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Maryland Climate Bulletin
Winter 2023-24

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DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE
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Maryland State Climatologist Office

Summary

Winter 2023-24 was warmer and wetter than normal (i.e., 1991-2020 averages), starting with a warmer and wetter December and January and ending with a warmer and drier-than-normal February. Seasonal mean temperatures were between 33 and 43°F, maximum temperatures were in the 41 and 52°F range, and minimum temperatures were between 25 and 34°F. Seasonal accumulated total precipitation was in the 10 to 16 inches range.

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

- Mean temperature was warmer than normal everywhere, notably in Garrett County (above 4.8°F), western Montgomery and Frederick counties, portions of Carroll and Baltimore counties (around 4.2°F), and the western counties of the Piedmont and Dorchester County (around 3.9°F).

- Maximum temperature was also warmer than normal throughout the state, especially in Garrett County (above 4.8°F), eastern Howard, western Baltimore, and northern Anne Arundel counties (around 4.2°F), and parts of Talbot, Dorchester, and Wicomico counties (around 3.9°F).

- Minimum temperature was warmer than normal in the state, too, particularly over Garrett County (above 4.8°F), parts of Montgomery, Frederick, Carroll, and Baltimore counties (above 4.2°F), and the western counties of the Piedmont and Queen Anne's, Talbot, and Dorchester counties (around 3.9°F).

- Precipitation was above normal practically everywhere, notably over southern Baltimore County and Baltimore City (around 6.5 in), eastern Caroline County (around 6 in), and around the counties of the coastal plains from Calvert to Harford to Dorchester counties (around 5.5 in). The southern tip of Garrett County was the only area with below-normal precipitation.

- The partial water year 2024 (October 2023−February 2024) was above normal over the majority of the state, especially over southern Baltimore County, Baltimore City, and parts of Anne Arundel and Kent counties (around 3.5 in), and over the counties around the Bay from Saint Mary's, Calvert to Cecil to Talbot and Caroline counties (around 2.5 in). These regions had around 15-21% more water than their climatological amounts at this time of the year. On the other hand, the southern half of Garrett County had 6-9% less water than their climatological amounts, while western Allegany and western Charles counties had around 3-6% less water.

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

- All eight climate divisions were warmer and wetter than normal. However, climate division 8, the Allegheny Plateau, had the largest mean temperature departure from normal (5.0°F) and the smallest precipitation departure from normal (0.94 in). In contrast, climate division 5, the Northeastern Shore, had the smallest mean temperature deviation from normal (3.0°F) and the largest precipitation deviation from normal (5.81 in).

- Statewide precipitation anomalies changed notably from anomalously dry in summer (–1.41 in) and fall (–2.82 in) to anomalously wet in winter (4.61 in). Statewide mean temperature anomalies evolved from anomalously cold in summer (–0.4°F) to anomalously warm in fall (0.8°F) to much warmer in winter (3.7°F).

Historical Context (Figure 8, Tables A1 and A2)

- Winter 2023-24's statewide mean, maximum, and minimum temperatures (39.8, 48.7, and 30.8°F) were above the long-term (1896-2024) average and within 5% of the largest values on record. However, they remained short of the records established in 1932 (42.0, 51.3, and 32.7°F). The statewide accumulated total precipitation (14.22 in) was above the long-term average and within 5% of the largest values on record. Still, it was far from the wettest winter in 1979 (17.35 in).
- Winter 2023-24's statewide temperatures and precipitation reached the fifth warmest and fifth wettest winter values on record.
- Winter 2023-24's temperatures at the county level reached the fifth warmest winter values in Anne Arundel, Calvert, Frederick, and Howard counties; the fourth warmest in Carroll, Dorchester, Montgomery, Prince George's, and Talbot counties; the third warmest in Allegany County, and the second warmest in Garrett County.
- Winter 2023-24's precipitation at the county level reached the fourth wettest winter values in Anne Arundel, Calvert, Dorchester, Harford, Howard, Kent, and Saint Mary's counties; the third wettest in Baltimore, Cecil, Prince George's, and Queen Anne's counties; the second wettest in Baltimore City, Caroline, and Talbot counties.

Century-Plus Trends (Figures 9, 10)

- Statewide mean temperature in winter showed a significant warming trend (3.1°F/century), while heating degree-days had a significant decreasing trend (−292.2°F degree-days/century). Statewide accumulated total precipitation, however, had a small, non-significant increasing trend (0.06 in/century), and the partial water (October−February) year had a significant increasing trend (1.45 in/century).
- Regionally, winter mean temperatures showed significant warming trends everywhere in the state. They ranged from around 2.0°F/century over Garrett County, above 2.8°F on the eastern shore, to around 3.6°F over the limits of Frederick and Montgomery counties, portions of Baltimore City, Baltimore, Howard, and Caroll counties, and northern Harford and Cecil counties, and to 3.8°F in the northeastern corner of Cecil County.
- Regionally, accumulated total precipitation in winter showed non-significant trends throughout the state. The largest wetting trends were over Garret County, the central Piedmont counties, and southern Worcester County (0.5°F/century). The largest drying trends were in Kent and Queen Anne's 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. This is the seasonal version of the bulletin.

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 seasonal 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 seasonal surface climate conditions for winter 2023-24 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, heating 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 is provided via tables and plots in Appendices A-B; climatology and variability maps are in Appendices C-E.

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 3/10/2024.

- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20240306) at: https://www.ncei.noaa.gov/pub/data/cirs/climdiv/
  Data was downloaded on 3/8/2024.

Water year data is calculated from the monthly total precipitation.

Some definitions:

About the seasons: Seasons are defined following the common three-month meteorological definitions as follows. 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 the anomalies: Anomalies for a given season (e.g., winter 2023-24) are the departures of the seasonal value from the corresponding season's 30-year average (i.e., from the average of 30 winters) during 1991-2020; the 30-year average (or mean) is the climate normal, or just the 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 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*.

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* 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 February.

3. Winter 2023-24 Maps

A. Mean Temperatures

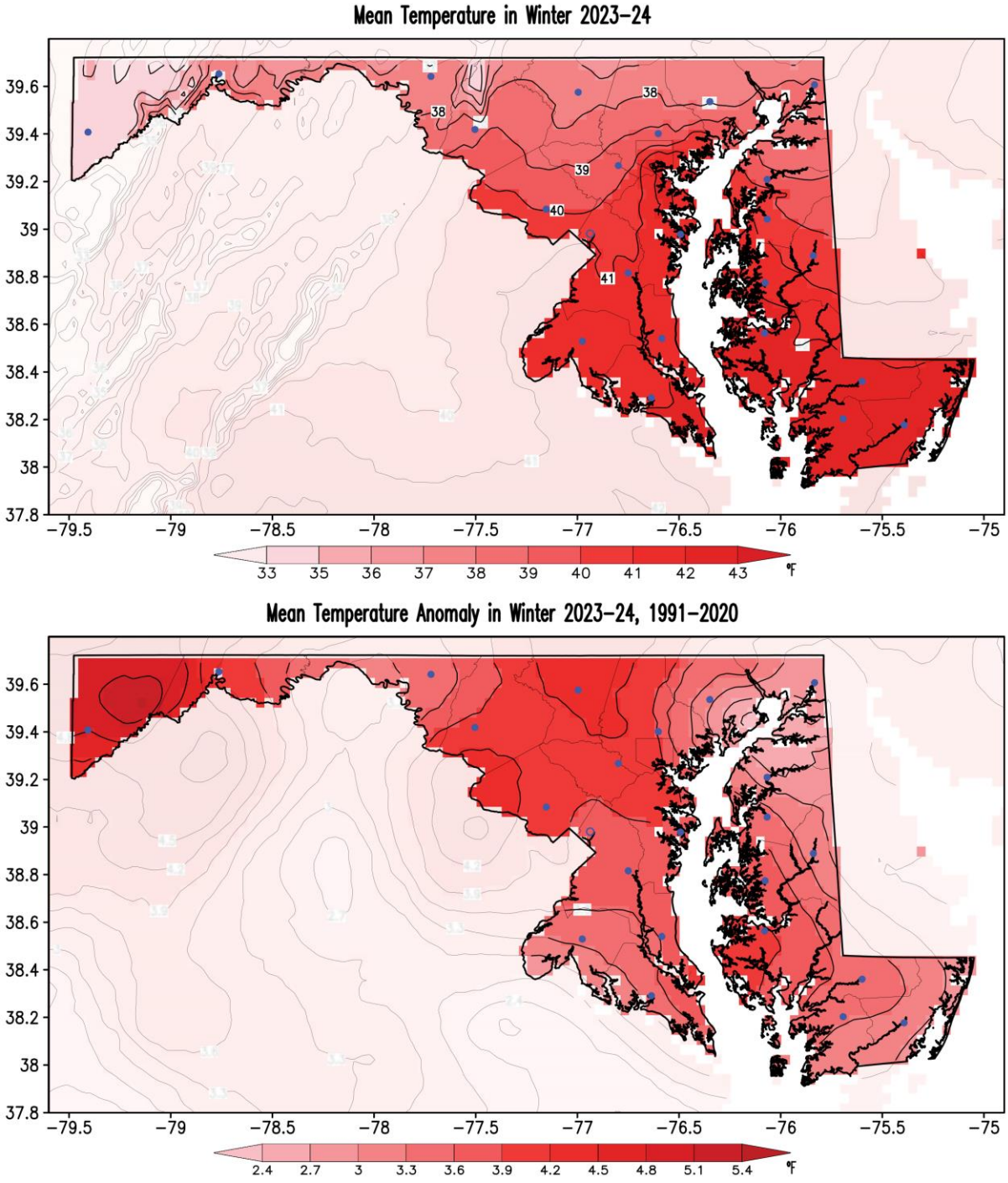

Figure 1. Seasonal mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for winter 2023-24. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

