SOA Research INSTITUTE

Actuarial Weather Extremes Series

Analysis of Total Snowfall and Precipitation from Nov 2022 to Feb 2023 Across the United States

Catastrophe and Climate

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Summary

During the period from November 2022 through February 2023, the United States (U.S.) experienced numerous major winter storms, including a blizzard in mid-November that blanketed some areas around the Great Lakes with more than three feet of snow, and two blizzards in December that led to significant snowfall stretching from the Midwest to the Northeast. In California and Nevada, a series of atmospheric rivers in late December and January led to unusually heavy rainfall and, in some locations, heavy snowfall.

This analysis examines precipitation and snowfall totals across the entire November-to-February period which, in this report, we refer to as the "2022/2023 winter season". Data for this period was compared to data from prior winters, focusing solely on weather stations with at least 50 years of historical data. For each weather station, separately for snowfall and precipitation data, cumulative November-to-February snowfall/precipitation was ranked against the corresponding four-month totals from prior winters. A rank of 100% indicates that this winter's snowfall/precipitation exceeded the corresponding value for all prior winters; a rank of 0% indicates that this winter's snowfall/precipitation was the lowest on record, and a rank of "N" percent indicates that this winter's snowfall/precipitation falls at the n^{th} percentile of the historical data.

To be clear, a high percentile does not imply that a weather station experienced a large snowfall/precipitation in an absolute sense; rather, the correct interpretation is that the station's 2022/2023 winter snowfall/precipitation was large relative to its own historical data. While a total winter snowfall of 20 inches would be a record for Atlanta, Georgia, it would constitute an average season for New York City. Thus, the threshold for "extreme" or "unusual" snowfall or precipitation varies from one geographic location to another.

The analysis reveals that much of the Western U.S. and parts of the Midwest experienced relatively high snowfall and/or precipitation across winter 2022/2023, with some locations experiencing record highs. Conversely, much of the mid-Atlantic and the Southeast experienced relatively low precipitation or snowfall, with some locations experiencing record lows.

While broad regional patterns are clearly visible in maps of the data, there are interesting cases in which a weather station that experienced record or near-record snowfall or precipitation is located just a short distance from a station that experienced a record or near-record low. For example, Buffalo and Albion, New York are separated by merely 40 miles, but their snowfall rankings are at opposite ends of the spectrum: a ranking of 95.2% for Buffalo, but merely 3.8% for Albion. This difference is due to a winter storm that hit the Great Lakes region in mid-November, dropping 37 inches of snow in Buffalo, but only 4 inches in Albion. In Lake View, New York – merely 12 miles from Buffalo – total snowfall was 81 inches. This example illustrates that it is possible for snowfall or rainfall accumulations to vary significantly across short distances.

This report presents maps of the results. In addition, flexible maps are available online, with features that allow a user to focus on a particular region, or on stations that experienced extreme precipitation or snowfall. Two sets of online maps are provided: (1) maps that display total inches of snowfall or precipitation for winter 2022/2023, and (2) maps that display snowfall/precipitation 2022/2023 accumulations ranked against historical data.

Data

This analysis uses data from the Global Historical Climatology Network Daily dataset. This dataset consists of daily temperature, precipitation and wind speed observations collected from over 100,000 land-based weather stations, of which about 70,000 are in the United States (U.S.) and 9,000 are in Canada. Some of these stations are no longer active – that is, they provided data in the past, but are no longer operational. Of those that remain active, only some stations provide snowfall and/or precipitation data on a regular basis. Note that precipitation observations capture all forms of precipitation, with any snowfall converted to liquid form to facilitate measurement.

For this analysis, we focused on weather stations in the U.S. that provided at least 60 days of snowfall and/or precipitation data during the 120-day period from November 1, 2022, to February 28, 2023. The 60-day threshold does not imply that it snowed or rained on at least 60 of the 120 days. Rather, it means that a station's data captures at least 60 daily snowfall or precipitation observations, including observations of zero inches. After applying the 60-day threshold, the resulting dataset contains 15,803 stations with sufficient snowfall data and 22,804 stations with sufficient precipitation data. We refer to this set of stations as the "broad" dataset, and we used it to create maps of total snowfall and rainfall (in inches) for the 2022/2023 winter season.

