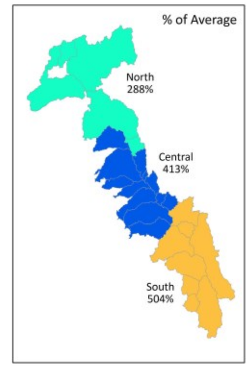
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California

May 15, 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 May 15, percent of average SWE is highest in the south (504%), then central (413%) and lowest in the north (288%). 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](#)**.

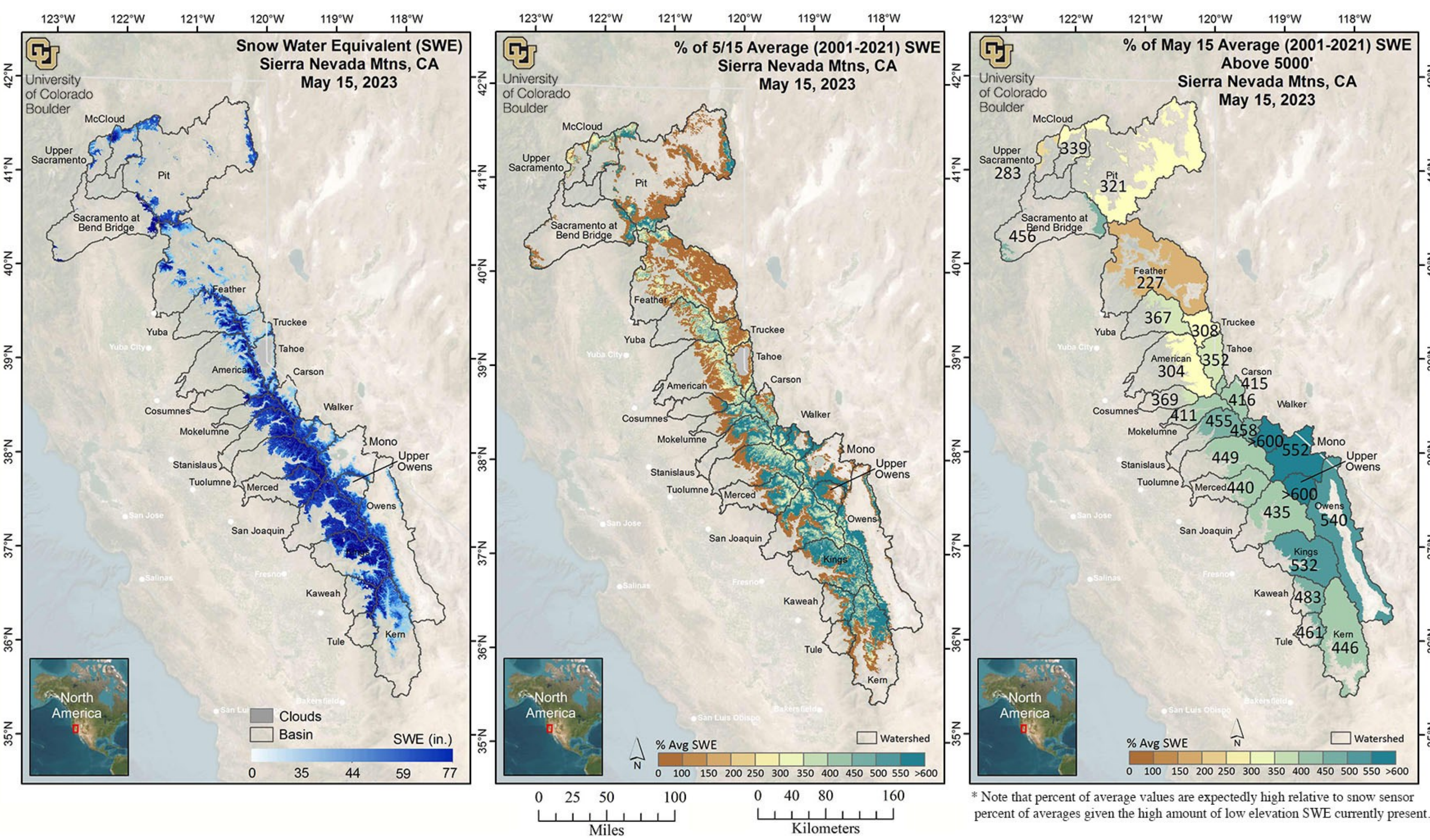

Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for May 15, 2023 (left), and percent of average (2001-2021) SWE for May 15, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

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

91 snow pillow sites in the Sierra Nevada network were recording SWE values out of a total of 128 sites, 37 were offline, and 6 were recording zero (shown in black, red and yellow, 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.