B. Maximum Temperatures

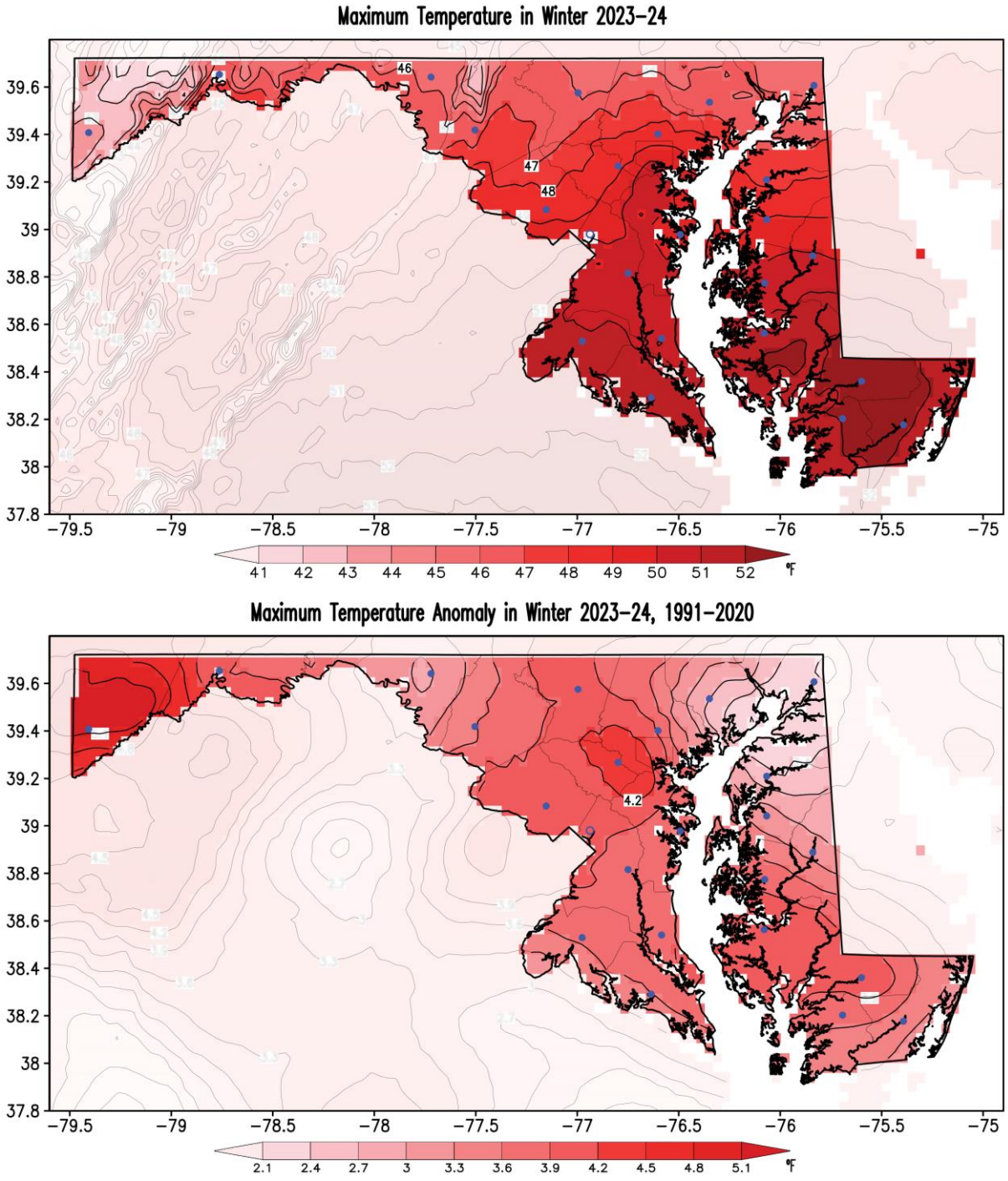

Figure 2. Seasonal maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for winter 2023-24. Temperatures are in °F following the color bar. Red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

C. Minimum Temperatures

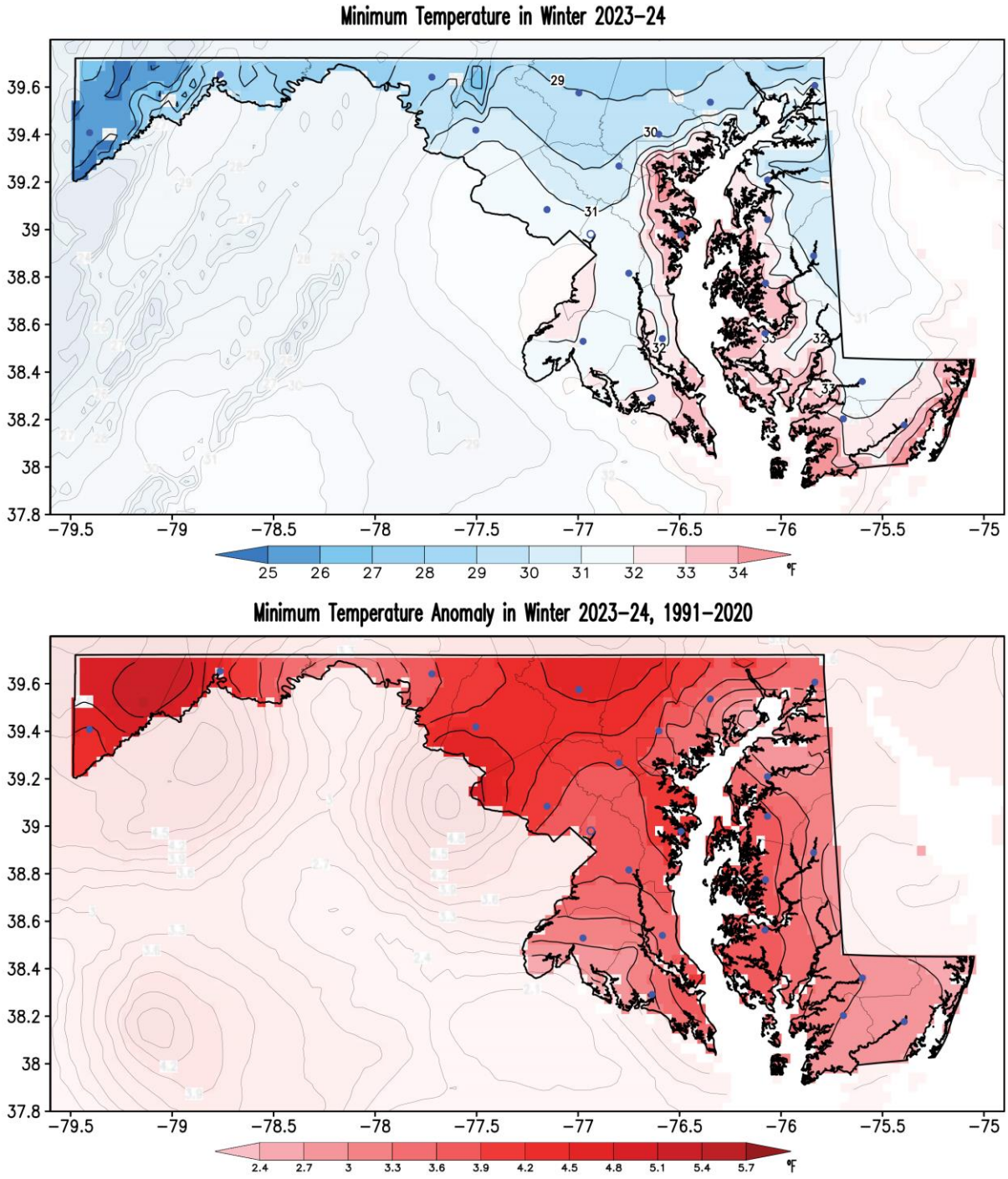

Figure 3. Seasonal minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for winter 2023-24. Temperatures are in °F following the color bar. Blue/red shading in the temperature map shows temperatures below/above 32°F, while red shading in the anomaly map marks warmer than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

