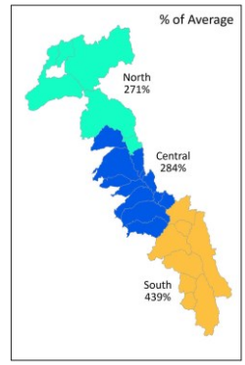
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California

April 1, 2023



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Summary of current conditions

The regional summary map above shows the mean SWE above 5000' elevation for three major regions of the Sierra Nevada, percent of average is calculated from a long-term average of 2001-2021. As of April 1, percent of average SWE is highest in the south (439%), then central (284%) and lowest in the north (271%). This snow year has produced sporadic percent of averages, especially in low-elevation areas, and will be higher than historical averages. **NEW this year, scroll down for comparison maps of CU SWE versus ASO SWE**. Detailed SWE maps (in JPG format) and summaries of SWE (in Excel format) by individual basin and elevation band accompany the report and are publicly available on our website **here**.

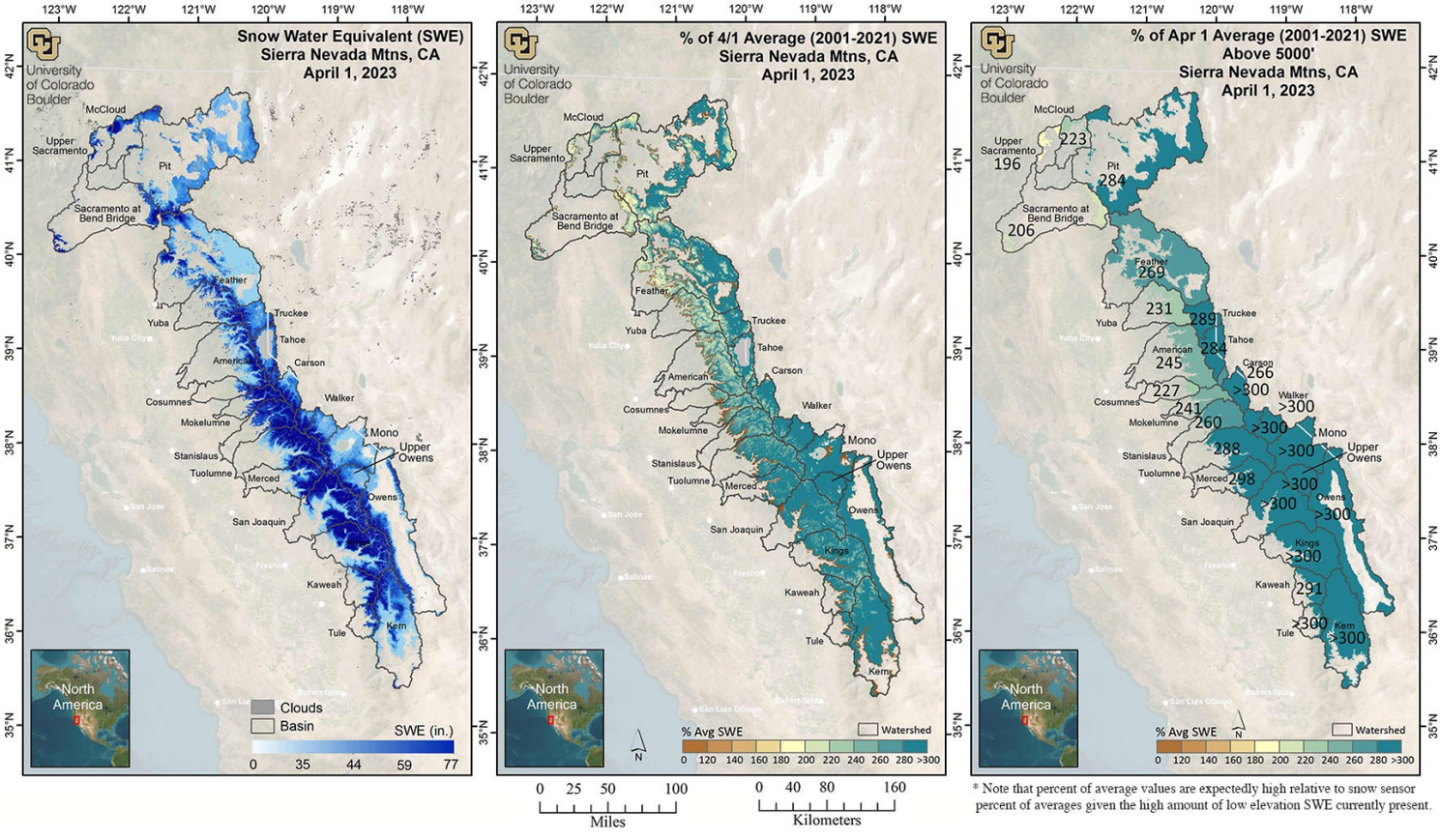

Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for April 1, 2023 (left), and percent of average (2001-2021) SWE for April 1, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

Location of Reports and Excel Format Tables

https://www.colorado.edu/instaar/research/labs-groups/mountain-hydrology-group/sierra-nevada-swe-reports

About this report

This is an experimental research product that provides near-real-time estimates of snow-water equivalent (SWE) at a spatial resolution of 500 m for the Sierra Nevada in California from mid-winter through the melt season. The report is typically released within a week of the date of data acquisition at the top of the report. A similar report covering the Intermountain West is available and is distributed to water managers in Colorado, Utah and Wyoming.

The spatial SWE analysis method for the Sierra Nevada uses the following data as inputs:

- In-situ SWE from all operational CA and NV snow pillow sensor sites and CoCoRaHS SWE values when available and applicable
- MODSCAG fractional snow-covered area (fSCA) data from recent cloud-free MODIS satellite images
- Physiographic information (elevation, latitude, upwind mountain barriers, slope, etc.)
- Historical daily SWE patterns (1985-2016) retrospectively generated using historical MODSCAG data and an energy-balance model that back-calculates SWE given the fSCA time-series and meltout date for each pixel.
- Satellite-observed daily mean fractional snow-covered area (DMFSCA).

For more details on the estimation method see the *Methods* section below. Please be sure to read the *Data Issues / Caveats* section for a discussion of persistent challenges or flagged uncertainties of the SWE product.

Data availability for this report

90 snow pillow sites in the Sierra Nevada network were recording SWE values out of a total of 128 sites, an unprecedented 38 were offline, and we used 11 CoCoRaHS measurements (shown in black, red and green, respectively, in Figure 5, left map).

The value of spatially explicit estimates of SWE

Snowmelt makes up the large majority (~60-85%) of the annual streamflow in the Sierra Nevada. The spatial distribution of snow-water equivalent (SWE) across the landscape is complex. While broad aspects of this spatial pattern (e.g., more SWE at higher elevations and on north-facing exposures) are fairly consistent, the details vary a lot from year to year, influencing the magnitude and timing of snowmelt-driven runoff.

SWE is operationally monitored at over a hundred and thirty snow pillow sensor sites spread across the Sierra Nevada, providing a critical first-order snapshot of conditions, and the basis for runoff forecasts from the CA DWR, NRCS, and NOAA. However, conditions at snow pillow sites (e.g., percent of normal SWE) may not be representative of conditions in the large areas between these point measurements, and at elevations above and below the range of the sensor sites. The spatial snow analysis creates a detailed picture of the spatial pattern of SWE using snow sensors, satellite, and other data, extending beyond the snow sensor sites to unmonitored areas.

Interpreting the spatial SWE estimates in the context of snow pillows

The spatial product estimates SWE for every pixel where the MODSCAG product identifies snow-cover. Comparatively, snow sensor samples 8-20 points per basin within a narrower elevation range. Thus, the basin-wide percent of average from the spatial SWE estimates is not directly comparable with the snow sensor basin-wide percent of average. A better comparison might be made with the % of average in the elevation bands (Table 2) that contain snow sensor sites.

