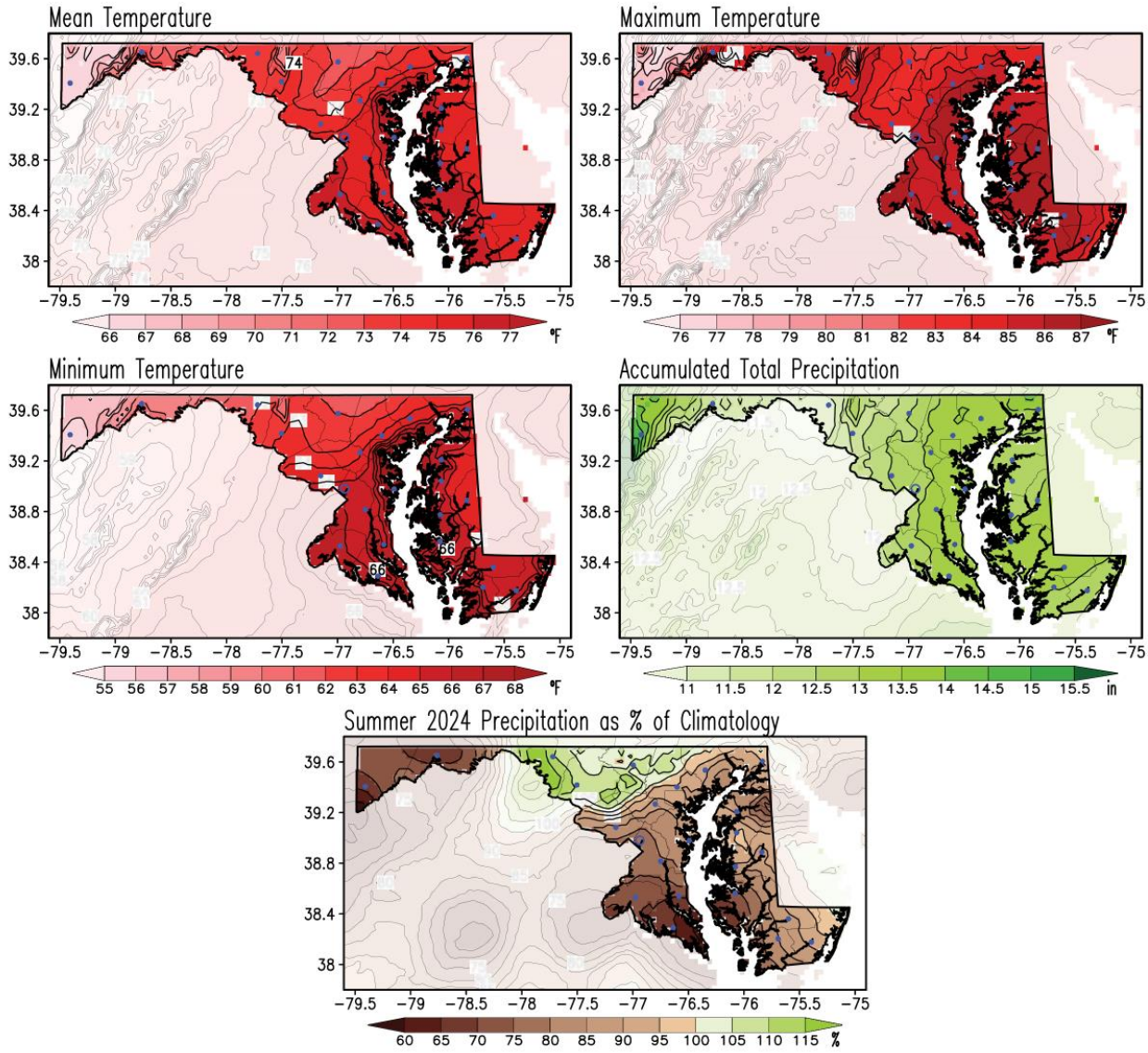

Figure C1. Summer climatology of the seasonal mean, maximum and minimum surface air temperatures, and accumulated total precipitation for the period 1991-2020 (upper and middle rows), and precipitation in summer 2024 as a percentage of climatology (bottom row). Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the summer 2024 conditions are compared to obtain the summer anomalies (from Figure 1 to 4). The precipitation as a percentage is obtained by dividing the total precipitation (from Figure 4) by the climatology (from the middle right panel) and multiplying that ratio by 100 so units are in percent of climatology (%); brown/green shading in this map shows drier/wetter than normal conditions. Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

Appendix D: The Water Year 1991-2020 Climatology, and October 2023 – August 2024 as Percentage of Climatology