D. Precipitation

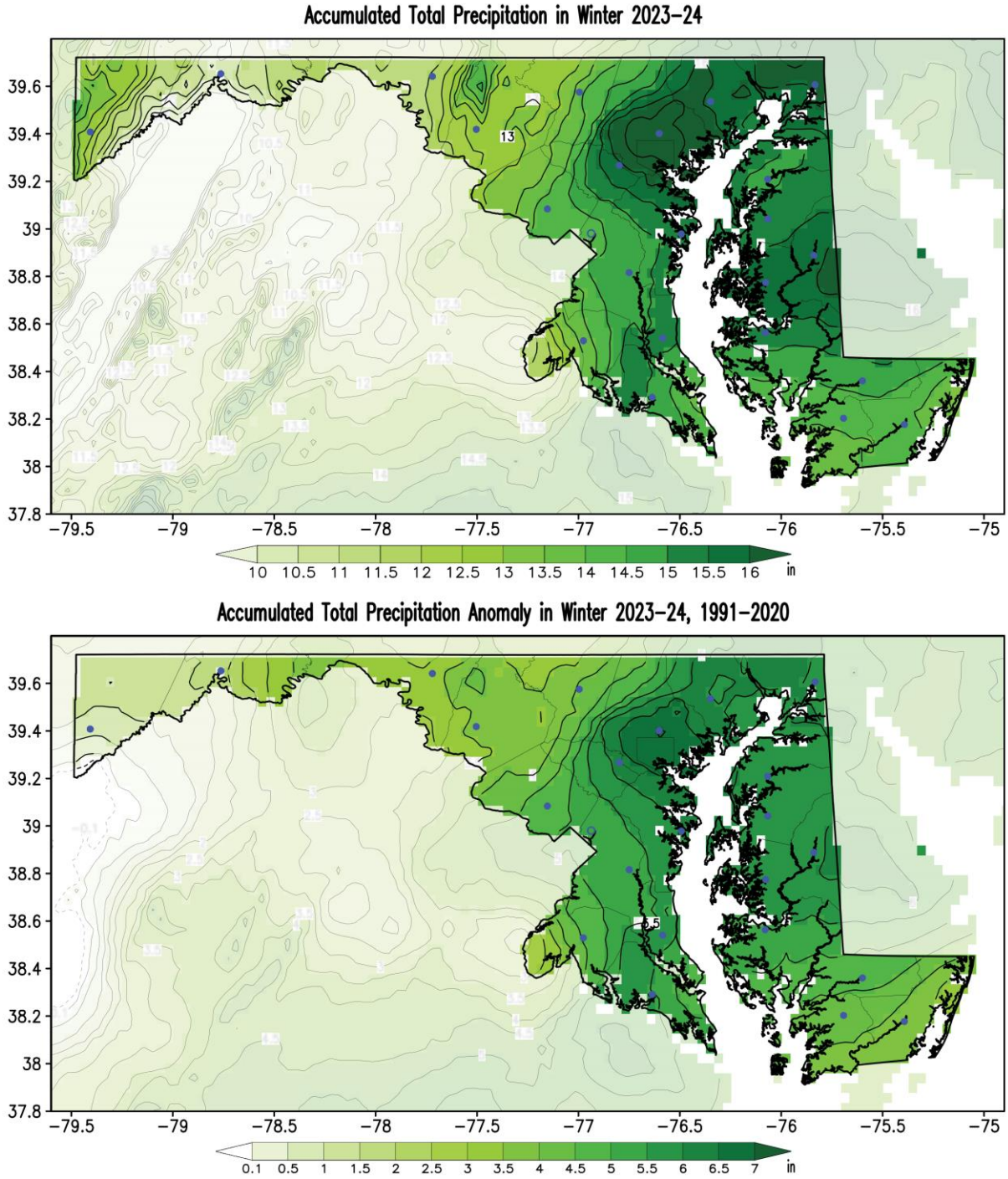

Figure 4. Seasonal accumulated total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for winter 2023-24. Precipitation is in inches following the color bar. Green shading in the anomaly map marks wetter than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

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

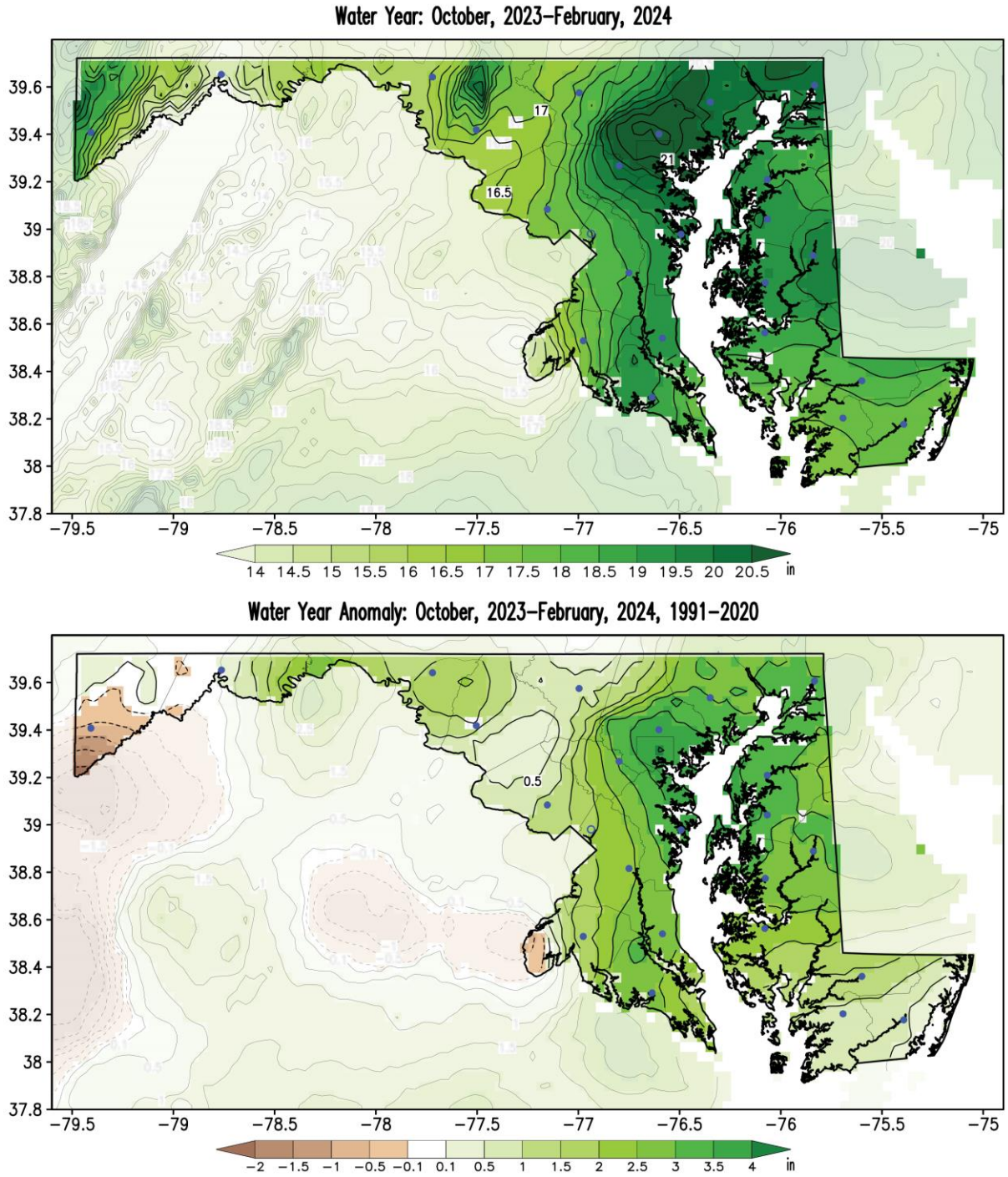

Figure 5. Partial water year until February 2024 (top panel), and its anomaly with respect to the 1991-2020 climatology (bottom panel). Water year is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. The current maps display the partial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