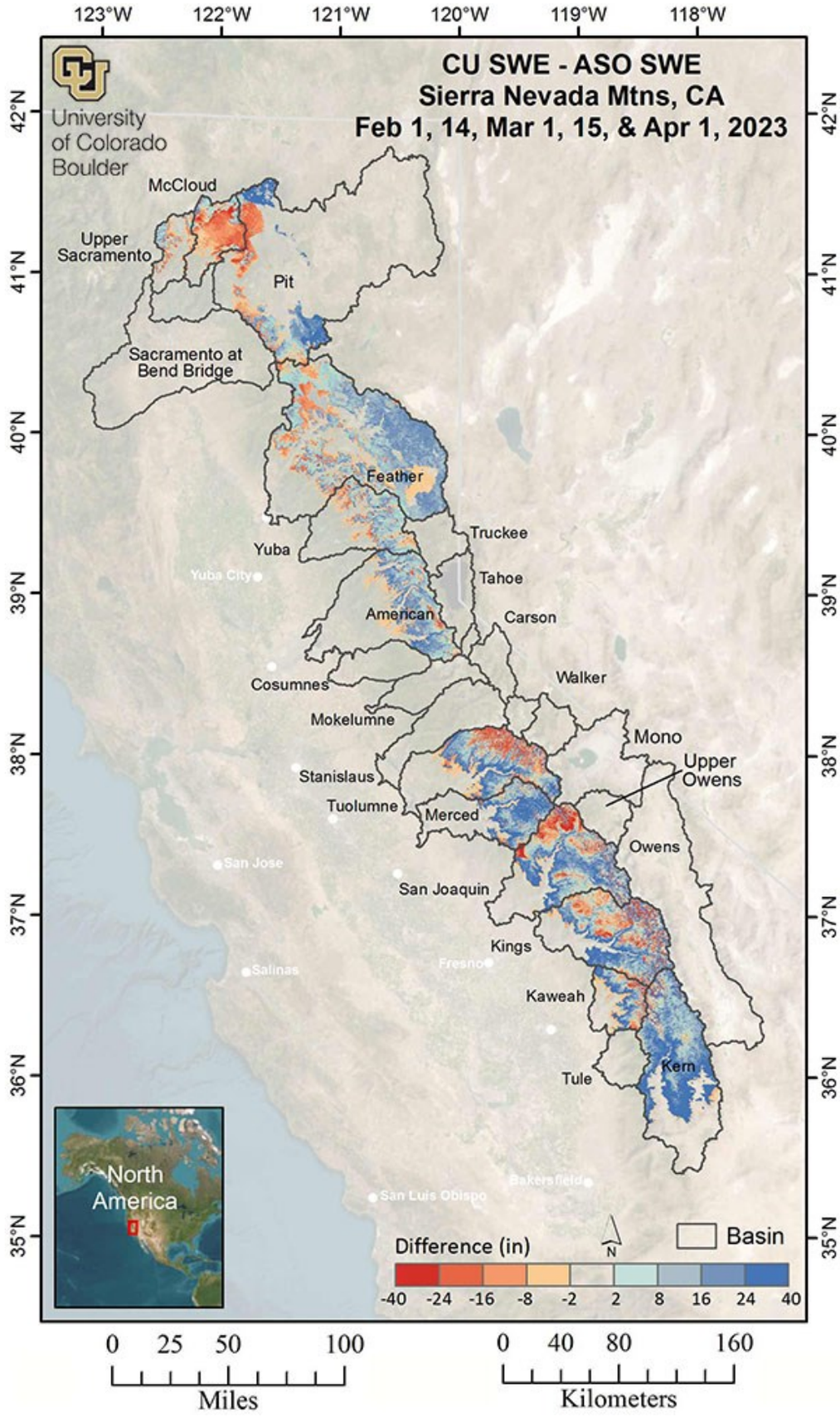

Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the February 1, February 14, March 1, March 15, and April 1, 2023 CU SWE model run and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins. Red colors show where CU SWE is lower than ASO SWE and blue colors show where CU SWE is higher than ASO SWE. The CU SWE model runs are only for areas above 5000', so any snow imaged by ASO below 5000' will show up as light red colors. This map will be updated as new ASO data becomes available.

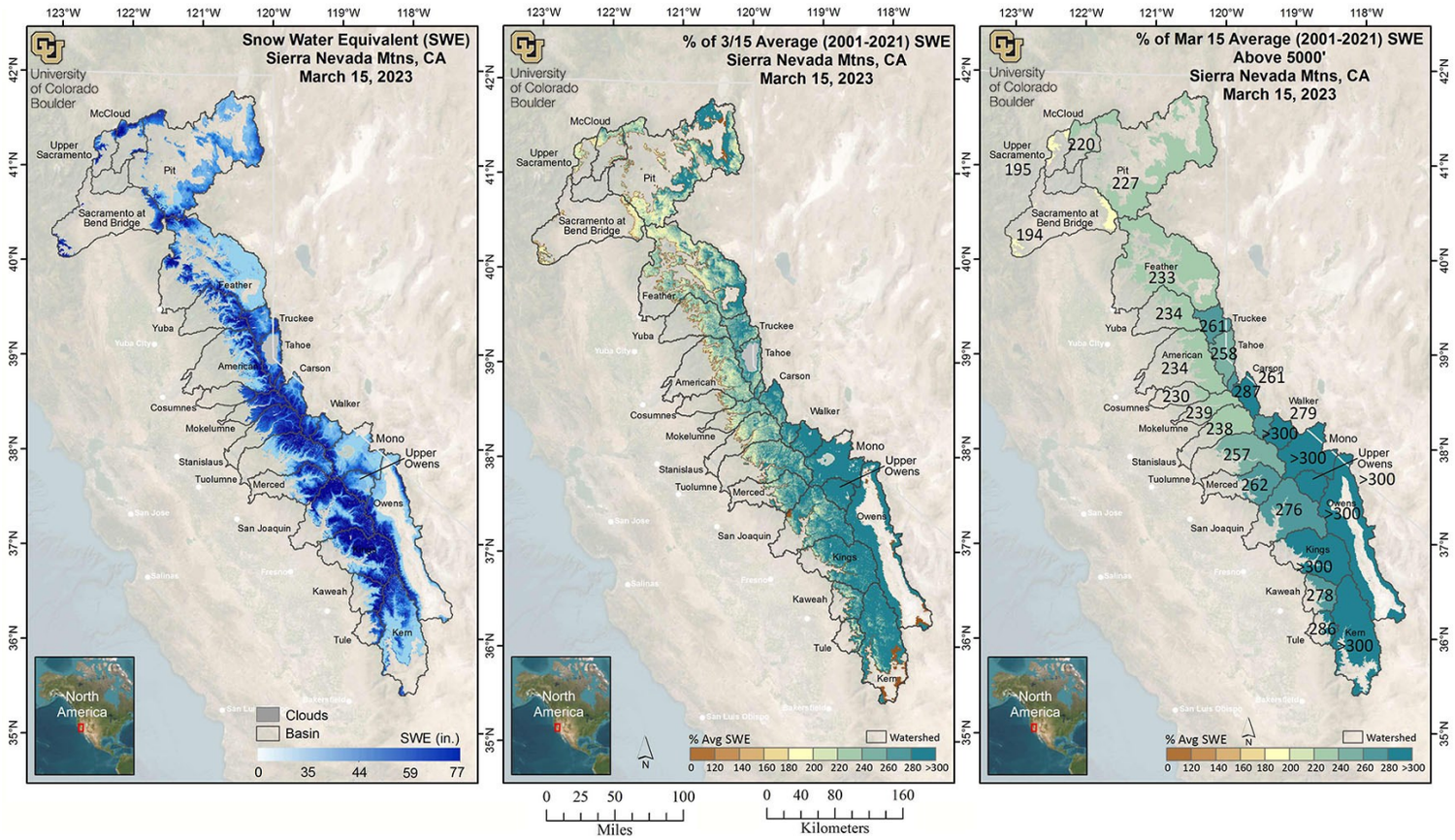

Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for March 15, 2023 (left), and percent of average (2001-2021) SWE for March 15, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