While maps with total inches of snowfall and rainfall for this past winter are interesting, the central purpose of this analysis is to determine how the 2022/2023 winter season compares to prior winter seasons. To rank the 2022/2023 winter against prior winters, we further restricted the dataset, focusing on those stations with at least 50 prior winters of snowfall and/or precipitation data. The rationale for the 50-year threshold is that a lengthy historical period is needed to provide a meaningful backdrop against which to compare the 2022/2023 data.

To assess whether a station satisfies the 50-year criteria, we again applied a 60-day threshold to prior winters, defined as the four-month period running from November through February. If, for example, a station had only 55 days of data between November 1, 1990, and February 29, 1991, then the 1990/1991 winter season was not counted towards the required 50-year minimum (and the station's 1990/1991 data was discarded from the analysis). Stations failing to meet the 50-year threshold were excluded from the narrow dataset.

Because much of the southern U.S. experiences little or no snow, we restricted the narrow dataset to weather stations with average historical November-to-February snowfall of 6 inches or greater. Similarly, we restricted the precipitation analysis to stations with average November-to-February precipitation of 1 inch or greater. No restrictions were placed on 2022/2023 snowfall/precipitation; consequently, some of the stations captured in both the narrow and broad datasets have little or no 2022/2023 snowfall/precipitation.

The resulting "narrow" dataset consists of 1,874 stations with snowfall data and 3,426 stations with precipitation data. Nearly all of the stations in the snowfall data subset can also be found in the precipitation data subset.

Most Notable Record-Low and Record-High Snowfall and Precipitation Totals

The snowfall analysis revealed 56 stations with record-low November-to-February snowfall totals, and 27 stations with record-high totals. The precipitation analysis revealed 34 stations with record-low November-to-February totals, and 70 with record-highs. The data for these records – and the data for all the stations in the analysis – is available in an Excel file that accompanies this paper. Below, in tables 1 through 4, we highlight the top five of each type of record.

Table 1

TOP FIVE NEW RECORD-HIGH CUMULATIVE SNOWFALLS FOR THE NOVEMBER TO FEBRUARY PERIOD

Weather Station	State	Lat (N)	Lon (W)	Inches of Snow			
				Total from Nov 2022 to Feb 2023	Excess Over Prior Record	Prior Record High	Historic Average
RUBY LAKE NWR	NV	40.2	115.4	118.2	42.4	75.9	32.4
SHOSHONI	WY	43.2	108.1	44.9	18.1	26.7	11.4
AFTON	WY	42.7	110.9	123.9	17.8	106.0	57.1
RIVERTON	WY	43.0	108.3	67.9	15.7	52.1	19.7
VALENTINE MILLER FLD AP	NE	42.8	100.5	58.5	15.1	43.5	19.9

Table 2

TOP FIVE NEW RECORD-LOW CUMULATIVE SNOWFALLS FOR THE NOVEMBER TO FEBRUARY PERIOD

Weather Station	State	Lat (N)	Lon (W)	Inches of Snow			
				Total from Nov 2022 to Feb 2023	Compared to Prior Record	Prior Record Low	Historic Average
FIRST CONNECTICUT LAKE	NH	45.0	71.2	27.5	-31.0	58.5	103.2
HIRAM	OH	41.3	81.1	0.0	-19.6	19.6	49.6
ELKINS- RANDOLPH CO AP	WV	38.8	79.8	9.7	-17.6	27.3	56.2
OSWEGO	NY	43.4	76.5	36.3	-12.4	48.7	117.9
SODUS 1W	NY	43.2	77.0	12.5	-10.6	23.1	67.8

Table 3

TOP FIVE RECORD-HIGH CUMULATIVE PRECIPITATION TOTALS FOR THE NOVEMBER TO FEBRUARY PERIOD

Weather Station	State	Lat (N)	Lon (W)	Inches of Precipitation			
				Total from Nov 2022 to Feb 2023	Excess Over Prior Record	Prior Record High	Historic Average
MINDEN	NV	38.9	119.7	17.0	4.6	12.3	4.9
ALPINE	UT	40.4	111.7	16.0	2.9	13.1	7.1
MT HAMILTON	CA	37.3	121.6	36.5	2.6	33.9	14.6
COUDERAY 7 W	WI	45.8	91.4	14.3	2.2	12.1	5.8
RANGELY 1E	CO	40.0	108.7	6.5	2.0	4.5	2.4