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

A. Winter 2023-24 Scatter Plots

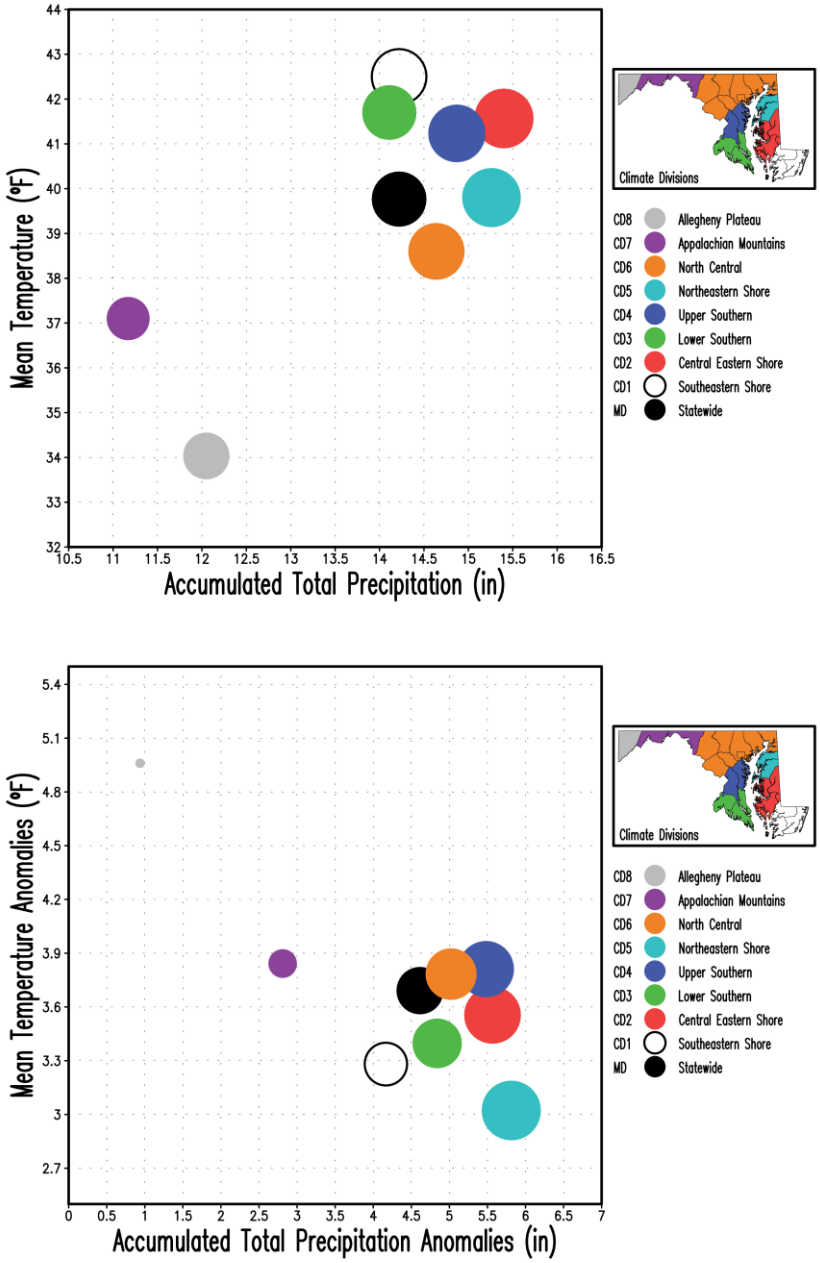

Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) seasonal mean surface air temperature vs. accumulated total precipitation for winter 2023-24. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 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 (15.40 inches in CD2, top panel) and by the maximum precipitation anomaly (5.81 inches in CD5, bottom panel) among the nine regions. Note that the color of the filled circles corresponds to the color in the Climate Divisions according to the inset map.

B. Summer, Fall 2023 – Winter 2023-24 Scatter Plots

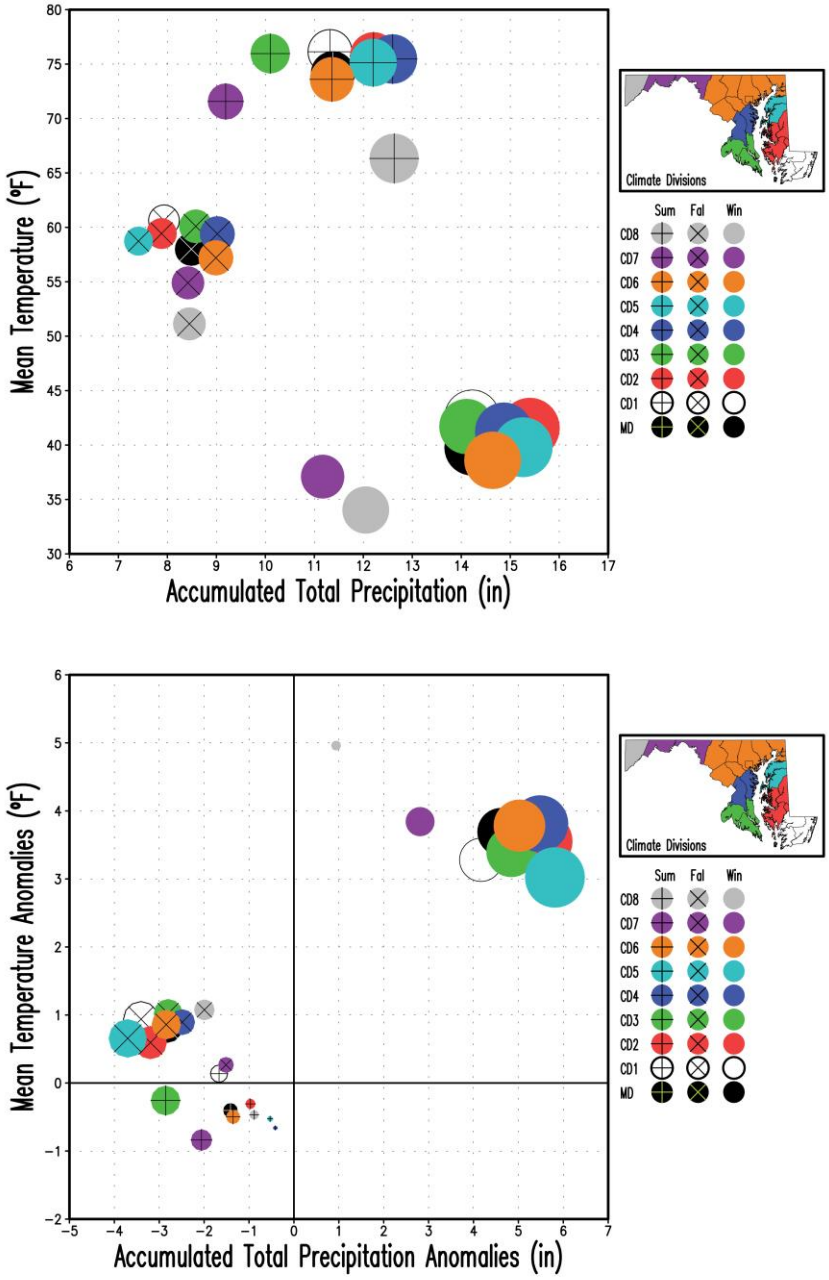

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) seasonal mean surface air temperature vs. accumulated total precipitation for summer, fall 2023, and winter 2023-24. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies 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 (15.40 inches in CD2 in winter, top panel) and by the maximum precipitation anomaly (5.81 inches in CD5 in winter, bottom panel) among the nine regions and three months. Winter is displayed with filled circles only, while fall and summer are displayed with superposed multiplication and addition signs, respectively.