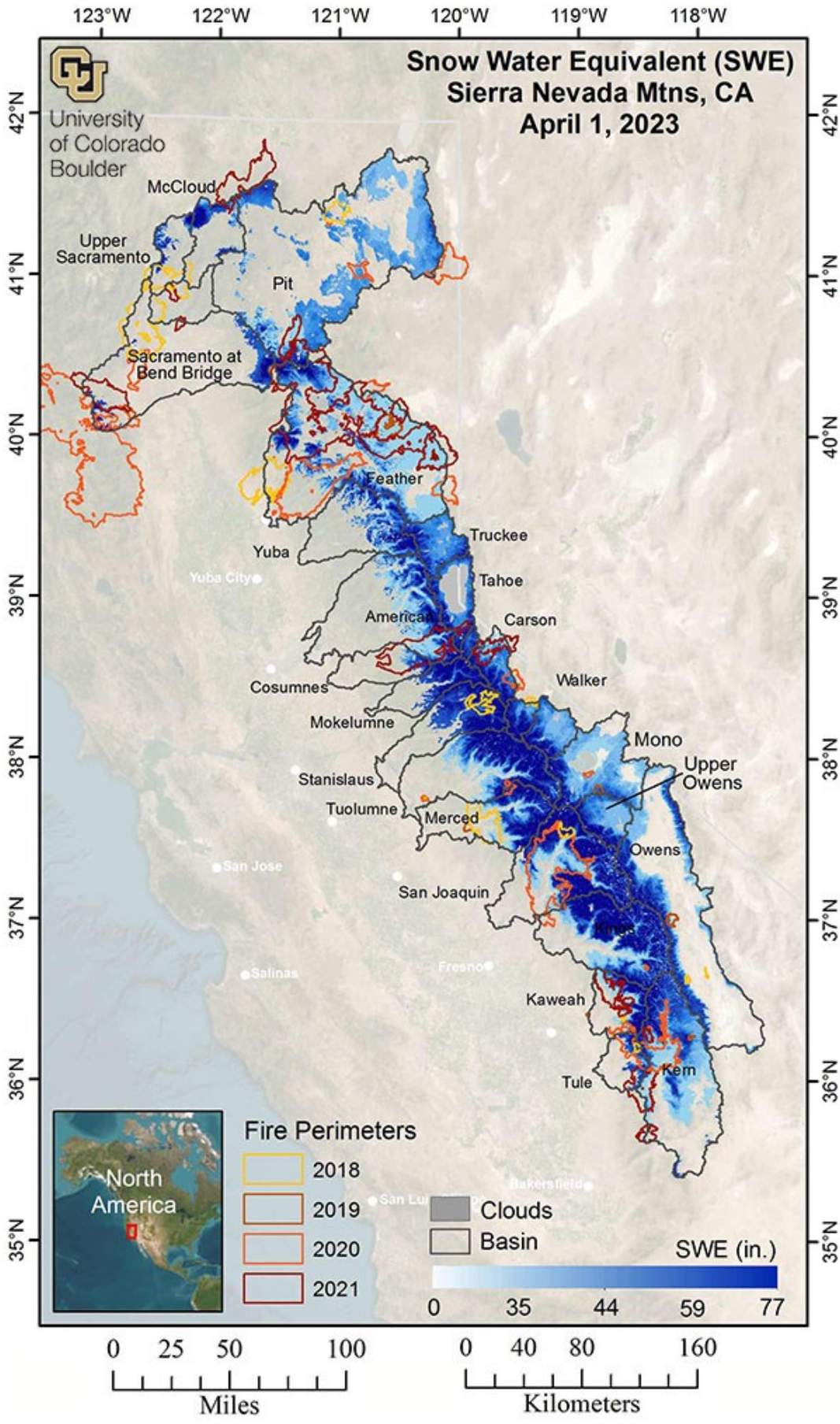

Figure 4. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts for April 1, 2023 are shown with fire perimeters from 2018-2021 (colored from yellow to red).

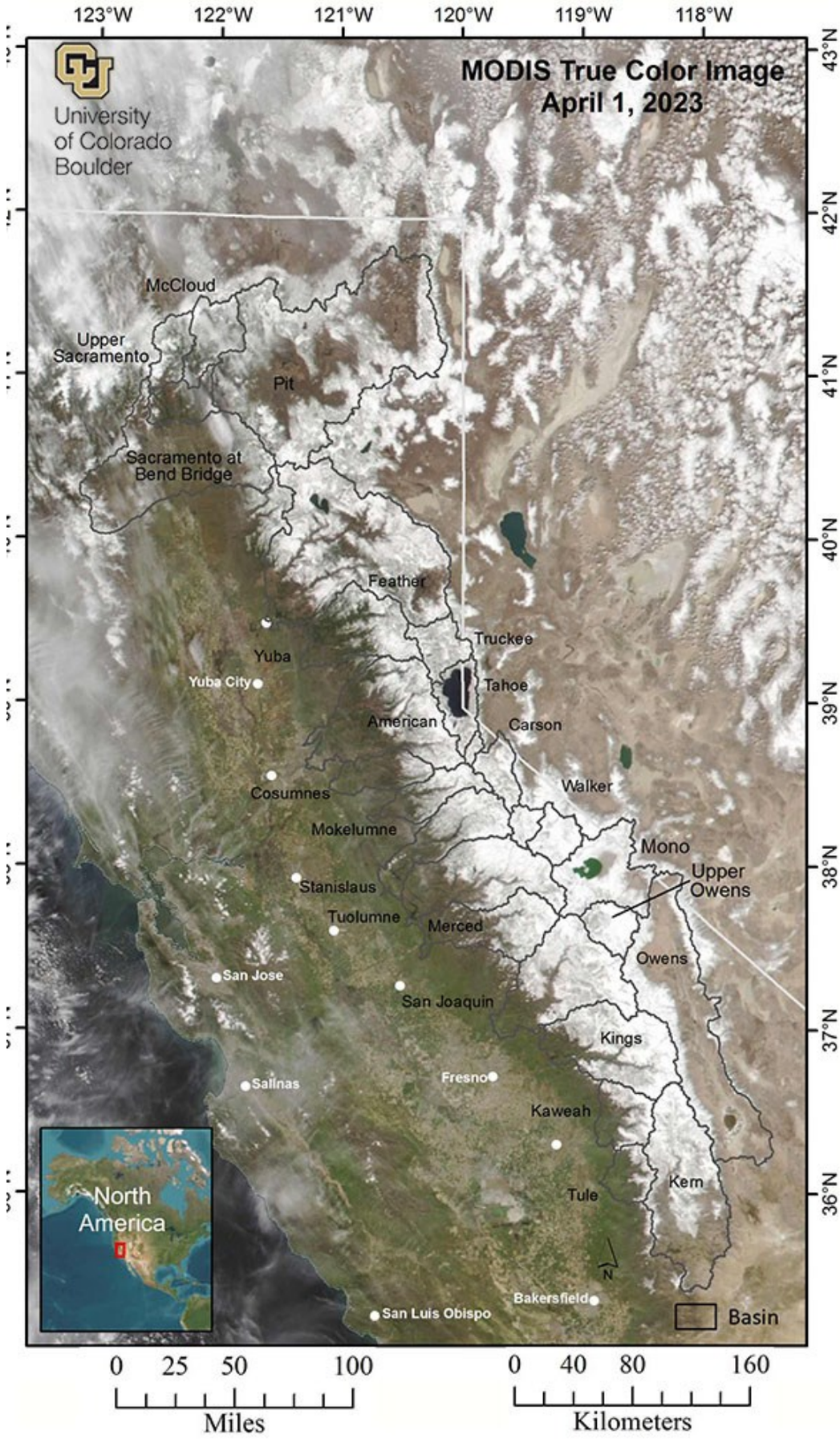

Figure 5. MODIS image, Sierra Nevada. A mostly cloud-free true color MODIS image, showing an image close to what was used for the April 1, 2023 regression model run.