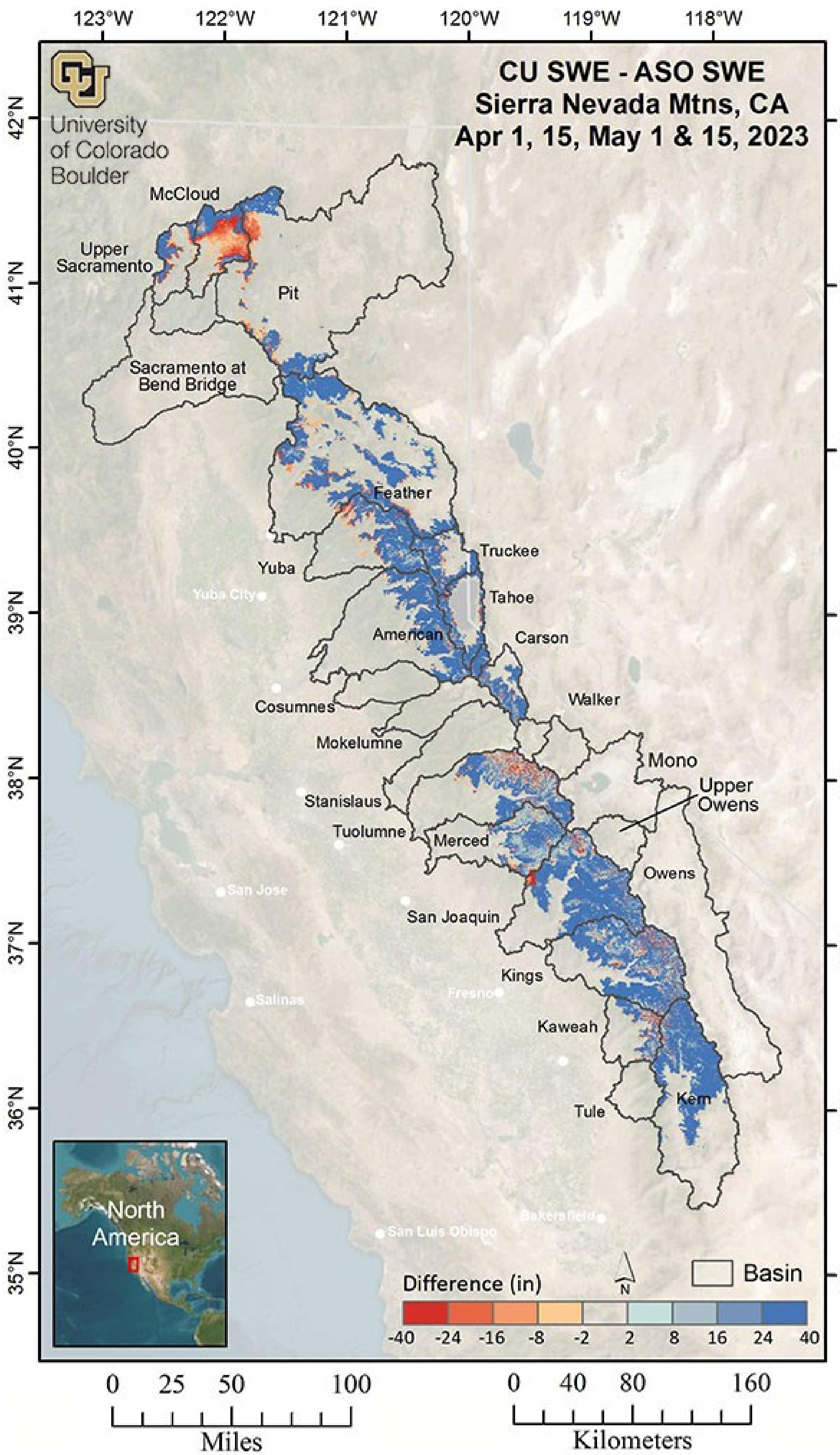

Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the April 1, 15 and May 1 and 15, 2023 CU SWE model run and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins. Red colors show where CU SWE is lower than ASO SWE and blue colors show where 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.