Table 4

TOP FIVE RECORD-LOW CUMULATIVE PRECIPITATION TOTALS FOR THE NOVEMBER TO FEBRUARY PERIOD

Weather Station	State	Lat (N)	Lon (W)	Inches of Precipitation			
				Total from Nov 2022 to Feb 2023	Compared to Prior Record	Prior Record Low	Historic Average
GASQUET RS	CA	41.8	123.9	12.8	-2.9	15.7	55.6
SANDPOINT EXP STN	ID	48.2	116.5	3.7	-2.2	5.8	16.1
VALLEY HEAD	AL	34.5	85.6	10.2	-2.1	12.4	20.8
WALLACE	ID	47.4	115.9	5.4	-2.0	7.4	18.6
LOUISIANA	MO	39.4	91.0	1.3	-1.9	3.3	8.5

Online Tableau Maps Offer Flexible Views of the Data

Maps of the data are available online, with features that allow a user to focus on a particular region, or on stations that experienced extreme precipitation or snowfall. Two sets of online maps are provided:

1. maps that display total inches of snowfall or precipitation for winter 2022/2023 [1]
2. maps that display snowfall/precipitation 2022/2023 accumulations ranked against historical data [2]

Snowfall data and precipitation data are plotted on separate maps. Only one map is visible at time; use the tabs in the upper lefthand corner of each Tableau exhibit to jump from one map to another.

Each weather station is represented by a dot on the map. The dots are color-coded, as indicated on the color legend of each map. By default, all stations in a particular dataset are displayed on a map. However, each map has a series of checkboxes that permit a user to focus on the extremes. Using these boxes, for example, one could focus solely on stations with percentile rankings below 2% or above 98% (or, alternatively, below 10% and above 90%).

If you place your cursor on a particular dot, data for the associated station will appear in a pop-up window, including the station's latitude, longitude, percentile ranks, and snowfall and precipitation data measured in inches.

Maps of Snowfall and Precipitation Totals for the 2022/2023 Winter Season

In the pages that follow, eight maps are presented with data for the 2022/2023 winter season, which we define as the period from November 1, 2022, through February 28, 2023:

Map 1. Total snowfall, in inches, across the 2022/2023 winter season

Map 2. Total precipitation, in inches, across the 2022/2023 winter season

Map 3. Percentile rankings for total 2022/2023 winter snowfall

Map 4. Percentile rankings for total 2022/2023 winter precipitation

Map 5. Identical to Map 3, but displaying only those stations with percentiles below 10% and above 90%

Map 6. Identical to Map 4, but displaying only those stations with percentiles below 10% or above 90%

Map 7. Identical to Map 3, but displaying only those stations with percentiles of 0% or 100%

Map 8. Identical to Map 4, but displaying only those stations with percentiles of 0% or 100%

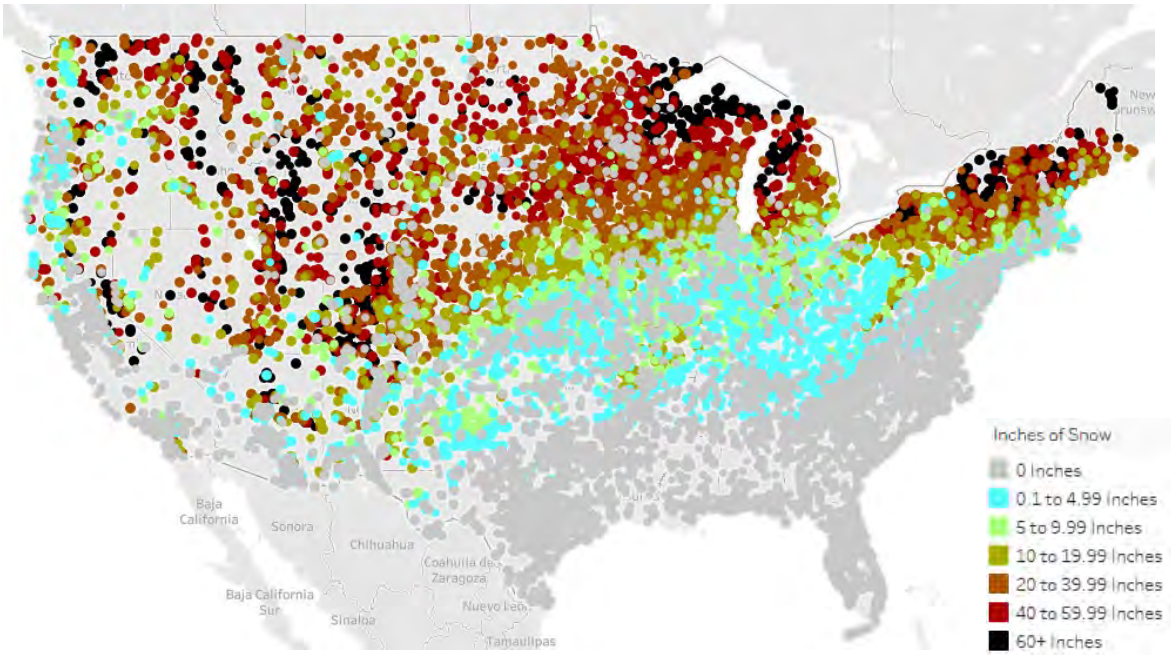
The first two maps were constructed using the "broad" dataset, while maps three through eight were constructed using the narrow dataset. Recall that stations in the narrow dataset are required to have at least 50 years of historical data. This lengthy history serves as a "measuring rod" against which to compare the 2022/2023 winter season. In contrast, maps one and two are not dependent on data history, but rather show only data from the 2022/2023 winter. Therefore, for these maps, we can use the broad dataset which provides more complete geographic coverage compared to the narrow dataset.