5. Winter 2023-24 Statewide Averages in the Historical Record

A. Box and Whisker Plots

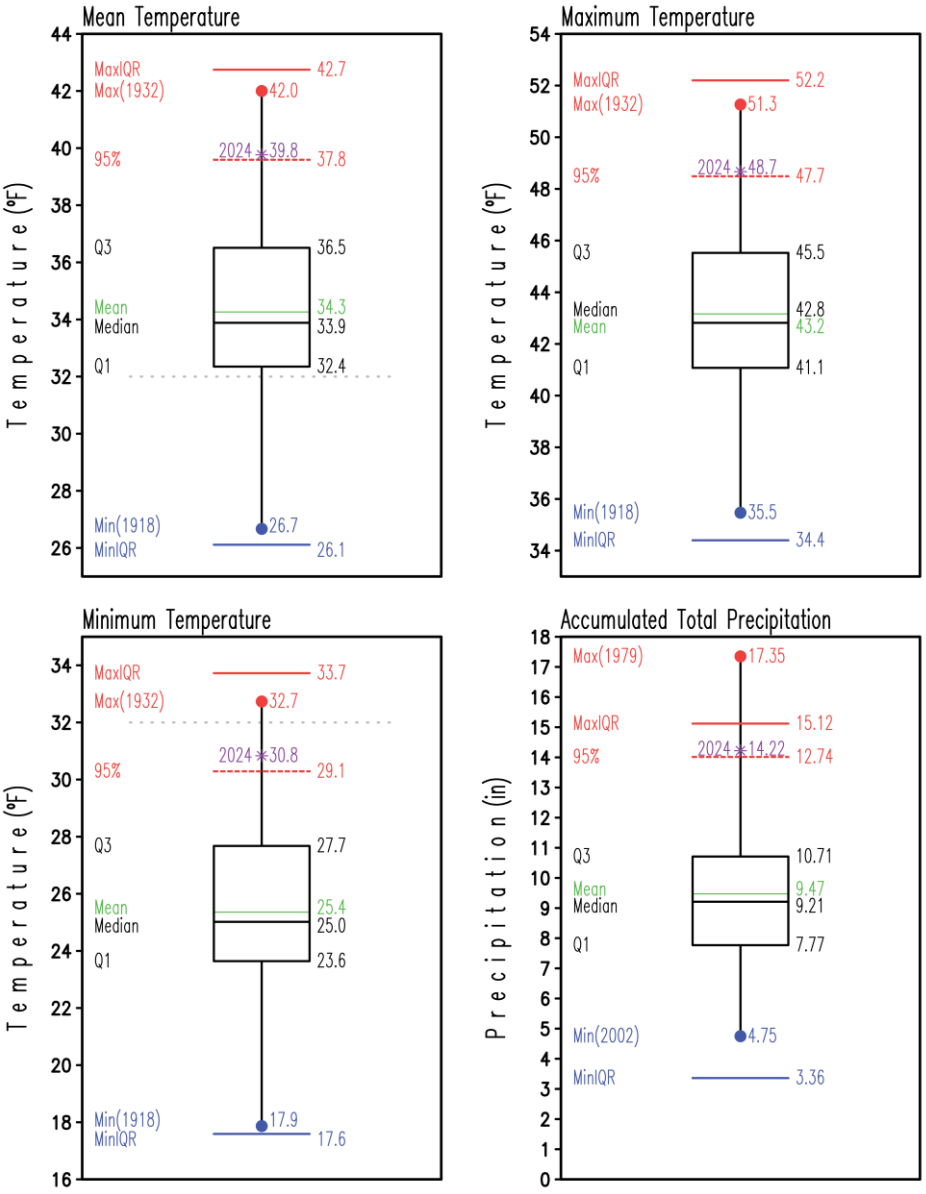

Figure 8. Box and Whisker plots of Maryland (statewide) seasonal mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and accumulated total precipitation (lower right) for winter for the period 1896-2023. The label and asterisk in purple represent conditions for winter 2023-24. Statistics for the period 1896-2023 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. For reference, the 32°F temperature is displayed with a horizontal, dotted, gray line.

6. 1896-2024 Trends

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

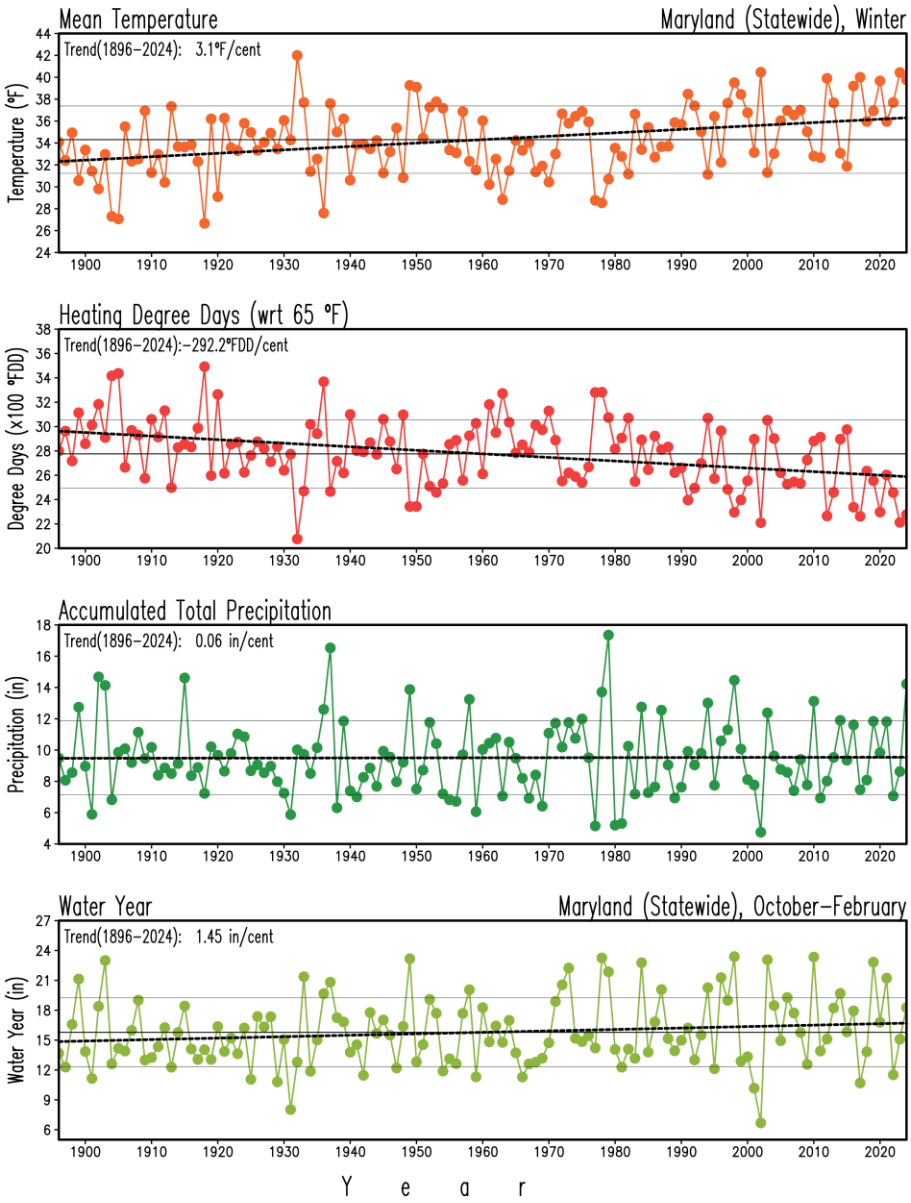

Figure 9. Maryland (statewide) mean surface air temperature, heating degree-days, accumulated total precipitation in winter, and partial (October-February) water year for the period 1896-2024. Temperature is in °F, heating degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (34.3°F, 2775.5°FDD, 9.51 in, and 15.78 in, 1896-2024), and the double thin, continuous gray lines indicate the standard deviation (3.1°F, 279.2°FDD, 2.36 in, and 3.46 in) above/below the long-term mean. The thick dashed black lines show the long-term linear trend. The warming temperature trend (3.1°F/century), the decreasing heating degree-days trend (−292.2°FDD/century), and the increasing water year trend (1.45 in/century) are statistically significant at the 95% level (*Student's t-test* −Santer et al. 2000), but not the small increasing precipitation trend (0.06 in/century).