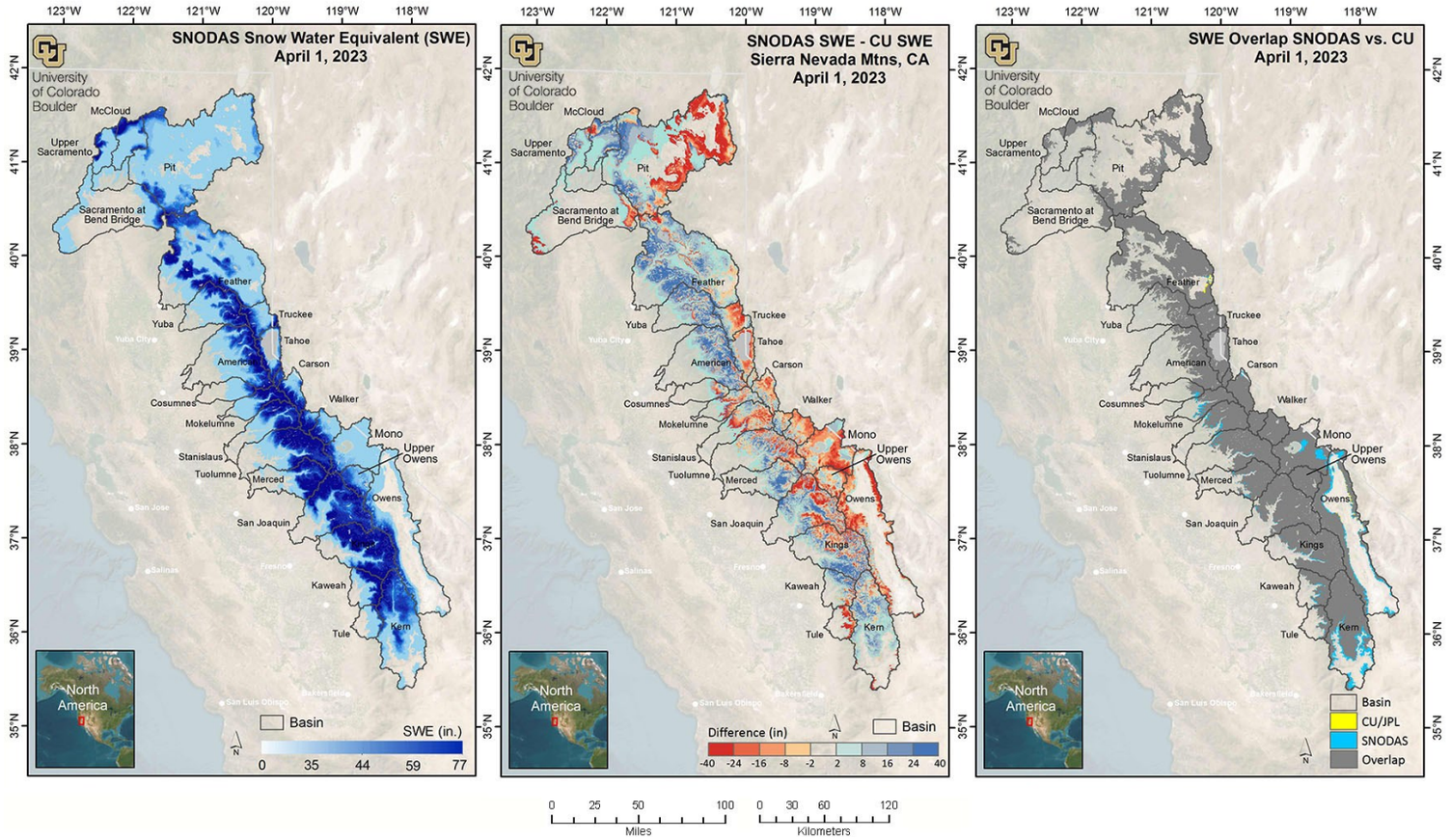

Figure 6. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE for April 1st from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows the difference between the April 1st SNODAS SWE estimate and CU regression SWE estimate. Red pixels denote areas where SNODAS SWE is less than CU SWE and blue pixels show areas where SNODAS SWE is higher than CU SWE. Light blue areas in low elevations are below 5000' where the CU SWE model doesn't calculate SWE estimates. The map on the right shows the snow-cover extent of SNODAS and CU SWE estimates. Yellow pixels show where the location of CU snow extends beyond the location of the SNODAS snow extent. Blue pixels show where the SNODAS snow extends beyond the CU snow extent. Gray areas indicate regions where both products agree on the snow-cover extent.

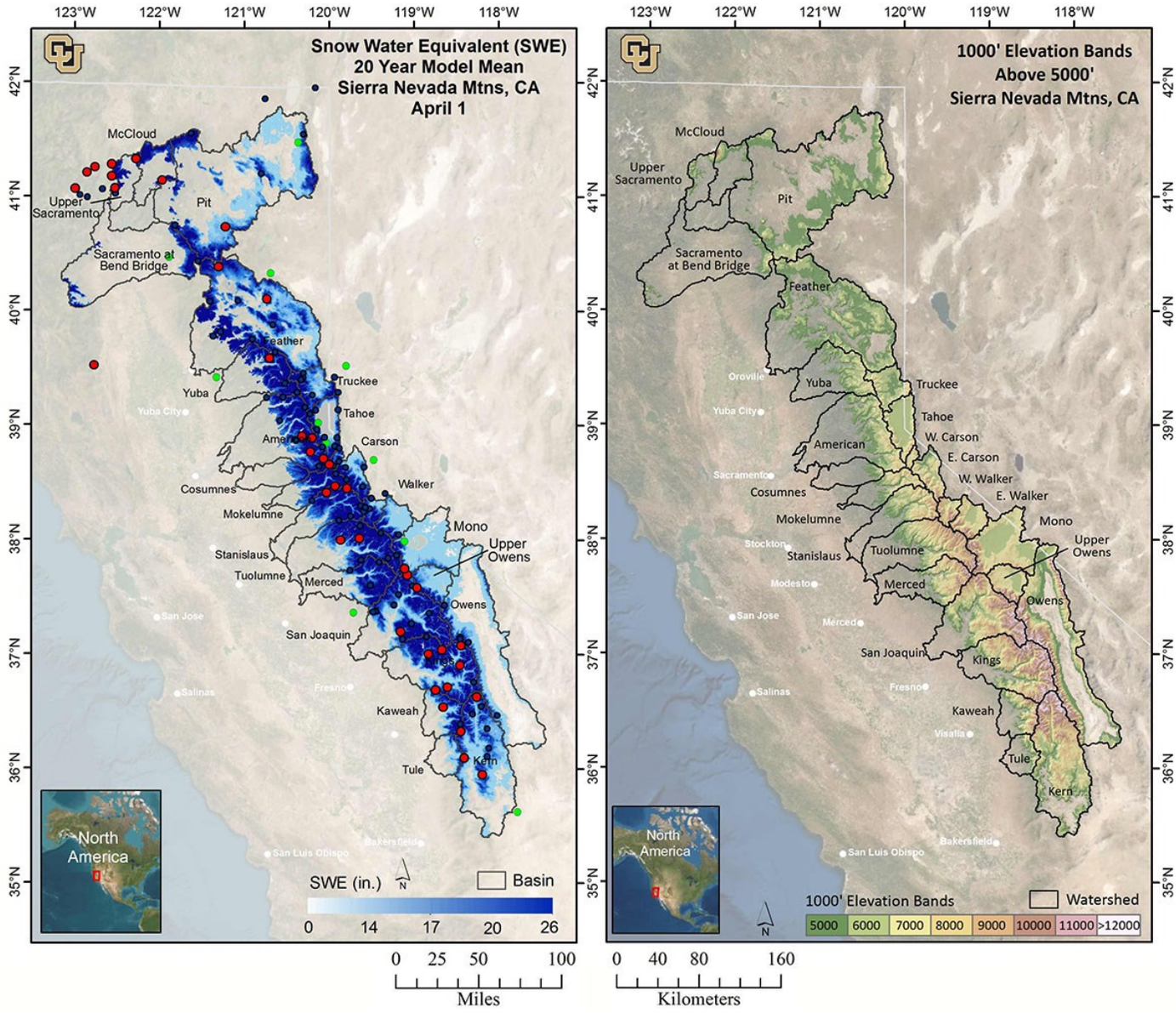

Figure 7. Historical average April 1st and Elevation Bands for the Sierra Nevada. Average SWE (2001-2021) for April 1st (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and Table 2. Map on left shows snow pillow sensor sites recording SWE on April 1st (black), sites that were offline are shown in red, and CoCoRaHS sites are shown in green. Note the average SWE map is using a different color ramp than the April 1 modeled SWE map shown in Figure 1.

Methods

The spatial SWE estimation method is described in Yang, et al. (2022) and Schneider and Molotch (2016). The method uses linear regression in which the dependent variable is derived from the operationally measured in situ SWE from all online snow pillow sensor sites in the domain. The snow pillow sensor SWE observations are scaled by the fractional snow-covered area (fSCA) across the 500 m pixel containing that snow pillow sensor site before being used in the linear regression model. The fSCA is a combination of a near-real-time cloud-free MODIS satellite image which has been processed using the MODIS Snow Cover and Grain size (MODSCAG) fractional snow-covered area algorithm program (Painter, et al. 2009) and the Snow Today fSCA image when necessary (Rittger, et al. 2019, https://nsidc.org/snow-today).

The following independent variables (predictors) enter into the linear regression model:

- Physiographic variables that affect snow accumulation, melt, and redistribution, including elevation, latitude, upwind mountain barriers, slope, and others. See Table 1 in Yang, et al. (2022) for the full set of these variables.
- The historical daily SWE pattern (1985-2016) retrospectively generated using historical MODSCAG data, and an energy-balance model that back-calculates SWE given the fractional Snow-Covered Area (fSCA) time series and meltout date for

each pixel. See Margulis, et al. (2016) for details. (For computational efficiency, only one image during the 1985-2016 period that best matches the real-time snow pillow-observed pattern is selected as an independent variable.)
- Satellite-observed daily mean fractional snow-covered area (DMFSCA) derived from Rittger, et. al., 2019 data.