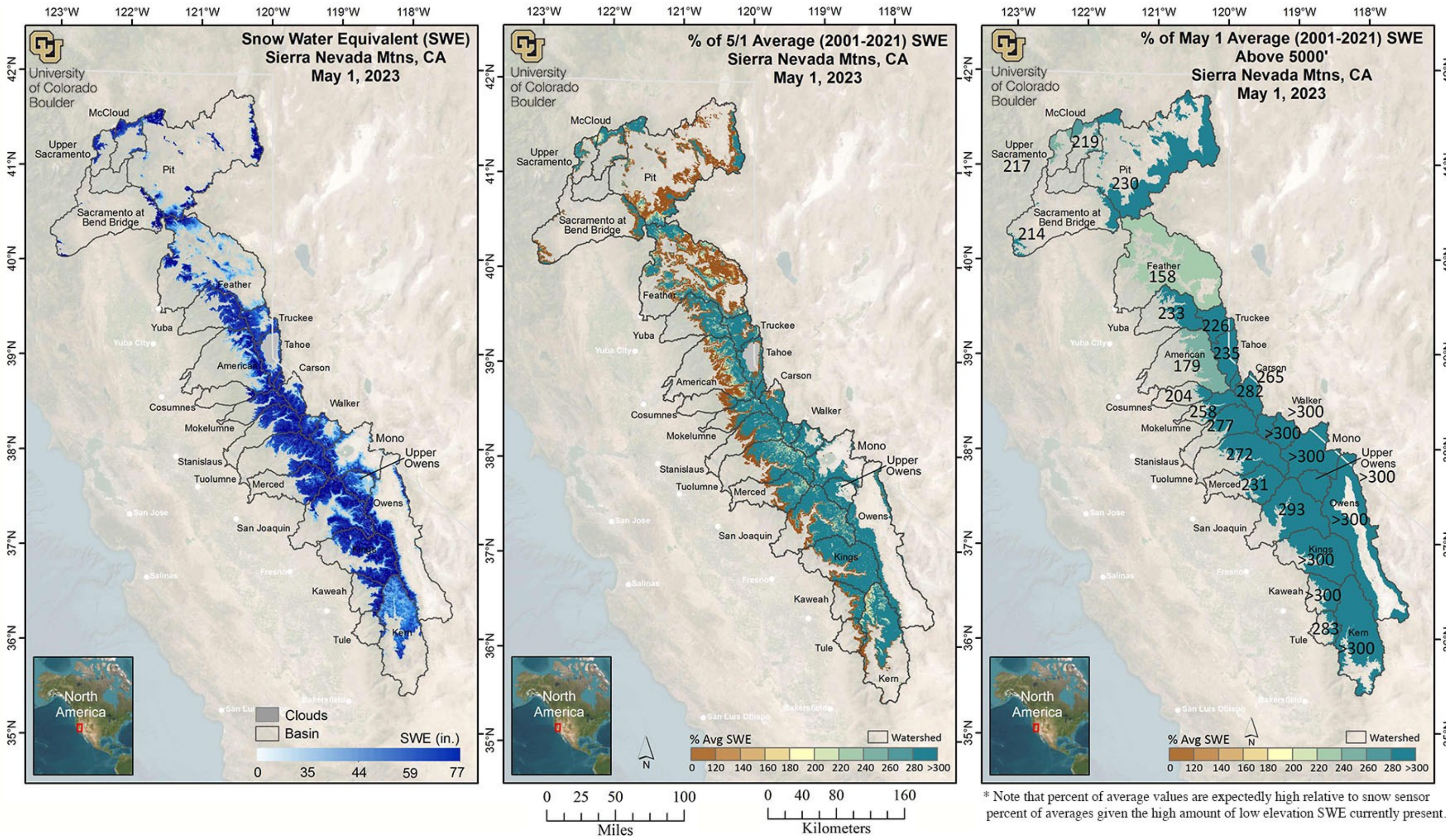

Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for May 1, 2023 (left), and percent of average (2001-2021) SWE for May 1, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

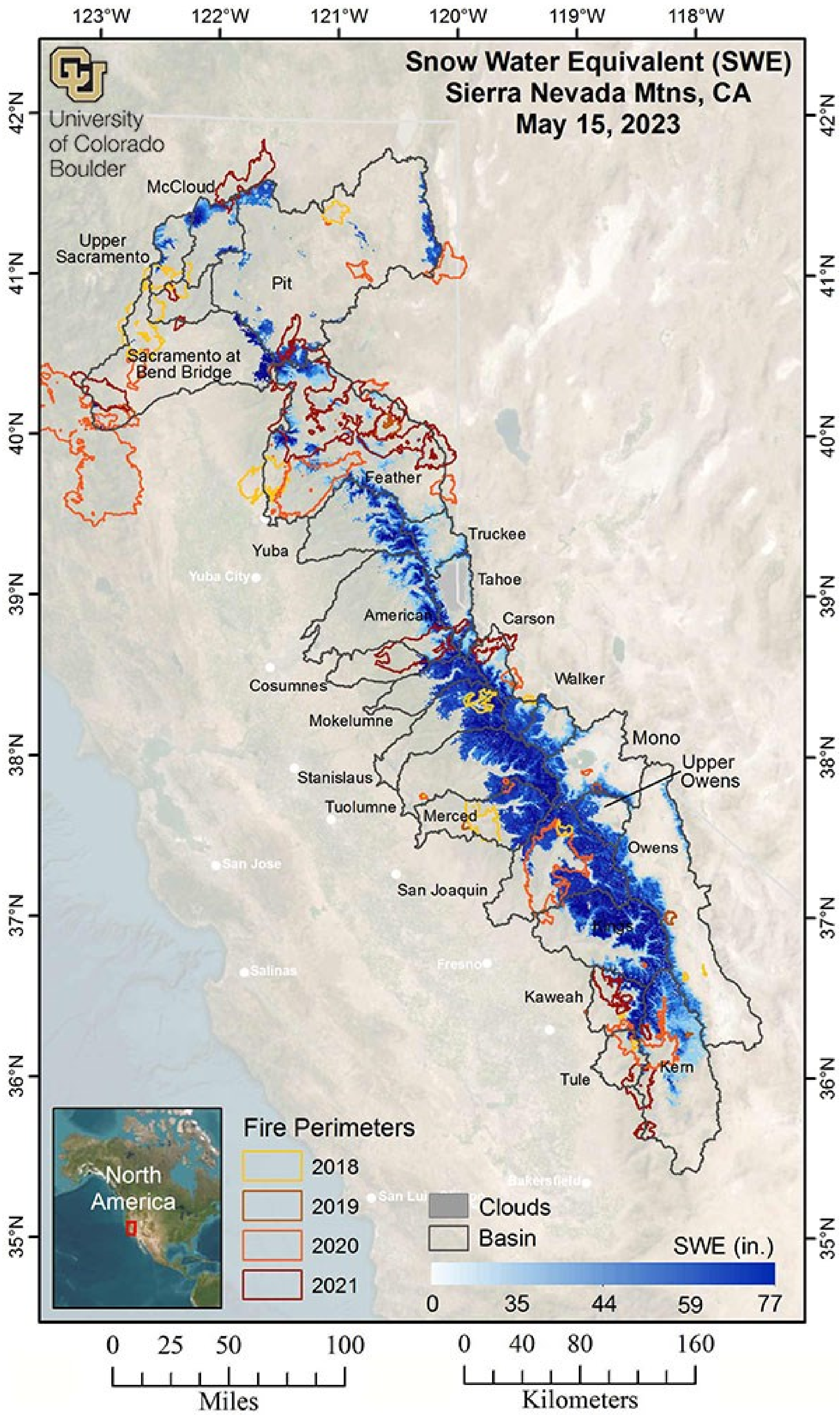

Figure 4. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts for May 15, 2023 are shown with fire perimeters from 2018-2021 (colored from yellow to red).