B. Temperature and Precipitation Maps

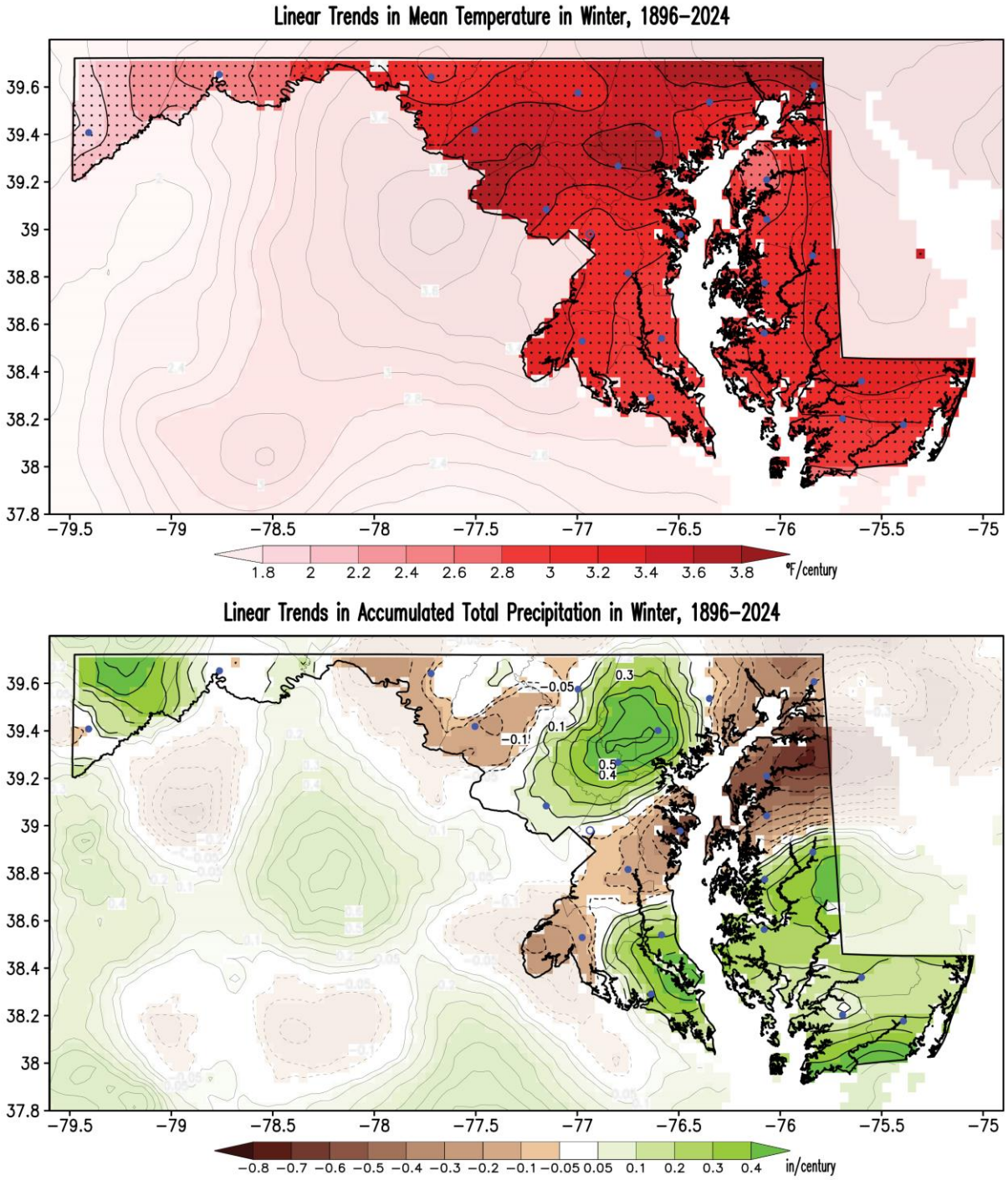

Figure 10. Linear trends in winter surface air mean temperature and accumulated total precipitation for the period 1896-2024. Temperatures are in °F/century, and precipitation is in inches/century following the color bars. Red shading in the temperature map marks warming trends. Brown/green shading in 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. Winter 2023-24 Tables: Statewide, Climate Divisions, and Counties

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)
Statewide	39.8	125
Climate Division 1	42.5	123
Climate Division 2	41.6	126
Climate Division 3	41.7	124
Climate Division 4	41.2	125
Climate Division 5	39.8	123
Climate Division 6	38.6	124
Climate Division 7	37.1	124
Climate Division 8	34.0	128
Allegany	36.9	127
Anne Arundel	41.5	125
Baltimore	38.8	124
Baltimore City	40.9	124
Calvert	41.7	125
Caroline	40.6	122
Carroll	37.8	126
Cecil	38.1	122
Charles	41.5	123
Dorchester	42.2	126
Fredrick	38.2	125
Garrett	34.1	128
Harford	38.1	123
Howard	39.2	125
Kent	39.5	121
Montgomery	39.8	126
Prince George's	41.0	126
Queen Anne's	40.2	123
Saint Mary's	42.0	124
Somerset	42.6	122
Talbot	41.7	126
Washington	37.3	124
Wicomico	42.3	124
Worcester	42.6	121

Region	Acc. Total Precipitation (in)	Rank (#)
Statewide	4.74	125
Climate Division 1	4.74	121
Climate Division 2	5.13	127
Climate Division 3	4.70	126
Climate Division 4	4.96	126
Climate Division 5	5.09	127
Climate Division 6	4.88	125
Climate Division 7	3.72	118
Climate Division 8	4.02	98
Allegany	3.52	116
Anne Arundel	5.10	126
Baltimore	5.30	127
Baltimore City	5.52	128
Calvert	4.95	126
Caroline	5.28	128
Carroll	4.53	123
Cecil	5.31	127
Charles	4.47	120
Dorchester	4.98	126
Fredrick	4.32	122
Garrett	4.01	98
Harford	5.29	126
Howard	5.00	126
Kent	5.05	126
Montgomery	4.59	124
Prince George's	4.86	127
Queen Anne's	5.10	127
Saint Mary's	4.92	126
Somerset	4.66	120
Talbot	5.21	128
Washington	3.91	121
Wicomico	4.89	122
Worcester	4.69	118

Table A1. Seasonal mean surface air temperature (left) and accumulated total precipitation (right) at Maryland (statewide), climate division, and county levels for winter 2023-24. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for winter 2023-24 occupies among the 129 winters 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, 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	48.7	125
Climate Division 1	52.0	123
Climate Division 2	50.9	126
Climate Division 3	51.2	123
Climate Division 4	50.2	125
Climate Division 5	48.4	118
Climate Division 6	47.1	125
Climate Division 7	45.8	124
Climate Division 8	42.6	127
Allegany	45.7	125
Anne Arundel	50.1	125
Baltimore	47.6	125
Baltimore City	49.5	125
Calvert	50.9	123
Caroline	50.1	123
Carroll	46.4	125
Cecil	46.0	119
Charles	51.3	123
Dorchester	51.6	126
Fredrick	46.5	125
Garrett	42.6	127
Harford	46.4	119
Howard	48.3	125
Kent	47.8	118
Montgomery	48.4	125
Prince George's	50.3	124
Queen Anne's	48.9	119
Saint Mary's	51.4	123
Somerset	51.8	122
Talbot	50.4	126
Washington	46.0	122
Wicomico	52.3	125
Worcester	51.9	122

Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	30.8	125
Climate Division 1	33.0	124
Climate Division 2	32.3	126
Climate Division 3	32.2	123
Climate Division 4	32.3	127
Climate Division 5	31.2	124
Climate Division 6	30.1	127
Climate Division 7	28.4	126
Climate Division 8	25.6	127
Allegany	28.1	126
Anne Arundel	32.9	128
Baltimore	30.0	127
Baltimore City	32.3	127
Calvert	32.4	127
Caroline	31.0	124
Carroll	29.1	128
Cecil	30.2	123
Charles	31.8	124
Dorchester	32.7	126
Fredrick	29.9	128
Garrett	25.6	127
Harford	29.7	125
Howard	30.2	126
Kent	31.1	124
Montgomery	31.3	126
Prince George's	31.7	125
Queen Anne's	31.5	126
Saint Mary's	32.5	124
Somerset	33.4	122
Talbot	32.9	127
Washington	28.7	127
Wicomico	32.2	124
Worcester	33.2	121

Table A2. Seasonal maximum (left) and minimum (right) surface air temperatures at Maryland (statewide), climate division, and county levels for winter 2023-24. Temperatures are in °F. The rank is the order that the variable for winter 2023-24 occupies among the 129 winters 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, 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. Winter 2023-24 Bar Graphs: Statewide, Climate Divisions, and Counties