The real-time regression model for this date has been validated by cross-validation, whereby 10% of the snow pillow data are randomly removed and the model prediction is compared to the measured value at the removed snow pillow stations. This is repeated 30 times to obtain an average R-squared value, which denotes how closely the model fits the snow pillow data. During development of this regression method, the model was also validated against independent historical SWE data collected in snow surveys at 9 locations in Colorado, and an intensive field survey in north-central Colorado. Data utilized to generate this report change to optimize model performance. To maintain consistency across the historical record, the percent of average values are based on our baseline algorithm and therefore there can be discrepancies between absolute SWE values and corresponding percent of averages.

Data Issues/Caveats for* April 1, 2023 – *IMPORTANT – READ THIS!

- CLOUD COVER – Cloud cover can obscure satellite measurements of snow-cover. While careful checks are made, occasionally the misclassification of clouds as snow or *vice versa* may result in the mischaracterization of SWE or bare-ground.
- RECENT SNOWFALL – There are occasionally problems with lower-elevation SWE estimates due to recent snowfall events that result in extensive snow-cover extending to valley locations where measurements are not available. This scenario results in an over-estimation of lower- elevation SWE.
- ANOMALOUS SNOW PATTERNS – Anomalous snow years or snow distributions may cause SWE error due to the model design to search for similar SWE distributions from previous years. If no close seasonal analogue exists, the model is forced to find the most similar year, which may result in error.
- PERCENT OF AVERAGE CALCULATIONS - Data utilized to generate this report change to optimize model performance. To maintain consistency across the historical record, the percent of average values are based on our baseline algorithm and therefore there can be discrepancies between absolute SWE values and corresponding percent of averages.
- MODELING METHODS - We work to generate the best SWE estimates for each reporting date. Our methods can change from one report to another. Sometimes data changes between reports is an artifact of method changes.

List of All Known Data Issues/Caveats

- NEW AVERAGE CALCULATIONS – Average calculations are based on 2001-2021 model values, this includes the drought years (2012-2016) which brings our overall average SWE down considerably, thereby increasing percent of averages.
- RECENT SNOWFALL – There are occasionally problems with lower-elevation SWE estimates due to recent snowfall events that result in extensive snow-cover extending to valley locations where measurements are not available. This scenario results in an over-estimation of lower- elevation SWE.
- LIMITED SNOW PILLOW DATA – When snow at the snow pillow sites melts out, but remains at higher elevations, the model tends to underestimate SWE at the under-monitored upper elevations. This issue typically occurs late in the melt season, resulting in less accurate SWE prediction at higher elevations compared to earlier in the snow season.
- CLOUD COVER – Cloud cover can obscure satellite measurements of snow-cover. While careful checks are made, occasionally the misclassification of clouds as snow or *vice versa* may result in the mischaracterization of SWE or bare-ground.
- LOW LOOK ANGLE – When a satellite does not pass directly over a region but the area is still included within the satellite sensor's field of view, this is referred to as a low "look angle". The resulting image has lower effective resolution – this "blurry" MODSCAG data still contains useful information but may lead to overestimation of SWE near the margins of the snow-cover extent.
- POOR QUALITY SNOW SENSOR DATA – Although data QA/QC is performed, occasional sensor malfunction may result in localized SWE errors.
- ANOMALOUS SNOW PATTERNS – Anomalous snow years or snow distributions may cause SWE error due to the model design to search for similar SWE distributions from previous years. If no close seasonal analogue exists, the model is forced to find the most similar year, which may result in error.
- DENSE FOREST COVER – Dense forest cover at lower elevations where snow-cover is discontinuous can cause the satellite to underestimate the snow-cover extent, leading to underestimation of SWE.
- MISSING SWE VALUES - Volume calculations for the Kings, Kaweah, Kern, and Tule basins are based on place-holder values for SWE in the lower elevations. Place-holder values are based on average SWE accumulation values at higher elevations where we have higher confidence in the SWE estimates.
- PERCENT OF AVERAGE CALCULATIONS - Data utilized to generate this report change to optimize model performance.

To maintain consistency across the historical record, the percent of average values are based on our baseline algorithm and therefore there can be discrepancies between absolute SWE values and corresponding percent of averages.

- MODELING METHODS - We work to generate the best SWE estimates for each reporting date. Our methods can change from one report to another. Sometimes data changes between reports is an artifact of method changes.

Table 1. Estimated SWE by basin. *The basin-wide SWE values and averages, are across all pixels at elevations >5000'. Shown are March 15th percent of March 15th average SWE, April 1st percent of April 1st average SWE (between 2001-2021 as derived from the regression model), March 15th mean SWE, April 1st mean SWE, April 1st percent of snow-covered area, April 1st water volume (acre-feet), the area (mi^2) inside each basin that contains data pixels (not including cloud-covered pixels, lakes or other satellite no data pixels), April 1st surveys, March 15th snow pillow data, and April 1st snow pillow data for those areas collected, summarized for each basin. The last column shows April 1st mean SWE from SNODAS*.*

Basin	3/15/23 % 3/15 Avg.	4/1/23 % 4/1 Avg.	3/15/23 SWE (in)	4/1/23 SWE (in)	4/1/23 % SCA	4/1/23‡ Vol (af)	Area (mi2) > 5000'	4/1/23 Surveys	3/15/23 Pillows	4/1/23 Pillows	4/1/23 SNODAS* (in)
Upper Sacramento§	195	196	46.0	52.1	98.2	333,382	120.0	38.5 (2)	59.0 (2)	73.6 (1)	57.5
McCloud§	220	223	55.5	60.2	99.3	563,041	175.3	37.0 (1)	NA	NA	62.7
Pit§	227	>250†	31.7	30.6	97.9	3,679,748	2252.6	28.7 (3)	35.8 (4)	40.9 (4)	18.9
Sac at Bend Bridge	194	206	52.2	57.0	98.3	766,544	252.0	21.5 (1)	NA	NA	37.1
Feather§	233	>250†	27.1	27.0	97.1	3,241,956	2,254.1	43.0 (19)	58.3 (6)	68.5 (5)	35.6
Yuba§	234	231	47.0	46.5	97.9	1,330,880	536.8	75.3 (7)	74.2 (3)	81.6 (3)	60.0
American§	234	245	37.5	40.0	99.0	1,778,814	834.8	51.8 (15)	49.5 (9)	52.8 (8)	52.8
Cosumnes	230	227	51.0	43.4	82.2	217,929	94.1	NA	NA	NA	40.9
Mokelumne	239	241	57.2	60.3	91.7	1,082,935	336.7	70.4 (9)	68.0 (1)	72.8 (1)	57.3
Stanislaus	238	>250†	55.9	61.1	95.6	1,925,648	590.9	72.8 (14)	66.7 (4)	73.2 (4)	55.3
Tuolumne§	>250†	>250†	41.9	60.0	95.9	3,070,612	959.6	60.8 (10)	66.9 (7)	74.2 (5)	60.6
Merced§	>250†	>250†	43.7	51.5	96.4	1,550,056	564.3	82.1 (4)	75.4 (2)	72.3 (3)	60.9
San Joaquin§	>250†	>250†	57.1	59.5	96.2	4,031,646	1,270.4	65.9 (19)	64.5 (8)	70.8 (8)	58.3
Kings§	>250†	>250†	59.3	58.2	96.1	3,911,200	1,260.4	74.4 (19)	68.0 (5)	72.3 (2)	62.4
Kaweah§	>250†	>250†	42.5	48.5	92.1	841,693	325.6	65.8 (2)	52.0 (2)	83.5 (1)	56.1
Tule	>250†	>250†	46.7	47.1	86.2	360,181	143.2	29.5 (2)	NA	NA	26.9
Kern§	>250†	>250†	25.1	26.8	74.4	2,494,201	1,744.4	52.9 (14)	49.3 (9)	49.4 (5)	31.5
Truckee	>250†	>250†	46.1	45.5	99.4	1,084,923	447.2	NA	41.7 (5)	44.1 (5)	41.2
Tahoe	>250†	>250†	49.8	52.2	99.6	931,991	334.6	43.0 (6)	53.8 (7)	57.0 (7)	47.8
W Carson	>250†	>250†	55.9	58.6	99.4	219,355	70.2	77.0 (1)	61.1 (2)	65.1 (2)	56.2
E Carson	>250†	>250†	46.5	46.5	89.5	945,179	381.4	NA	51.8 (5)	54.3 (5)	42.4
W Walker	>250†	>250†	53.6	60.4	98.6	616,182	191.4	55.0 (2)	65.2 (3)	68.4 (3)	61.5
E Walker	>250†	>250†	41.1	43.5	97.6	876,825	377.6	NA	49.0 (1)	53.8 (1)	35.7
Mono	>250†	>250†	28.3	28.8	84.7	1,637,409	1,067.9	81.5 (3)	NA	NA	19.6
Upper Owens	>250†	>250†	39.6	44.6	96.7	944,212	397.3	79.8 (3)	88.0 (1)	NA	37.0
Owens	>250†	>250†	24.4	23.1	50.4	2,288,324	1,854.0	41.1 (7)	45.3 (5)	50.2 (5)	14.8

§ Data in all ASO-collected basins have been bias-corrected using ASO data and therefore the SWE changes might not represent snowmelt but rather an update to the SWE estimates based on airborne data.