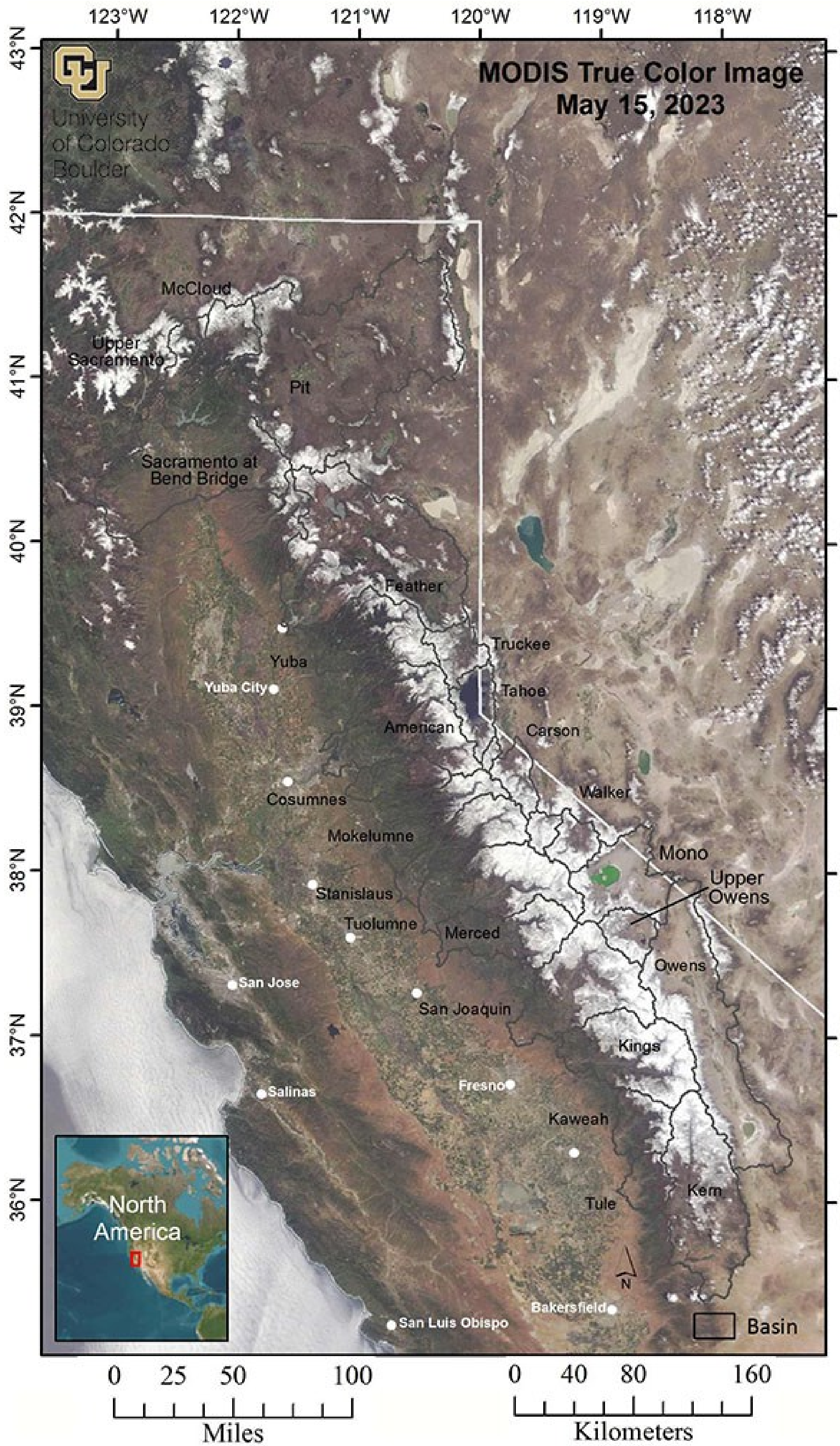

Figure 5. MODIS image, Sierra Nevada. A cloud-free true color MODIS image, showing the image that used for the May 15, 2023 regression model run.