A. Temperatures and Precipitation

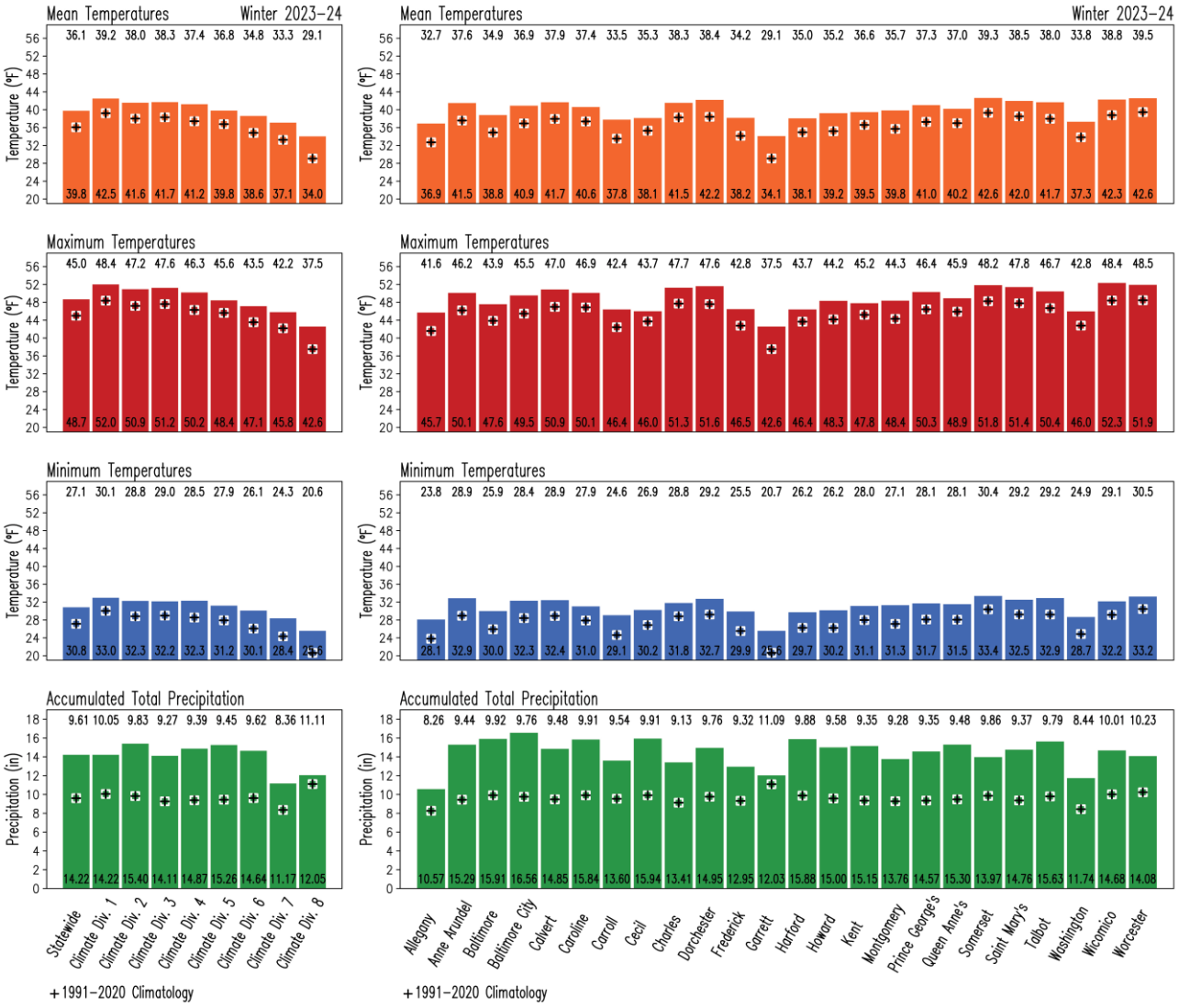

Figure B1. Seasonal surface variables in Maryland for winter 2023-24. Color bars represent the variables as follows: mean surface air temperature (orange), maximum surface air temperature (red), minimum surface air temperature (blue) and accumulated total precipitation (green) at statewide and climate 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 winter 2023-24. For comparison, the corresponding 1991-2020 climatological values for winter are displayed as black addition signs, and their magnitudes are shown at the top of the panels.

B. Temperature and Precipitation Anomalies

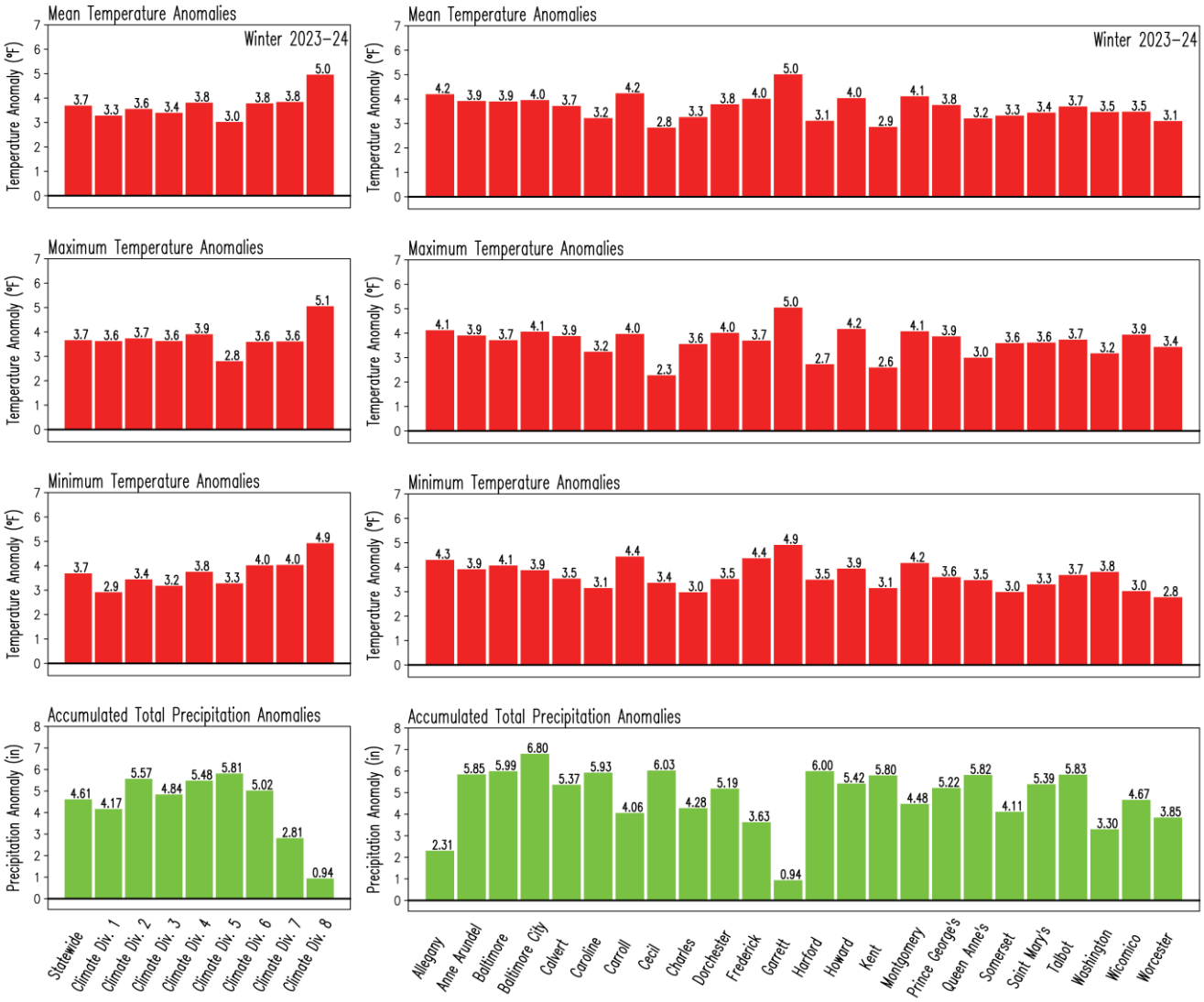

Figure B2. Anomalies of the seasonal surface variables in Maryland for winter 2023-24. Anomalies are with respect to the 1991-2020 climatology. The red color represents positive anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top), while the green color indicates 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 winter 2023-24.

Appendix C. Winter 1991-2020 Climatology Maps and Winter 2023-24 Precipitation as Percentage of Climatology

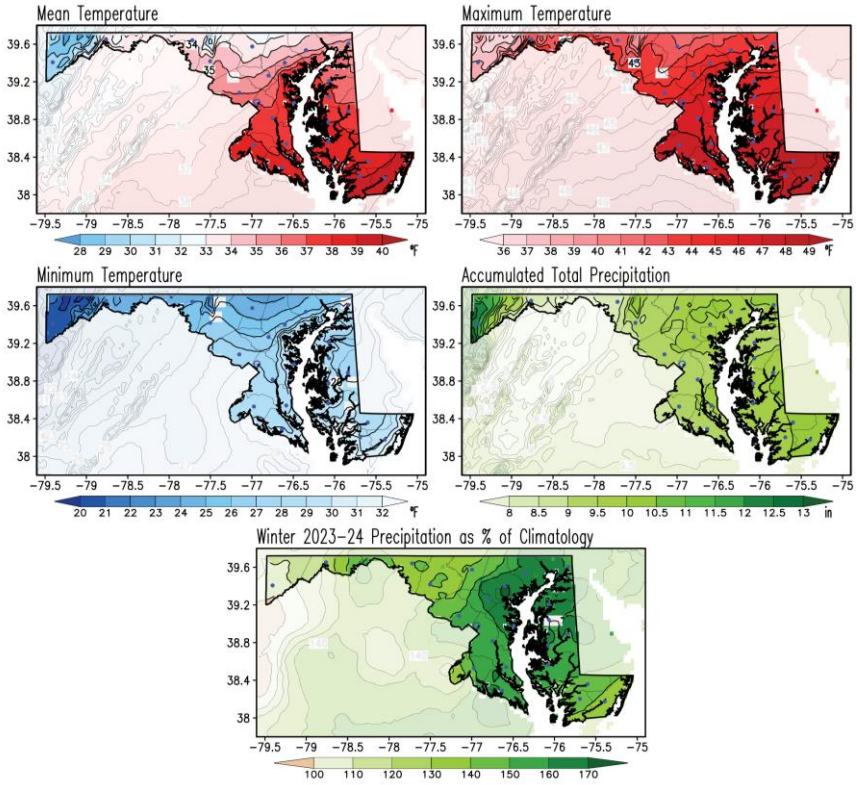

Figure C1. Winter climatology of the seasonal mean, maximum and minimum surface air temperatures, and accumulated total precipitation for the period 1991-2020 (upper and middle rows), and precipitation in winter 2023-24 as a percentage of climatology (bottom row). Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the winter 2023-24 conditions are compared to obtain the winter 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.