[1] Map URL: https://tableau.soa.org/#/site/soa-public/views/InchesofSnoworPrecip_v2021_2/1_Snow?:iid=1

[2] Map URL: https://tableau.soa.org/#/site/soa-public/views/SnowandPrcpPercentiles/1_MapofSnowfallPercentiles?:iid=2

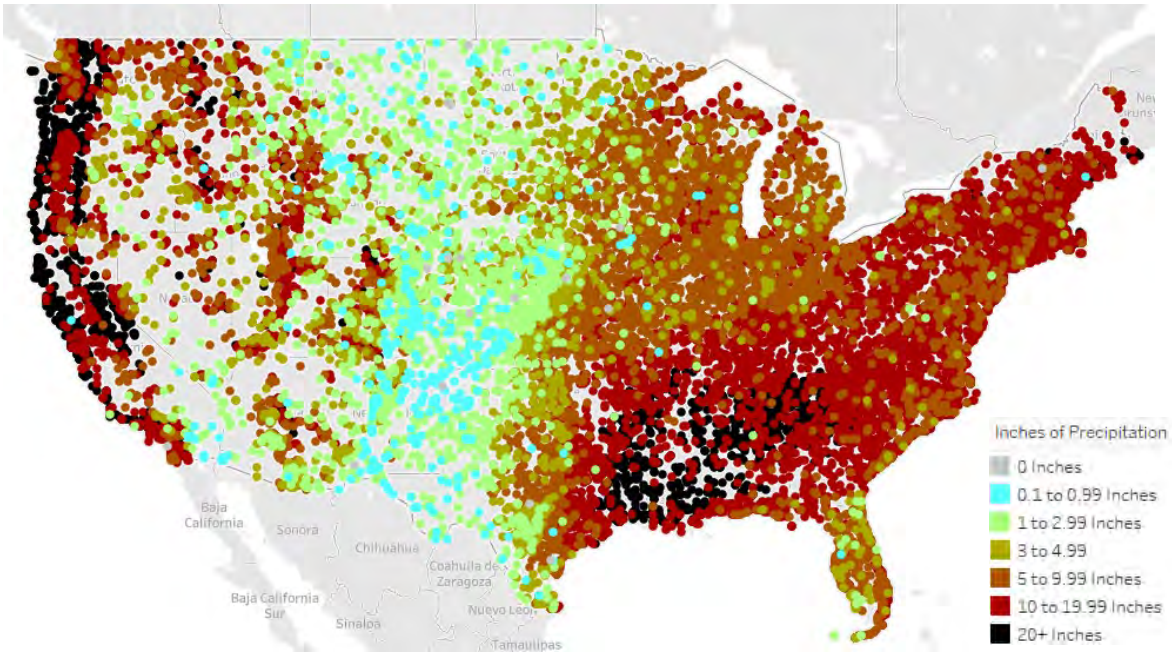