† Deep, and particularly low-elevation snow in areas that typically are snow-free can report exceptionally high percent of average for this date because the mean 2001-2021 regression-derived SWE for that area is low or 0.

‡ For volume totals above Shasta Lake add Upper Sac, McCloud and Pit volumes. For volume totals above Bend Bridge add Upper Sac, McCloud, Pit and Sac at Bend Bridge volumes.

* This is a comparison to the SNODAS (SNOw Data Assimilation System) nationwide product from the National Weather Service.

Table 2. Estimated SWE by basin and elevation band. *The basin-wide SWE values and averages, are across all pixels at elevations >5000'. Elevation bands begin at 5000' and extend past the highest point in the basin. Note that the area of the highest 2-5 bands is typically much smaller than the lower bands. Shown are March 15th percent of March 15th average SWE, April 1st percent of April 1st average SWE (between 2001-2021 as derived from the regression model), March 15th mean SWE, April 1st mean SWE, April 1st percent of snow-covered area, April 1st water volume (acre-feet), the area (mi²) inside each basin that contains data pixels (not including cloud-covered pixels, lakes or other satellite no data pixels), April 1st surveys, March 15th snow pillow data, and April 1st snow pillow data for those areas collected, summarized for each 1000' elevation band inside each basin. The last column shows April 1st mean SWE from SNODAS*.*

Basin	Elevation Band	3/15/23 % 3/15 Avg.	4/1/23 % 4/1 Avg.	3/15/23 SWE (in)	4/1/23 SWE (in)	4/1/23 % SCA	4/1/23‡ Vol (af)	4/1/23 Area (mi2)	4/1/23 Surveys	3/15/23 Pillows	4/1/23 Pillows	4/1/23 SNODAS* (in)
Upper Sacramento§	5000-6000'	208	211	43.2	44.8	97.8	162,173	67.9	NA	66.0 (1)	73.6 (1)	52.5
	6000-7000'	190	191	48.7	56.6	98.5	108,161	35.8	38.5 (2)	52.0 (1)	NA	66.0
	7000-8000'	168	176	49.4	68.2	97.8	31,451	8.6	NA	NA	NA	60.9
	8000-9000'	156	153	56.4	80.4	99.4	13,156	3.1	NA	NA	NA	61.8
	9000-10,000'	148	151	57.4	83.4	100.0	9,310	2.1	NA	NA	NA	60.6
	10,000-11,000'	160	152	58.9	86.4	100.0	5,787	1.3	NA	NA	NA	54.9
	> 11,000'	144	105	36.0	52.9	100.0	3,344	1.2	NA	NA	NA	48.8
McCloud§	5000-6000'	229	237	48.5	46.4	98.9	255,094	103.0	37.0 (1)	NA	NA	56.7
	6000-7000'	213	214	59.1	65.3	100.0	151,983	43.7	NA	NA	NA	73.0
	7000-8000'	204	219	79.0	106.6	100.0	80,899	14.2	NA	NA	NA	70.3
	8000-9000'	209	214	75.3	103.7	100.0	37,400	6.8	NA	NA	NA	72.4
	>9,000'	213	194	71.0	98.0	100.0	16,397	3.1	NA	NA	NA	69.7
Pit§	5000-6000'	250	>300†	28.5	27.4	97.2	2,253,678	1,540.0	NA	56.6 (1)	63.7 (1)	13.7
	6000-7000'	199	210	36.4	34.6	99.3	1,014,732	550.0	28.7 (3)	31.0 (2)	35.6 (2)	27.8
	7000-8000'	196	192	45.0	45.6	99.8	339,086	139.5	NA	24.4 (1)	28.6 (1)	38.8
	>8,000'	197	191	51.3	56.5	100.0	64,294	21.3	NA	NA	NA	34.7
Sac at Bend Bridge	5000-6000'	192	214	43.2	50.1	97.9	447,131	167.4	21.5 (1)	NA	NA	30.5
	6000-7000'	194	199	53.6	64.4	99.0	216,461	63.0	NA	NA	NA	46.4
	>7,000'	203	194	66.6	86.1	99.9	75,619	16.5	NA	NA	NA	60.3
Feather§	5000-6000'	242	296	23.3	22.7	96.6	1,630,440	1,347.0	34.8 (9)	70.9 (1)	78.5 (1)	32.5
	6000-7000'	223	245	31.1	31.2	97.8	1,293,876	778.7	50.1 (7)	57.9 (4)	70.7 (3)	38.8
	7000-8000'	215	211	43.1	46.0	98.4	303,986	123.9	50.8 (3)	47.2 (1)	52.0 (1)	48.5
	8000-9000'	219	192	52.3	57.4	99.0	13,655	4.5	NA	NA	NA	49.8
Yuba§	5000-6000'	224	237	32.7	32.3	97.9	344,213	199.7	55.0 (1)	NA	NA	45.2
	6000-7000'	241	234	49.5	47.6	97.4	553,352	217.9	66.8 (3)	62.9 (2)	68.9 (2)	62.8
	7000-8000'	235	220	66.1	67.7	98.7	413,942	114.7	90.5 (3)	96.8 (1)	106.9 (1)	79.1
	8000-9000'	220	207	75.6	81.4	99.6	19,373	4.5	NA	NA	NA	92.7
American§	5000-6000'	223	257	19.0	19.6	98.1	315,292	302.3	33.2 (3)	34.0 (3)	37.0 (3)	34.1
	6000-7000'	238	245	35.7	36.1	99.2	531,165	275.6	53.8 (7)	52.1 (1)	55.0 (1)	52.7
	7000-8000'	239	239	55.7	60.3	99.9	569,291	176.9	60.3 (5)	57.1 (3)	61.3 (3)	74.6
	8000-9000'	239	228	74.0	82.7	99.5	312,262	70.8	NA	60.1 (2)	72.7 (1)	78.3
	9000-10,000'	236	217	91.1	104.3	99.8	50,804	9.1	NA	NA	NA	79.4
Cosumnes	5000-6000'	229	219	47.7	35.6	75.4	117,976	62.2	NA	NA	NA	32.0
	6000-7000'	232	239	55.8	55.3	94.0	73,481	24.9	NA	NA	NA	54.4
	7000-8000'	237	238	63.3	71.2	100.0	26,472	7.0	NA	NA	NA	72.4
Mokelumne	5000-6000'	222	190	44.5	33.7	70.9	158,697	88.3	15.5 (1)	NA	NA	23.0
	6000-7000'	235	257	53.6	55.9	97.5	204,065	68.4	48.5 (1)	NA	NA	50.7
	7000-8000'	247	256	62.6	70.8	99.8	344,677	91.2	75.9 (5)	NA	NA	75.8
	8000-9000'	246	247	66.8	78.7	100.0	336,377	80.1	95.0 (2)	68.0 (1)	72.8 (1)	77.6
	9000-10,000'	233	234	71.2	84.8	100.0	39,119	8.6	NA	NA	NA	75.7
Stanislaus	5000-6000'	220	230	42.0	37.4	81.7	221,994	111.4	NA	NA	NA	20.7
	6000-7000'	235	269	50.7	51.4	96.8	387,124	141.3	51.2 (3)	52.9 (1)	60.6 (1)	48.1
	7000-8000'	245	272	58.4	65.1	99.8	528,184	152.2	64.7 (6)	NA	NA	66.2
	8000-9000'	244	264	64.5	76.3	99.9	482,554	118.6	100.2 (3)	76.1 (2)	82.9 (2)	71.3
	9000-10,000'	237	249	69.0	84.3	99.4	242,200	53.8	88.3 (2)	61.6 (1)	66.3 (1)	75.1
	10,000-11,000'	237	245	71.9	87.6	96.5	61,884	13.3	NA	NA	NA	74.9
	> 11,000'	244	242	71.7	91.8	97.6	1,708	0.3	NA	NA	NA	72.7