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).

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

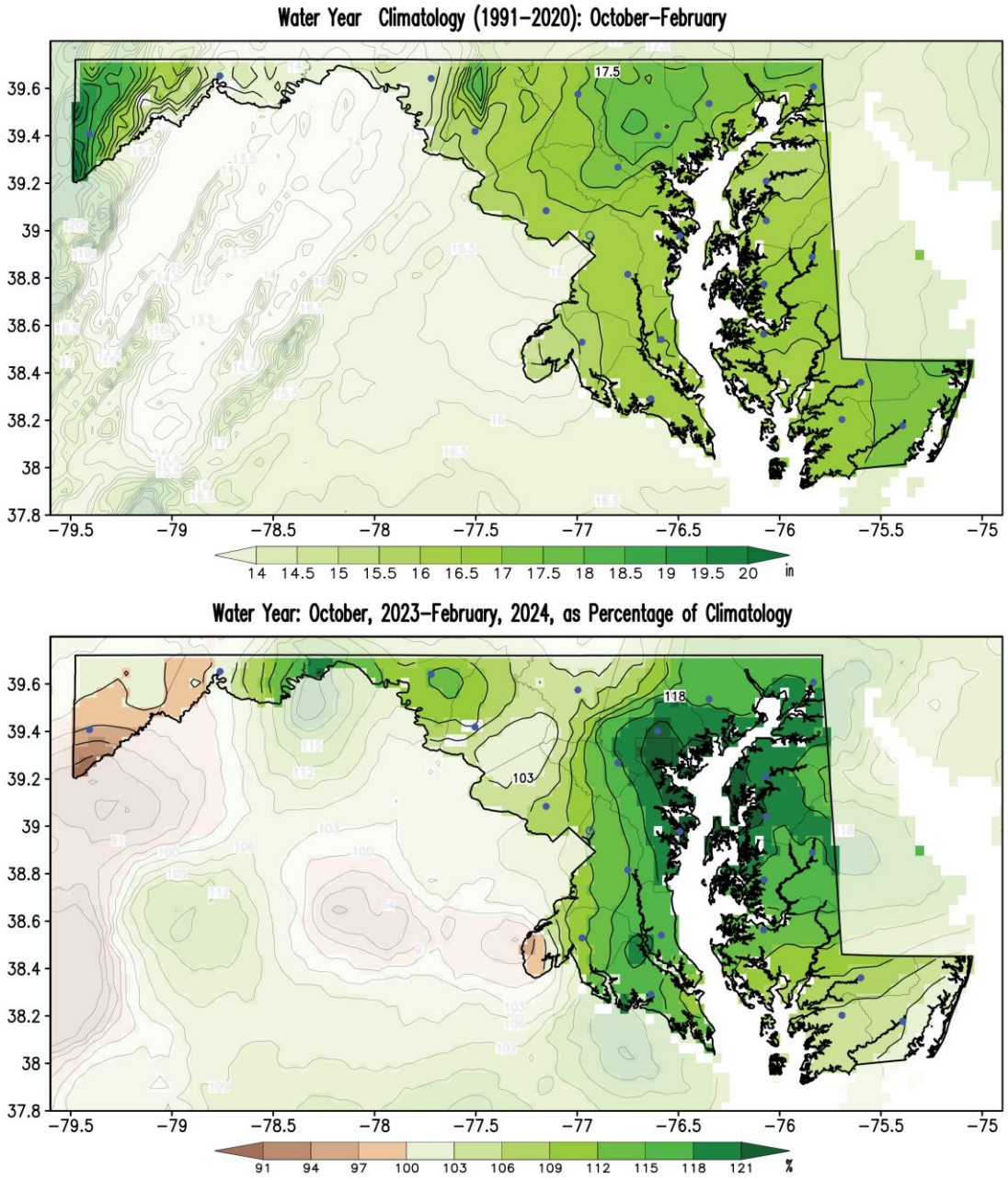

Figure D1. Climatology of the partial water year (October-February, top panel), and current partial water year (October 2023 – February 2024) as a percentage of the climatology (bottom panel). Climatology is for the period 1991-2020. The water year climatology is in inches following the color bar. The 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. Winter Standard Deviation and Winter 2023-24 Standardized Anomalies Maps

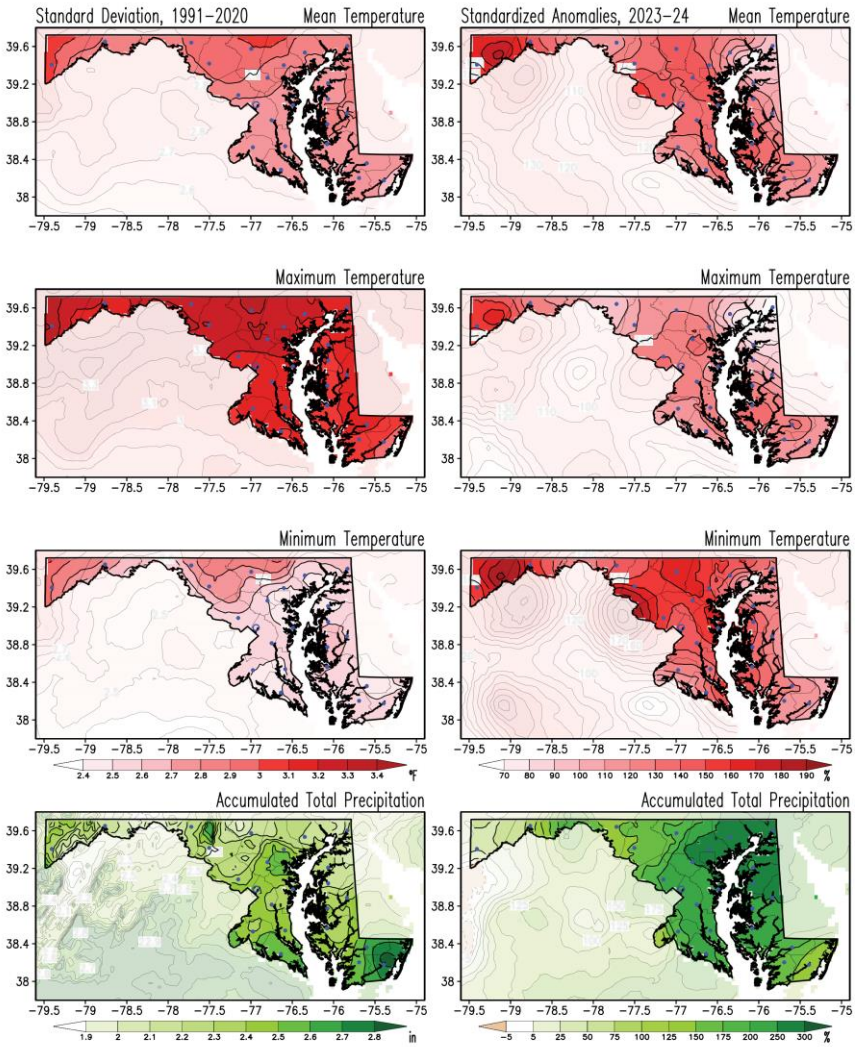

Figure E1. Standard deviation for winter and standardized anomalies of temperatures and precipitation for winter 2023-24. Standard deviations for seasonal mean, maximum, and minimum surface air temperatures and accumulated total precipitation were obtained for the 1991-2020 period (left column). Anomalies for winter 2023-24 (right column) are obtained as a percentage of the standard deviations. The standard deviations in temperatures are in °F, and those in precipitation are in inches according to the color bars. Red shading in the anomaly temperature maps marks warmer than normal conditions; brown/green shading in the anomaly precipitation map marks drier/wetter than normal conditions. The standardized anomalies are obtained by dividing the raw anomalies (from Figures 1 to 4) by the standard deviation (from left column panels) and multiplying that ratio by 100; hence units are in percent (%). Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

The 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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