Map 1

CUMULATIVE SNOWFALL (INCHES) FROM NOVEMBER 2022 TO FEBRUARY 2023



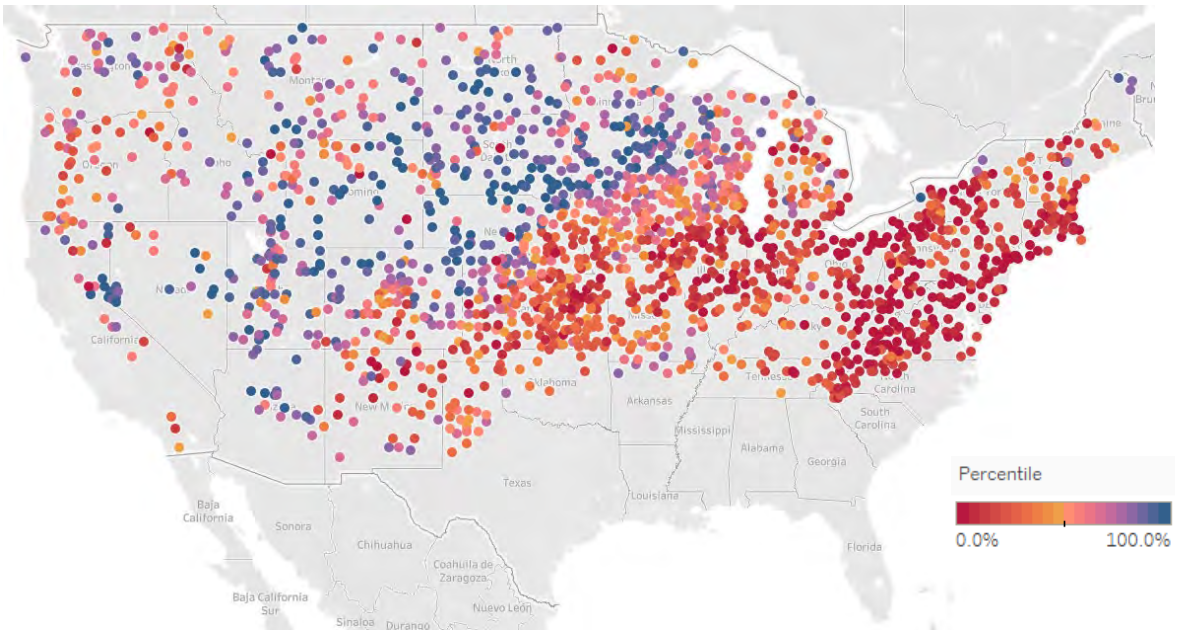
Map 2

CUMULATIVE PRECIPITATION (INCHES) FROM NOVEMBER 2022 TO FEBRUARY 2023



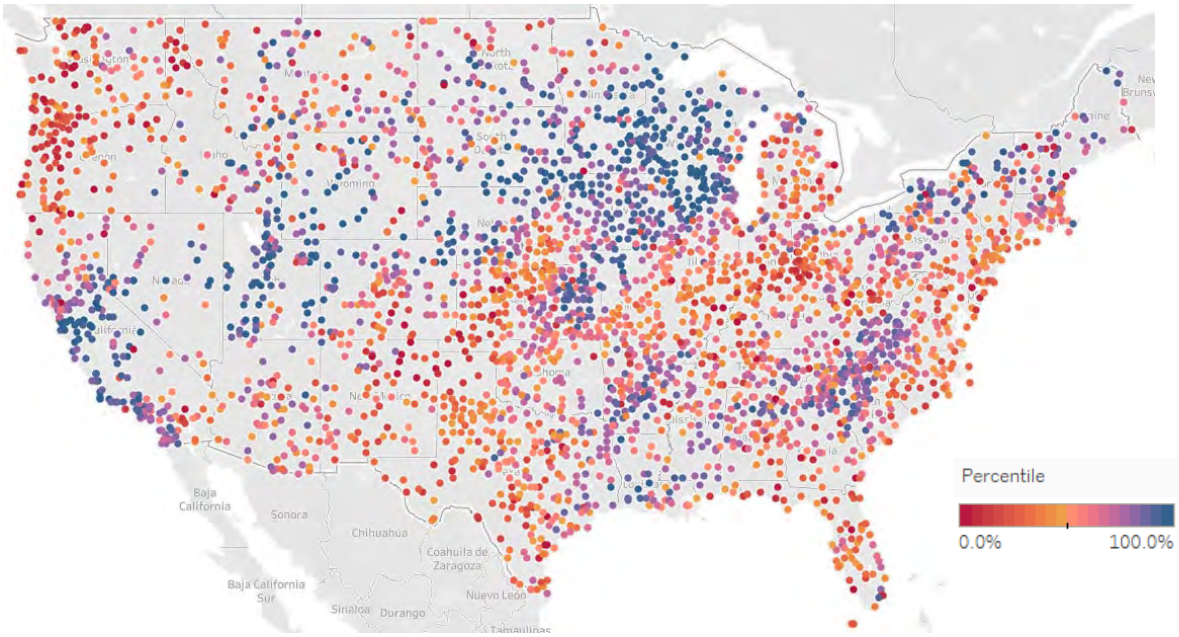