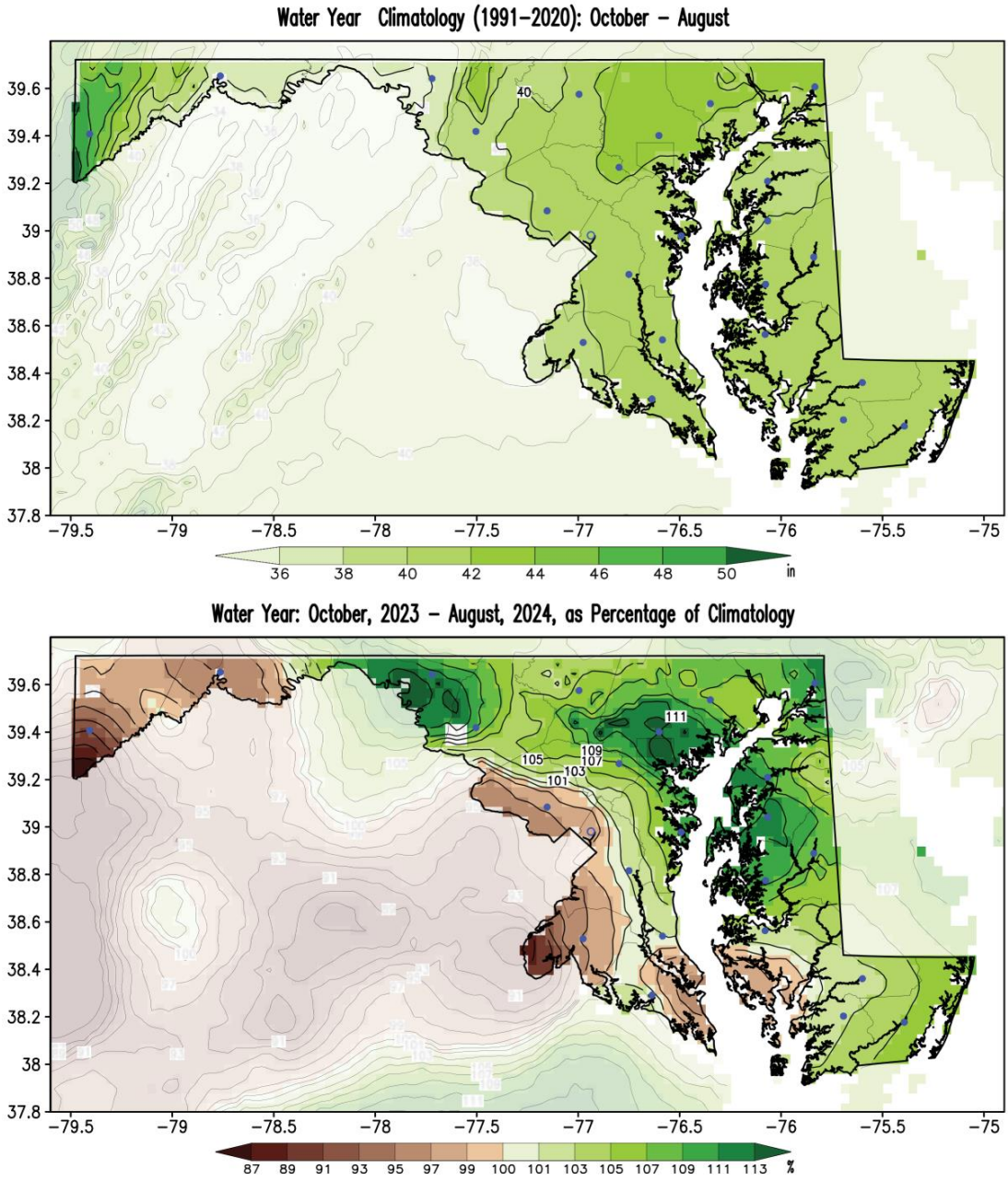

Figure D1. Climatology of the partial water year (October-August, top panel), and current partial water year (October 2023 – August 2024) as a percentage of the climatology (bottom panel). Climatology is for the period 1991-2020. The water year climatology is in inches following the color bar. The current water year as a percentage of climatology is obtained by dividing the current water year (Figure 5 upper panel) by the climatology (upper panel) and multiplying the ratio by 100; hence units are in percent (%). Brown/green shading in the percentage map highlights regions where the current water year is smaller/larger than normal. Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

Appendix E. Summer Standard Deviation and Summer 2024 Standardized Anomalies Maps