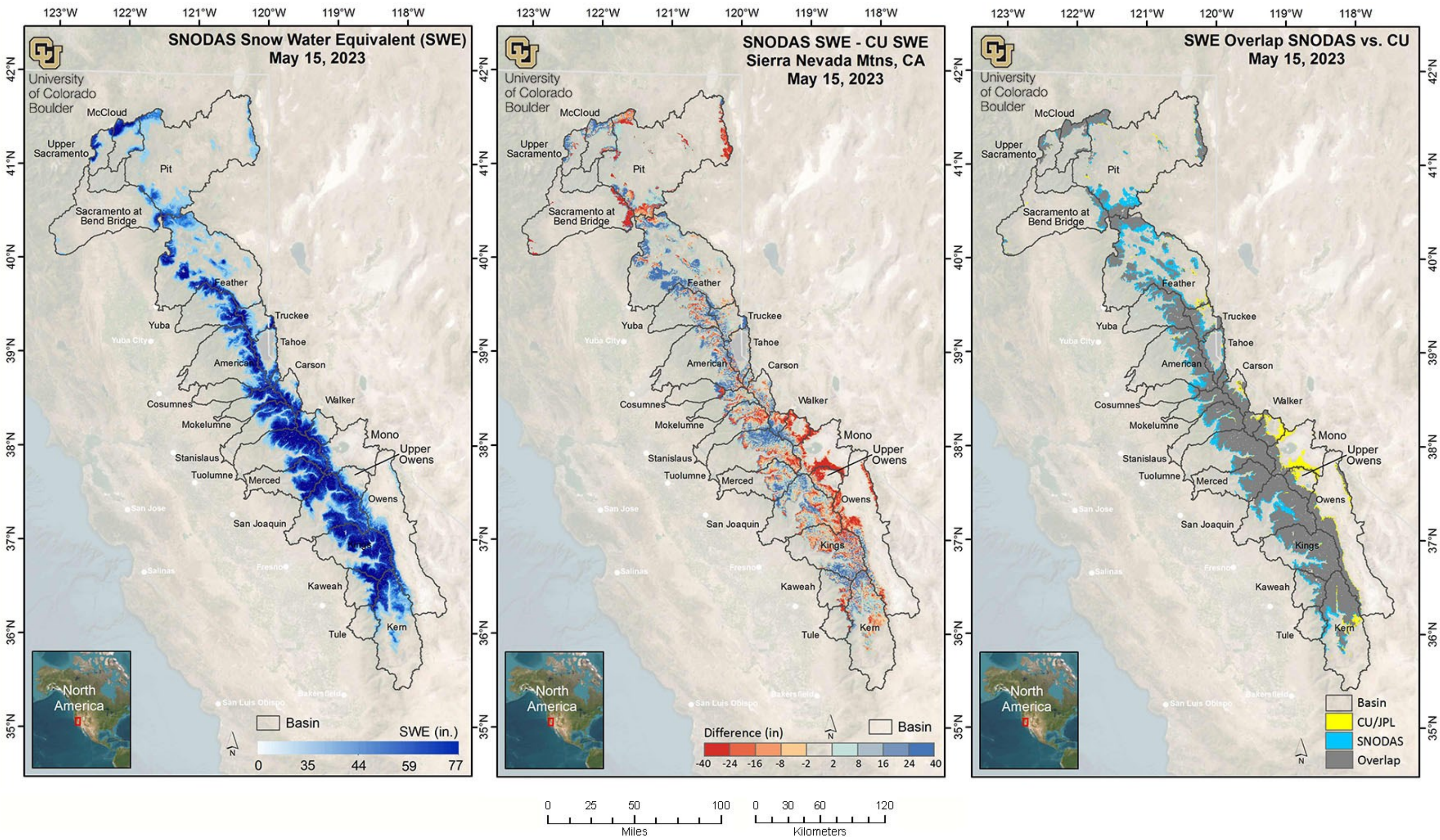

Figure 6. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE for May 15th from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows the difference between the May 15th 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.

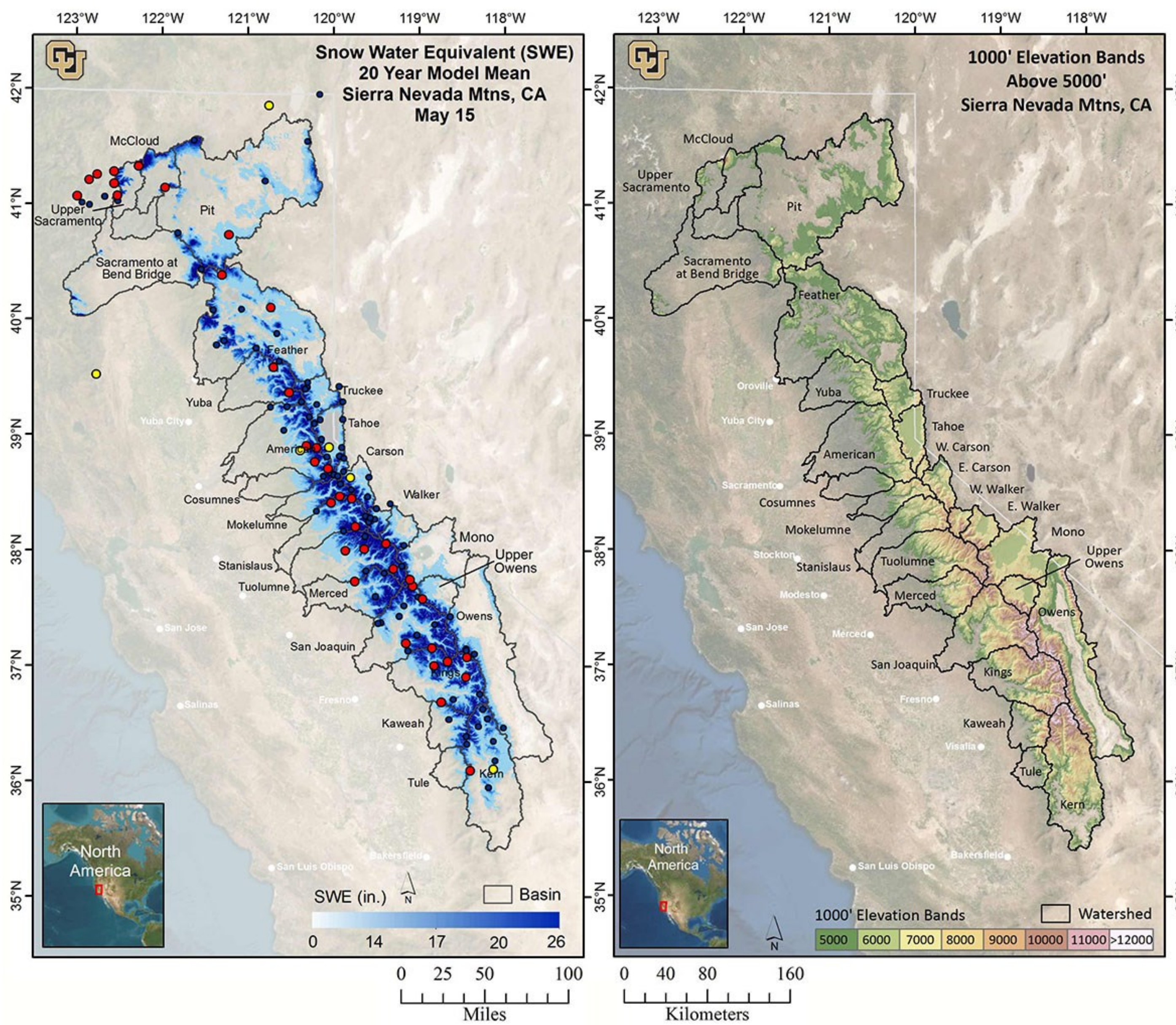

Figure 7. Historical average May 15th and Elevation Bands for the Sierra Nevada. Average SWE (2001-2021) for May 15th (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and Table 2. Map on left shows snow pillow sensor sites recording SWE on May 15th (black), sites that were offline are shown in red, and sites recording zero are shown in yellow. Note the average SWE map is using a different color ramp than the 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* May 15, 2023 *– IMPORTANT – READ THIS!