Map 3

SNOWFALL FROM NOV 2022 TO FEB 2023, RANKED AGAINST HISTORICAL DATA FOR THE NOV-FEB PERIOD



Map 4

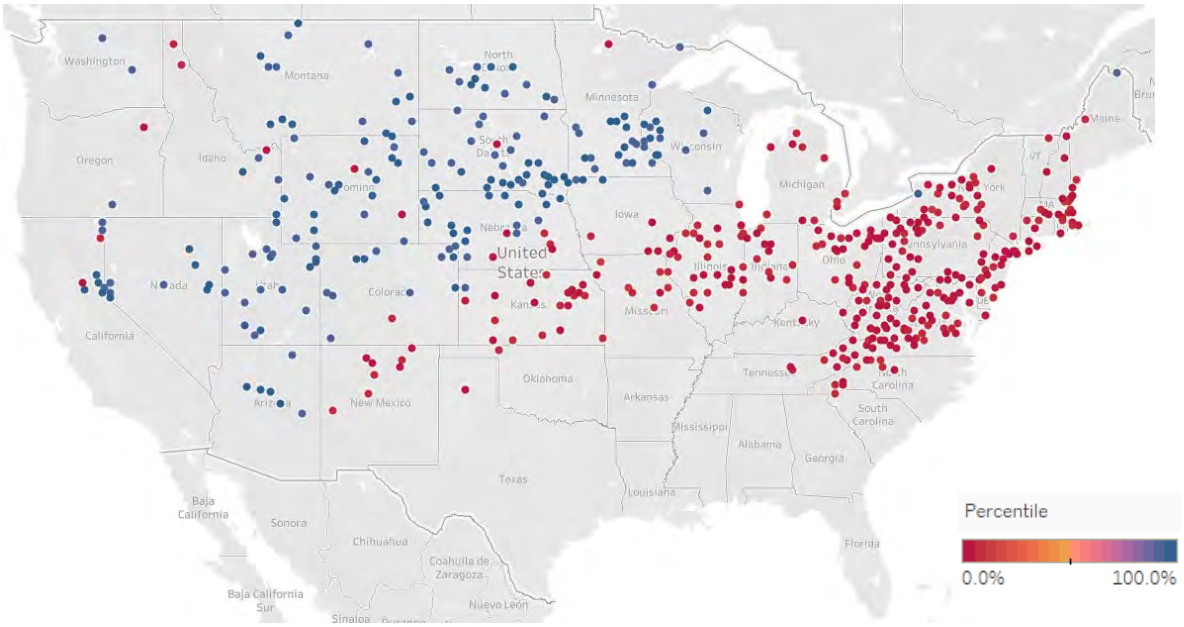
PRECIPITATION FROM NOV 2022 TO FEB 2023, RANKED AGAINST HISTORICAL DATA FOR THE NOV-FEB PERIOD