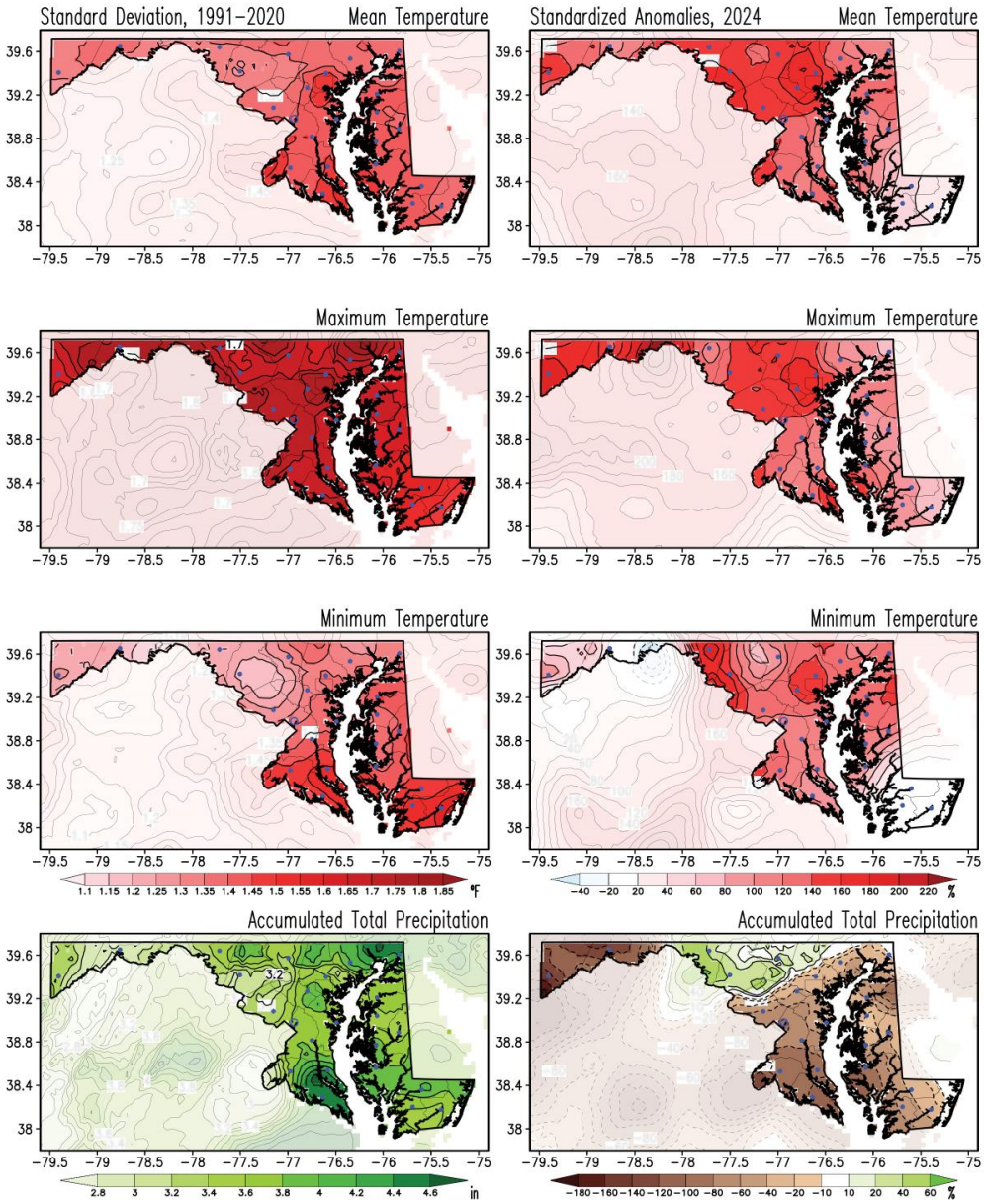

Figure E1. Standard deviation for summer and standardized anomalies of temperatures and precipitation for summer 2024. Standard deviations for seasonal mean, maximum, and minimum surface air temperatures and accumulated total precipitation were obtained for the 1991-2020 period (left column). Anomalies for summer 2024 (right column) are obtained as a percentage of the standard deviations. The standard deviations in temperatures are in °F, and those in precipitation are in inches according to the color bars. Blue/red shading in the anomaly temperature maps marks colder/warmer than normal conditions; brown/green shading in the anomaly precipitation map marks drier/wetter than normal conditions. The standardized anomalies are obtained by dividing the raw anomalies (from Figures 1 to 4) by the standard deviation (from left column panels) and multiplying that ratio by 100; hence units are in percent (%). Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

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