Basin	Elevation Band	3/15/23 % 3/15 Avg.	4/1/23 % 4/1 Avg.	3/15/23 SWE (in)	4/1/23 SWE (in)	4/1/23 % SCA	4/1/23‡ Vol (af)	4/1/23 Area (mi2)	4/1/23 Surveys	3/15/23 Pillows	4/1/23 Pillows	4/1/23 SNODAS* (in)
Tuolumne§	5000-6000'	243	290	16.5	17.3	86.6	164,843	178.2	NA	NA	NA	19.4
	6000-7000'	239	295	27.7	36.0	96.9	282,379	147.0	51.7 (6)	43.6 (1)	NA	47.8
	7000-8000'	>250†	299	45.5	60.3	98.4	505,255	157.2	NA	75.2 (2)	74.7 (1)	69.4
	8000-9000'	>250†	299	57.0	83.6	99.0	771,812	173.2	62.5 (1)	69.2 (2)	75.4 (2)	76.5
	9000-10,000'	>250†	281	56.2	89.3	98.5	875,731	183.8	78.5 (3)	68.0 (2)	72.6 (2)	79.9
	10,000-11,000'	>250†	266	49.7	77.2	97.3	376,894	91.5	NA	NA	NA	76.9
	11,000-12,000'	>250†	264	45.8	60.1	94.2	82,680	25.8	NA	NA	NA	64.1
	> 12,000'	>250†	269	60.9	70.5	94.0	11,018	2.9	NA	NA	NA	53.8
Merced§	5000-6000'	>250†	292	18.6	10.9	80.2	43,047	74.3	NA	NA	NA	17.3
	6000-7000'	235	>300†	24.5	28.8	95.8	125,987	82.1	61.5 (1)	NA	NA	42.9
	7000-8000'	>250†	>300†	40.3	49.2	99.7	373,008	142.1	NA	NA	55.8 (1)	67.9
	8000-9000'	>250†	>300†	57.1	67.0	100.0	445,608	124.7	89.0 (3)	75.4 (2)	80.5 (2)	75.3
	9000-10,000'	>250†	>300†	59.8	74.1	99.8	347,289	87.9	NA	NA	NA	72.9
	10,000-11,000'	>250†	278	60.1	76.1	97.3	161,841	39.9	NA	NA	NA	79.3
	11,000-12,000'	>250†	266	59.7	72.8	95.5	45,748	11.8	NA	NA	NA	76.6
	> 12,000'	>250†	276	71.7	88.0	98.4	7,528	1.6	NA	NA	NA	70.5
San Joaquin§	5000-6000'	>250†	>300†	23.0	12.0	85.1	92,192	144.4	NA	NA	NA	23.4
	6000-7000'	>250†	>300†	31.2	30.2	98.5	300,972	187.0	44.0 (1)	59.9 (2)	66.7 (2)	46.3
	7000-8000'	>250†	>300†	47.0	50.4	99.4	597,888	222.3	59.6 (5)	67.2 (4)	73.1 (4)	63.6
	8000-9000'	>250†	>300†	68.4	78.5	99.7	850,059	203.1	77.3 (2)	NA	NA	66.7
	9000-10,000'	>250†	>300†	78.4	88.1	99.1	974,135	207.3	75.1 (4)	71.8 (1)	79.6 (1)	66.8
	10,000-11,000'	>250†	296	77.4	81.8	96.0	703,029	161.1	66.7 (5)	55.6 (1)	61.5 (1)	71.9
	11,000-12,000'	>250†	277	71.9	68.5	91.4	428,917	117.4	61.0 (2)	NA	NA	63.6
	12,000-13,000	>250†	268	68.8	57.4	88.8	80,439	26.3	NA	NA	NA	50.3
	> 13,000	>250†	273	56.6	51.4	88.3	4,015	1.5	NA	NA	NA	37.4
Kings§	5000-6000'	>250†	>300†	17.1	10.4	80.3	55,673	100.8	NA	NA	NA	18.3
	6000-7000'	>250†	>300†	24.5	24.7	96.8	180,479	137.1	55.5 (1)	NA	NA	38.1
	7000-8000'	>250†	>300†	45.7	46.2	99.6	437,021	177.3	58.0 (3)	NA	NA	59.8
	8000-9000'	>250†	>300†	65.9	68.5	99.5	807,786	221.1	78.1 (7)	65.3 (1)	NA	71.7
	9000-10,000'	>250†	297	74.5	77.0	99.5	910,770	221.8	82.6 (5)	69.6 (2)	74.5 (1)	74.7
	10,000-11,000'	>250†	284	75.2	75.0	97.0	773,926	193.4	74.0 (2)	67.8 (2)	70.1 (1)	75.3
	11,000-12,000'	>250†	270	77.4	69.3	93.2	575,361	155.6	77.0 (1)	NA	NA	70.2
	12,000-13,000	>250†	264	72.7	60.4	90.5	158,479	49.2	NA	NA	NA	58.9
	>13,000'	>250†	265	64.2	53.3	84.9	11,705	4.1	NA	NA	NA	47.6
Kaweah§	5000-6000'	>250†	>300†	8.0	8.7	68.9	28,585	61.3	NA	NA	NA	14.4
	6000-7000'	>250†	>300†	17.9	21.9	95.0	70,919	60.7	NA	30.9 (1)	NA	36.0
	7000-8000'	>250†	293	37.2	42.6	98.8	141,607	62.3	NA	NA	NA	59.0
	8000-9000'	>250†	271	61.6	70.3	99.5	216,637	57.8	65.8 (2)	NA	NA	72.1
	9000-10,000'	>250†	262	73.2	84.4	99.3	196,904	43.7	NA	73.1 (1)	83.5 (1)	86.6
	10,000-11,000'	>250†	256	80.6	88.7	94.9	146,407	31.0	NA	NA	NA	91.7
	>11,000'	>250†	253	79.3	86.7	93.0	40,635	8.8	NA	NA	NA	85.2
Tule	5000-6000'	>250†	>300†	38.0	33.6	72.4	98,906	55.2	NA	NA	NA	8.7
	6000-7000'	240	>300†	45.3	47.5	92.8	106,105	41.8	25.0 (1)	NA	NA	21.9
	7000-8000'	>250†	291	54.5	56.9	95.4	81,526	26.8	34.0 (1)	NA	NA	44.2
	8000-9000'	>250†	275	63.4	69.7	98.6	54,922	14.8	NA	NA	NA	60.3
	9000-10,000'	>250†	263	66.0	77.4	100.0	18,722	4.5	NA	NA	NA	81.4
Kern§	5000-6000'	>250†	>300†	7.0	1.6	13.3	21,386	256.2	NA	NA	NA	3.9
	6000-7000'	>250†	>300†	8.8	9.2	49.1	174,810	357.1	NA	NA	NA	12.7
	7000-8000'	>250†	>300†	16.5	20.0	90.3	361,418	339.5	32.0 (1)	36.0 (2)	33.1 (1)	26.5
	8000-9000'	>250†	>300†	31.8	35.3	99.8	613,691	325.8	52.0 (3)	51.2 (3)	54.1 (2)	43.0
	9000-10,000'	>250†	>300†	43.5	47.0	99.9	484,458	193.2	49.7 (3)	60.9 (1)	NA	54.9
	10,000-11,000'	>250†	>300†	52.4	57.5	99.3	407,946	133.1	57.8 (5)	46.9 (2)	52.8 (2)	58.5
	11,000-12,000'	>250†	271	55.6	60.4	95.4	305,532	94.9	57.0 (2)	63.2 (1)	NA	61.6
	12,000-13,000	>250†	251	54.2	54.0	91.6	110,138	38.2	NA	NA	NA	51.8
	>13,000'	>250†	236	48.1	43.8	88.0	14,821	6.3	NA	NA	NA	37.5