Map 5

SNOWFALL FROM NOV 2022 TO FEB 2023, RANKED AGAINST HISTORICAL DATA FOR THE NOV-FEB PERIOD

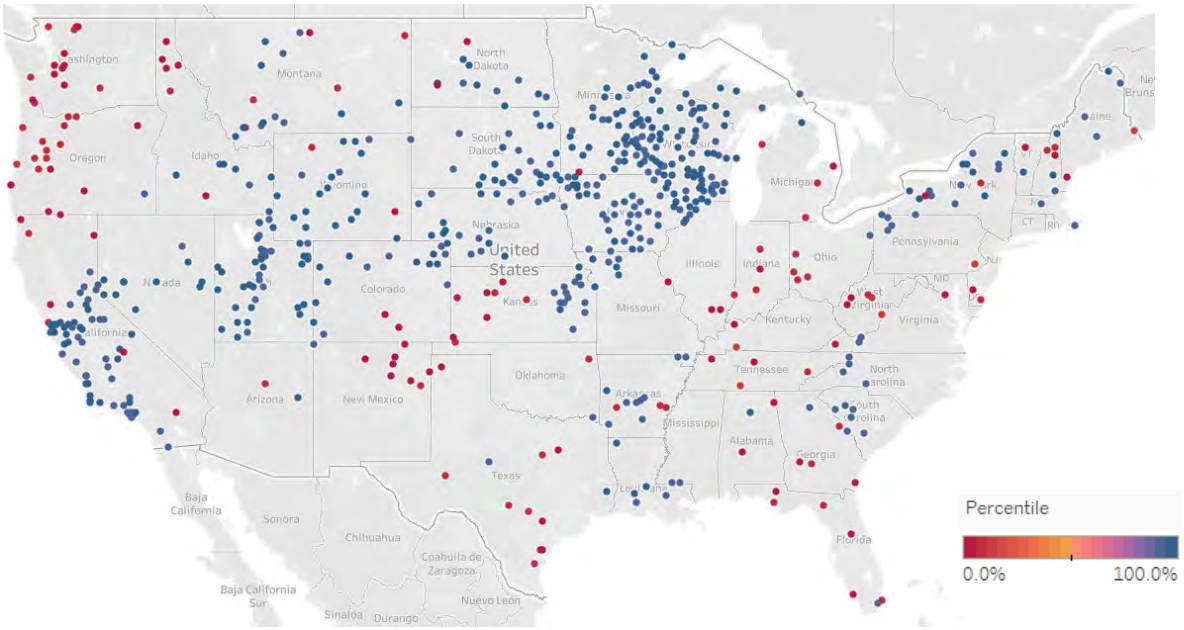
(Only those stations with a snowfall ranking below 10% or above 90% are shown on this map)



Map 6

PRECIPITATION FROM NOV 2022 TO FEB 2023, RANKED AGAINST HISTORICAL DATA FOR THE NOV-FEB PERIOD

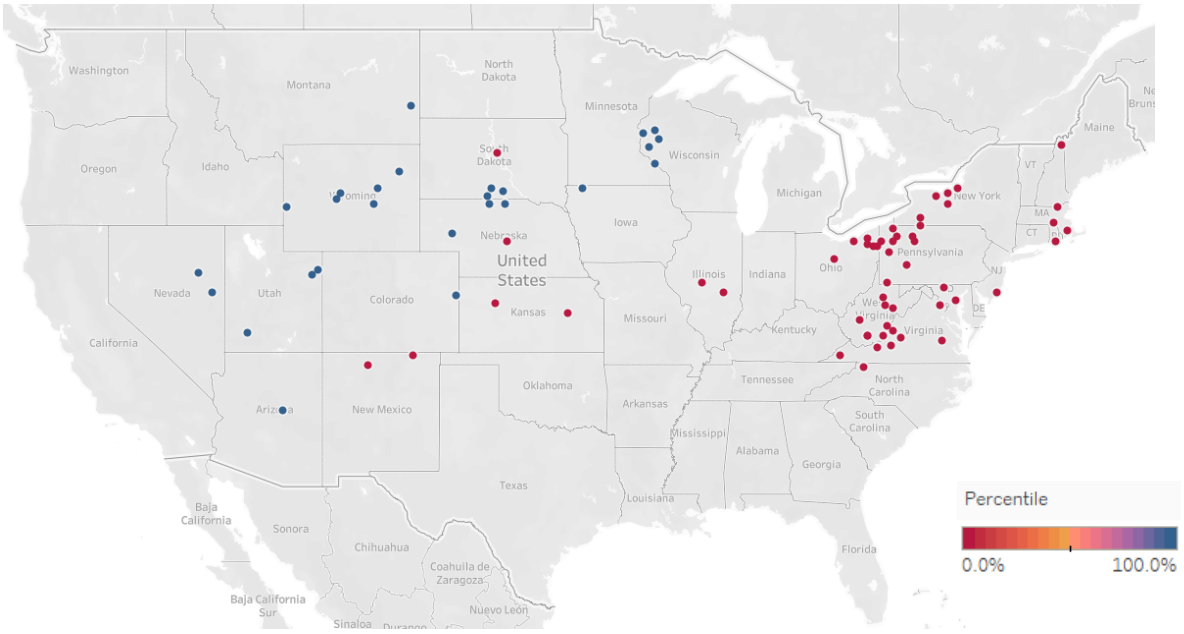
(Only those stations with a precipitation ranking below 10% or above 90% are shown on this map)