- 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.
- MISSING SWE VALUES - Data omitted due to inconsistencies with independent SWE estimates.
- 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.

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 - Data omitted due to inconsistencies with independent 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 May 1st percent of May 1st average SWE, May 15th percent of May 15th average SWE (between 2001-2021 as derived from the regression model), May 1st mean SWE, May 15th mean SWE, May 15th percent of snow-covered area, May 15th 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), May 1st snow pillow data, and May 15th snow pillow data for those areas collected, summarized for each basin. The last column shows May 15th mean SWE from SNODAS*.*

Basin	5/1/23 % 5/1 Avg.	5/15/23 % 5/15 Avg.	5/1/23 SWE (in)	5/15/23 SWE (in)	5/15/23 % SCA	5/15/23‡ Vol (af)	Area (mi2) > 5000'	5/1/23 Pillows	5/15/23 Pillows	5/15/23 SNODAS* (in)
Upper Sacramento§	257	283	53.0	36.6	89.1	247,922	127.1	71.7 (1)	49.1 (1)	46.0
McCloud§	262	339	53.1	44.6	94.4	420,943	177.1	NA	NA	53.0
Pit§	>300†	321	17.7	10.3	23.7	1,255,606	2285.6	29.4 (4)	24.1 (4)	8.0
Sac at Bend Bridge	>300†	456	47.2	40.3	55.4	549,987	255.8	NA	NA	19.3
Feather§	228	227	20.5	11.8	34.5	1,417,984	2,259.1	52.6 (5)	44.3 (5)	18.4
Yuba§	292	367	49.6	38.0	77.8	1,125,522	554.6	59.6 (2)	55.2 (2)	43.6
American§	253	304	37.2	26.5	63.7	1,197,495	847.5	38.9 (9)	33.7 (9)	31.8
Cosumnes	>300†	369	34.0	21.1	26.4	106,122	94.4	NA	NA	23.1
Mokelumne	>300†	411	49.3	40.6	70.2	727,667	335.8	65.4 (1)	61.2 (1)	43.4
Stanislaus	>300†	455	50.9	43.8	75.9	1,373,836	588.5	63.7 (3)	62.5 (3)	43.8
Tuolumne§	>300†	449	47.9	45.8	75.8	2,347,283	961.5	66.0 (3)	66.5 (3)	49.4
Merced§	>300†	440	48.4	43.3	76.9	1,306,567	565.2	62.6 (2)	67.3 (2)	47.3
San Joaquin§	>300†	435	49.0	42.7	74.1	2,891,676	1,269.7	58.7 (8)	51.2 (8)	44.3
Kings§	>300†	532	55.5	50.4	79.6	3,364,308	1,252.0	62.0 (3)	84.9 (2)	50.7
Kaweah§	>300†	483	41.0	34.8	54.6	590,818	318.7	47.2 (2)	38.3 (2)	38.5
Tule	>300†	461	18.9	14.7	20.1	112,153	143.0	NA	NA	10.6
Kern§	>300†	446	22.0	15.9	42.3	1,470,970	1,733.1	41.0 (5)	35.6 (8)	16.9
Truckee	>300†	308	43.3	19.0	58.9	454,482	449.0	32.7 (5)	24.7 (5)	24.4
Tahoe	>300†	352	45.7	27.8	63.8	493,898	333.6	42.5 (7)	37.9 (7)	29.6
W Carson	>300†	415	60.5	38.6	93.7	144,428	70.2	61.4 (2)	58.1 (2)	40.0
E Carson	>300†	416	40.0	26.6	59.5	538,529	379.0	44.3 (5)	41.2 (5)	27.3
W Walker	>300†	458	54.6	44.4	83.6	451,990	190.9	65.0 (3)	59.3 (3)	48.7
E Walker	>300†	>600†	37.7	26.9	56.0	533,077	372.1	47.3 (1)	45.8 (1)	19.1
Mono	>300†	552	18.6	12.7	27.5	718,443	1,061.5	NA	NA	6.4
Upper Owens	>300†	>600†	42.0	26.8	52.2	566,893	396.1	NA	NA	15.8
Owens	>300†	540	18.7	12.0	25.7	1,187,610	1,849.1	44.4 (5)	35.3 (5)	8.5

§ 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 May 1st percent of May 1st average SWE, May 15th percent of May 15th average SWE (between 2001-2021 as derived from the regression model), May 1st mean SWE, May 15th mean SWE, May 15th percent of snow-covered area, May 15th 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), May 1st snow pillow data, and May 15th snow pillow data for those areas collected, summarized for each 1000' elevation band inside each basin. The last column shows May 15th mean SWE from SNODAS*.*