Basin	Elevation Band	3/15/23 % 3/15 Avg.	4/1/23 % 4/1 Avg.	3/15/23 SWE (in)	4/1/23 SWE (in)	4/1/23 % SCA	4/1/23‡ Vol (af)	4/1/23 Area (mi2)	4/1/23 Surveys	3/15/23 Pillows	4/1/23 Pillows	4/1/23 SNODAS* (in)
Truckee	5000-6000'	>250†	>300†	31.2	32.9	98.4	122,840	69.9	NA	NA	NA	17.2
	6000-7000'	>250†	>300†	42.3	40.5	99.6	473,370	219.1	NA	41.7 (5)	44.1 (5)	33.5
	7000-8000'	>250†	242	56.6	55.5	99.8	352,523	119.1	NA	NA	NA	60.0
	8000-9000'	234	222	62.1	64.8	98.9	105,728	30.6	NA	NA	NA	69.9
	9000-10,000'	219	226	60.6	68.1	100.0	28,875	8.0	NA	NA	NA	72.8
	10,000-11,000'	208	233	61.2	71.2	100.0	1,588	0.4	NA	NA	NA	68.9
Tahoe	6000-7000'	>250†	>300†	38.6	40.1	99.9	280,973	131.3	37.8 (3)	42.2 (2)	45.0 (2)	29.3
	7000-8000'	>250†	272	52.4	54.1	99.5	326,085	113.0	48.2 (3)	59.3 (4)	62.8 (4)	55.9
	8000-9000'	245	238	62.0	66.1	99.4	255,668	72.5	NA	55.1 (1)	57.8 (1)	64.1
	9000-10,000'	234	224	65.1	72.8	99.8	66,094	17.0	NA	NA	NA	66.1
	10,000-11,000'	240	212	69.7	77.5	100.0	3,171	0.8	NA	NA	NA	55.0
W. Carson	5000-6000'	>250†	>300†	29.3	18.5	50.3	206	0.2	NA	NA	NA	16.6
	6000-7000'	>250†	>300†	38.6	39.6	92.6	4,711	2.2	NA	NA	NA	35.6
	7000-8000'	>250†	292	50.3	52.5	99.6	89,999	32.2	NA	NA	NA	55.4
	8000-9000'	>250†	247	60.6	63.8	99.8	94,848	27.9	77.0 (1)	61.1 (2)	65.1 (2)	58.2
	9000-10,000'	>250†	225	68.3	73.0	100.0	27,431	7.0	NA	NA	NA	60.3
	10,000-11,000'	214	220	60.9	64.5	100.0	2,160	0.6	NA	NA	NA	54.2
E. Carson	5000-6000'	>250†	>300†	26.0	13.9	41.7	36,668	49.6	NA	NA	NA	9.6
	6000-7000'	>250†	>300†	34.4	32.7	88.4	136,300	78.1	NA	22.5 (1)	21.5 (1)	22.9
	7000-8000'	>250†	>300†	45.9	46.0	98.8	256,677	104.7	NA	NA	NA	41.8
	8000-9000'	>250†	266	57.2	60.0	99.4	325,016	101.5	NA	59.1 (4)	62.5 (4)	62.3
	9000-10,000'	248	242	65.3	73.4	100.0	142,769	36.5	NA	NA	NA	69.2
	>10,000'	>250†	235	70.1	81.3	99.9	47,749	11.0	NA	NA	NA	63.8
W. Walker	6000-7000'	>250†	>300†	31.3	32.3	98.4	13,438	7.8	NA	NA	NA	24.8
	7000-8000'	>250†	>300†	35.9	37.1	98.3	80,636	40.7	NA	40.0 (1)	38.9 (1)	33.9
	8000-9000'	>250†	>300†	49.6	55.0	99.2	141,066	48.1	55.0 (2)	53.9 (1)	57.7 (1)	59.7
	9000-10,000'	>250†	277	62.5	72.8	99.1	253,247	65.2	NA	101.7 (1)	108.8 (1)	77.9
	10,000-11,000'	>250†	252	70.7	81.3	97.3	118,286	27.3	NA	NA	NA	76.6
	> 11,000'	>250†	254	71.0	79.9	94.6	9,508	2.2	NA	NA	NA	67.0
E. Walker	6000-7000'	>250†	>300†	23.9	27.1	98.4	87,370	60.5	NA	NA	NA	21.5
	7000-8000'	>250†	>300†	31.0	32.0	97.9	205,460	120.2	NA	NA	NA	21.6
	8000-9000'	>250†	>300†	41.9	41.9	97.3	214,973	96.2	NA	NA	NA	34.9
	9000-10,000'	>250†	>300†	57.5	62.3	98.1	189,908	57.2	NA	49.0 (1)	53.8 (1)	58.5
	10,000-11,000'	>250†	272	69.0	77.0	96.5	142,642	34.7	NA	NA	NA	67.1
	>11,000'	>250†	272	72.0	77.2	91.7	36,471	8.9	NA	NA	NA	60.6
Mono	6000-7000'	>250†	>300†	17.4	13.6	58.8	233,663	321.4	NA	NA	NA	11.7
	7000-8000'	>250†	>300†	22.5	24.1	95.6	535,781	416.8	NA	NA	NA	13.9
	8000-9000'	>250†	>300†	34.9	35.2	97.3	348,754	185.6	NA	NA	NA	19.0
	9000-10,000'	>250†	>300†	51.4	57.1	97.6	197,548	64.9	74.0 (2)	NA	NA	42.8
	10,000-11,000'	>250†	>300†	66.0	74.2	95.0	191,715	48.5	96.5 (1)	NA	NA	65.6
	11,000-12,000'	>250†	280	73.0	79.7	92.4	112,056	26.4	NA	NA	NA	60.8
	> 12,000'	>250†	283	73.4	76.4	88.1	17,892	4.4	NA	NA	NA	52.5
Upper Owens	6000-7000'	>250†	>300†	22.3	24.6	93.3	86,474	66.0	NA	NA	NA	27.2
	7000-8000'	>250†	>300†	30.1	33.4	98.1	271,788	152.7	NA	NA	NA	29.6
	8000-9000'	>250†	>300†	43.9	50.5	98.8	216,351	80.3	67.5 (2)	NA	NA	38.6
	9000-10,000'	>250†	>300†	55.5	65.6	97.9	154,256	44.1	104.5 (1)	88.0 (1)	NA	48.5
	10,000-11,000'	>250†	>300†	64.7	73.1	95.1	134,946	34.6	NA	NA	NA	60.3
	11,000-12,000'	>250†	290	74.5	77.4	89.6	66,255	16.0	NA	NA	NA	56.6
	> 12,000'	>250†	282	72.5	71.7	89.0	14,143	3.7	NA	NA	NA	43.0
Owens	5000-6000'	>250†	>300†	1.1	0.0	0.2	1,062	440.3	NA	NA	NA	0.2
	6000-7000'	>250†	>300†	9.3	4.3	16.1	80,825	356.1	NA	NA	NA	4.3
	7000-8000'	>250†	>300†	20.1	17.8	61.1	317,879	334.4	NA	NA	NA	9.9
	8000-9000'	>250†	>300†	27.9	31.0	85.9	313,200	189.2	31.5 (1)	NA	NA	17.7
	9000-10,000'	>250†	>300†	40.8	44.3	96.4	363,922	153.9	37.8 (3)	44.0 (3)	49.1 (3)	28.4
	10,000-11,000'	>250†	>300†	53.0	54.2	97.3	486,009	168.0	42.3 (2)	47.3 (2)	51.8 (2)	38.8
	11,000-12,000'	>250†	>300†	65.2	63.4	93.0	455,990	134.8	58.0 (1)	NA	NA	42.4
	12,000-13,000	>250†	292	72.0	66.1	89.9	235,196	66.7	NA	NA	NA	35.6
	>13,000'	>250†	270	69.8	60.6	87.9	34,241	10.6	NA	NA	NA	26.8

§ Data in all ASO-collected basins have been bias-corrected using ASO data and therefore the SWE changes might not represent snowmelt but rather an update to the SWE estimates based on airborne data.

‡ For volume totals above Shasta Lake add Upper Sac, McCloud and Pit volumes. For volume totals above Bend Bridge add Upper Sac, McCloud, Pit and Sac at Bend Bridge volumes.

† Deep, and particularly low-elevation snow in areas that typically are snow-free can report exceptionally high percent of average for this date because the mean 2001-2021 regression-derived SWE for that area is low or 0.

* This is a comparison to the SNODAS (SNOw Data Assimilation System) nationwide product from the National Weather Service.

Location of Reports and Excel Format Tables

https://www.colorado.edu/instaar/research/labs-groups/mountain-hydrology-group/sierra-nevada-swe-reports

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