Map 7

SNOWFALL FROM NOV 2022 TO FEB 2023, RANKED AGAINST HISTORICAL DATA FOR THE NOV-FEB PERIOD

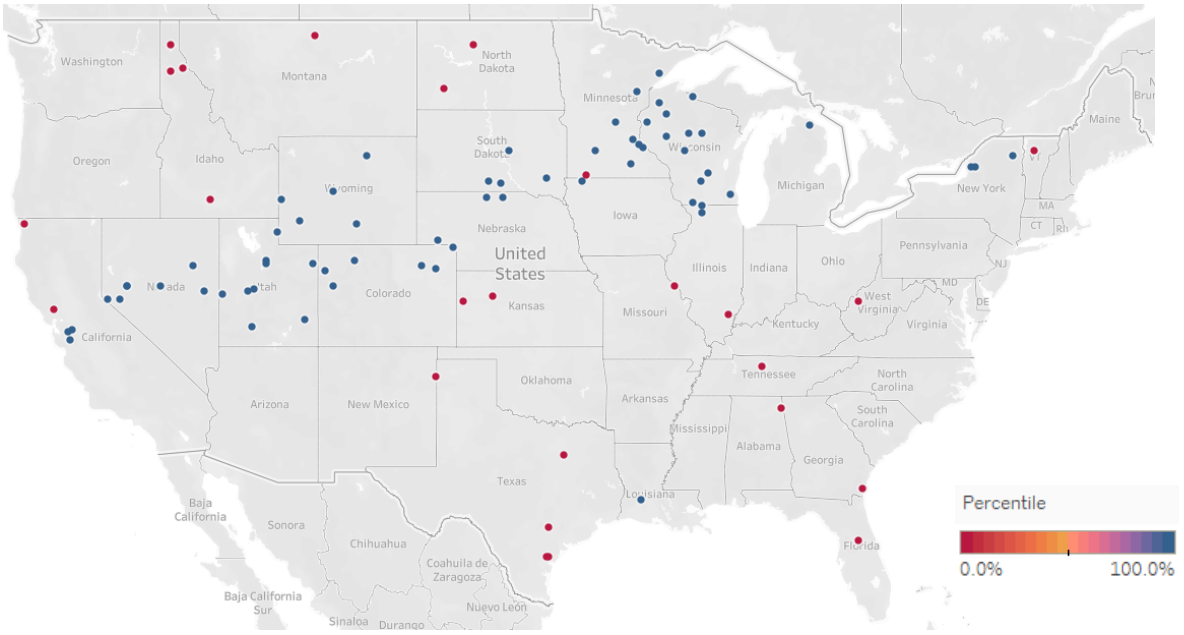
(Only those stations with a snowfall ranking of 0% or 100% are shown on this map)

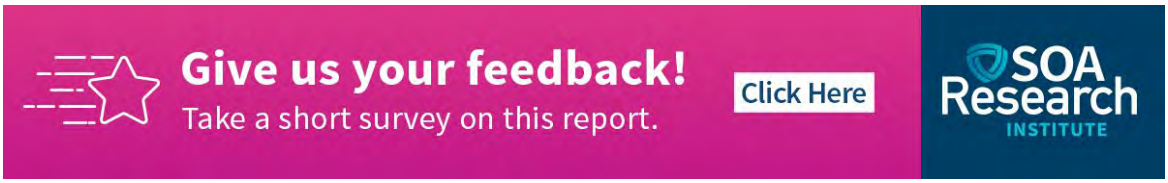


Map 8

PRECIPITATION FROM NOV 2022 TO FEB 2023, RANKED AGAINST HISTORICAL DATA FOR THE NOV-FEB PERIOD

(Only those stations with a precipitation ranking of 0% or 100% are shown on this map)





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