Basin	Elevation Band	5/1/23 % 5/1 Avg.	5/15/23 % 5/15 Avg.	5/1/23 SWE (in)	5/15/23 SWE (in)	5/15/23 % SCA	5/15/23‡ Vol (af)	5/15/23 Area (mi2)	5/1/23 Pillows	5/15/23 Pillows	5/15/23 SNODAS* (in)
Upper Sacramento§	5000-6000'	287	315	47.9	31.2	81.8	120,534	72.5	71.7 (1)	49.1 (1)	37.3
	6000-7000'	261	286	59.8	41.4	98.4	84,378	38.2	NA	NA	57.1
	7000-8000'	219	253	59.2	45.8	99.8	21,814	8.9	NA	NA	57.1
	8000-9000'	168	238	56.2	55.2	99.1	8,626	2.9	NA	NA	62.6
	9000-10,000'	140	202	56.6	59.8	99.1	6,677	2.1	NA	NA	63.8
	10,000-11,000'	151	157	72.7	56.7	97.8	3,794	1.3	NA	NA	56.5
	> 11,000'	140	96	65.4	33.2	91.0	2,099	1.2	NA	NA	47.5
McCloud§	5000-6000'	>300†	419	46.7	37.1	91.6	209,841	105.9	NA	NA	42.7
	6000-7000'	267	352	57.0	48.5	98.1	111,922	43.3	NA	NA	66.7
	7000-8000'	229	327	63.6	65.0	100.0	48,383	13.9	NA	NA	70.6
	8000-9000'	218	286	72.1	70.3	98.8	23,791	6.3	NA	NA	75.0
	>9,000'	204	229	77.9	67.4	98.4	11,033	3.1	NA	NA	72.8
Pit§	5000-6000'	236	224	6.5	3.4	8.7	287,921	1,569.0	51.7 (1)	46.4 (1)	3.7
	6000-7000'	>300†	353	34.2	19.2	45.6	569,203	555.8	24.8 (2)	17.9 (2)	13.5
	7000-8000'	>300†	429	-	-	94.0	329,410	138.3	16.4 (1)	14.3 (1)	29.5
	>8,000'	>300†	406	-	-	98.7	62,973	21.0	NA	NA	31.2
Sac at Bend Bridge	5000-6000'	286	412	30.2	23.6	37.9	213,920	169.6	NA	NA	11.8
	6000-7000'	>300†	532	-	-	87.0	231,151	65.3	NA	NA	28.3
	>7,000'	>300†	451	-	-	98.9	79,130	16.1	NA	NA	49.5
Feather§	5000-6000'	199	161	13.1	6.0	21.7	434,481	1,347.2	66.7 (1)	62.4 (1)	14.9
	6000-7000'	247	264	28.7	17.6	48.9	734,740	782.8	53.1 (3)	41.7 (3)	21.6
	7000-8000'	259	319	47.6	35.5	79.4	236,136	124.6	37.0 (1)	34.0 (1)	35.5
	8000-9000'	275	336	66.5	53.0	93.4	12,627	4.5	NA	NA	41.2
Yuba§	5000-6000'	275	211	32.3	13.5	46.5	146,041	203.2	NA	NA	24.1
	6000-7000'	>300†	407	56.6	44.5	93.9	544,926	229.4	59.6 (2)	55.2 (2)	46.8
	7000-8000'	273	419	65.0	66.1	99.3	414,376	117.6	NA	NA	69.3
	8000-9000'	247	420	73.2	84.8	99.3	20,179	4.5	NA	NA	96.3
American§	5000-6000'	125	85	9.8	3.4	21.9	56,004	310.1	15.5 (3)	9.6 (3)	9.8
	6000-7000'	253	277	38.4	23.6	78.7	353,882	280.7	51.0 (1)	47.5 (1)	32.5
	7000-8000'	>300†	383	-	50.5	97.0	476,179	176.9	46.6 (3)	41.1 (3)	55.7
	8000-9000'	>300†	411	-	-	99.5	269,663	70.6	56.5 (2)	51.7 (2)	62.8
	9000-10,000'	299	399	-	-	97.8	41,767	9.1	NA	NA	64.0
Cosumnes	5000-6000'	151	69	11.0	2.7	3.9	9,066	62.5	NA	NA	10.6
	6000-7000'	>300†	>600†	74.4	48.8	62.3	64,757	24.9	NA	NA	43.1
	7000-8000'	>300†	>600†	-	-	100.0	32,299	7.0	NA	NA	64.7
Mokelumne	5000-6000'	215	135	12.9	4.4	11.3	20,428	87.7	NA	NA	5.4
	6000-7000'	>300†	496	50.9	33.9	70.2	123,345	68.1	NA	NA	37.1
	7000-8000'	>300†	461	63.7	56.9	98.8	277,019	91.2	NA	NA	62.1
	8000-9000'	286	399	68.9	64.3	99.8	274,706	80.1	65.4 (1)	61.2 (1)	66.9
	9000-10,000'	259	371	72.5	69.7	98.1	32,169	8.6	NA	NA	65.9
Stanislaus	5000-6000'	237	164	11.7	4.5	10.4	26,579	110.0	NA	NA	4.9
	6000-7000'	>300†	577	48.6	35.3	74.6	263,742	140.2	50.2 (1)	42.2 (1)	34.3
	7000-8000'	>300†	520	60.0	53.0	96.5	430,416	152.2	NA	NA	54.4
	8000-9000'	>300†	437	67.3	63.6	99.7	401,869	118.6	83.0 (1)	84.7 (1)	64.0
	9000-10,000'	273	389	72.4	70.1	98.7	201,185	53.8	58.0 (1)	60.7 (1)	68.8
	10,000-11,000'	236	344	68.7	69.0	95.3	48,785	13.3	NA	NA	70.1
	> 11,000'	209	328	61.6	67.8	91.0	1,260	0.3	NA	NA	72.0

Basin	Elevation Band	5/1/23 % 5/1 Avg.	5/15/23 % 5/15 Avg.	5/1/23 SWE (in)	5/15/23 SWE (in)	5/15/23 % SCA	5/15/23‡ Vol (af)	5/15/23 Area (mi2)	5/1/23 Pillows	5/15/23 Pillows	5/15/23 SNODAS* (in)
Tuolumne§	5000-6000'	237	69	7.8	1.4	3.8	13,500	179.6	NA	NA	3.7
	6000-7000'	>300†	>600†	40.0	30.7	68.7	241,143	147.2	NA	NA	31.2
	7000-8000'	>300†	550	52.3	49.5	95.6	415,555	157.4	62.7 (1)	55.3 (1)	56.3
	8000-9000'	>300†	466	59.0	60.4	99.1	557,829	173.2	87.0 (1)	96.8 (1)	67.2
	9000-10,000'	282	430	65.5	68.2	99.2	668,531	183.8	48.4 (1)	47.4 (1)	75.2
	10,000-11,000'	265	394	68.4	70.0	97.5	341,457	91.5	NA	NA	69.9
	11,000-12,000'	259	387	68.8	71.0	90.2	97,688	25.8	NA	NA	55.3
	> 12,000'	246	366	71.4	74.1	84.2	11,581	2.9	NA	NA	43.8
Merced§	5000-6000'	69	49	1.9	0.9	2.5	3,452	74.7	NA	NA	0.8
	6000-7000'	>300†	460	31.1	20.8	45.7	91,499	82.6	NA	NA	21.1
	7000-8000'	>300†	594	54.5	48.6	92.5	368,587	142.1	46.1 (1)	NA	48.3
	8000-9000'	>300†	460	60.4	56.6	99.2	376,554	124.7	79.1 (1)	67.3 (2)	65.1
	9000-10,000'	290	390	64.2	59.2	99.7	277,621	87.9	NA	NA	69.9
	10,000-11,000'	263	352	70.3	65.5	98.6	139,353	39.9	NA	NA	73.5
	11,000-12,000'	223	320	67.7	68.7	94.6	43,201	11.8	NA	NA	69.6
	> 12,000'	235	293	82.4	73.7	96.5	6,301	1.6	NA	NA	61.7
San Joaquin§	5000-6000'	40	30	0.9	0.4	1.1	3,019	141.9	NA	NA	1.6
	6000-7000'	298	432	17.2	15.4	35.7	152,437	185.9	49.7 (2)	34.4 (2)	22.2
	7000-8000'	>300†	594	41.1	38.9	77.7	460,841	222.0	60.2 (4)	56.0 (4)	41.7
	8000-9000'	>300†	524	61.7	55.3	97.3	598,664	203.1	NA	NA	58.0
	9000-10,000'	>300†	436	70.4	59.6	99.2	659,344	207.5	72.6 (1)	68.9 (1)	63.7
	10,000-11,000'	>300†	388	74.5	62.1	98.7	536,290	162.0	56.6 (1)	48.2 (1)	64.8
	11,000-12,000'	>300†	354	74.7	61.9	94.0	392,851	119.0	NA	NA	52.0
	12,000-13,000	235	312	62.7	58.5	88.6	84,224	27.0	NA	NA	36.5
	> 13,000	229	290	58.1	51.3	84.5	4,005	1.5	NA	NA	22.7
Kings§	5000-6000'	168	21	2.5	0.2	1.1	1,006	99.1	NA	NA	0.5
	6000-7000'	>300†	331	22.2	9.5	34.4	68,842	135.5	NA	NA	11.2
	7000-8000'	>300†	579	46.4	32.8	78.7	308,402	176.4	NA	NA	35.3
	8000-9000'	>300†	>600†	57.9	54.9	94.1	640,772	218.8	NA	NA	60.6
	9000-10,000'	>300†	572	64.0	66.2	97.6	776,305	220.0	64.5 (2)	80.9 (1)	70.0
	10,000-11,000'	>300†	539	73.1	73.0	98.1	752,521	193.4	57.0 (1)	88.9 (1)	70.8
	11,000-12,000'	>300†	492	82.2	75.9	96.0	629,684	155.6	NA	NA	67.5
	12,000-13,000	>300†	403	84.6	66.4	91.6	174,245	49.2	NA	NA	55.8
	>13,000'	>300†	368	78.2	57.1	88.5	12,530	4.1	NA	NA	43.6
Kaweah§	5000-6000'	1	0	0.0	0.0	0.0	0	61.4	NA	NA	0.3
	6000-7000'	230	147	11.3	4.2	15.5	13,334	59.4	17.4 (1)	1.8 (1)	11.0
	7000-8000'	>300†	434	43.3	26.8	68.2	86,145	60.2	NA	NA	33.4
	8000-9000'	>300†	549	59.9	54.7	88.4	165,325	56.7	NA	NA	53.9
	9000-10,000'	>300†	554	70.1	70.6	91.0	156,604	41.6	77.0 (1)	74.9 (1)	77.0
	10,000-11,000'	>300†	520	84.8	79.2	89.8	129,276	30.6	NA	NA	84.3
	>11,000'	>300†	509	94.2	85.6	91.3	40,135	8.8	NA	NA	79.9
Tule	5000-6000'	0	0	0.0	0.0	0.0	0	55.2	NA	NA	0.0
	6000-7000'	66	36	2.9	0.9	1.9	1,998	41.7	NA	NA	2.9
	7000-8000'	>300†	444	38.1	25.3	39.1	36,229	26.8	NA	NA	20.8
	8000-9000'	>300†	>600†	77.5	68.5	88.2	53,503	14.6	NA	NA	37.0
	9000-10,000'	>300†	>600†	89.8	84.5	99.4	20,422	4.5	NA	NA	63.9
Kern§	5000-6000'	0	16	0.0	0.0	0.1	145	255.4	NA	NA	0.0
	6000-7000'	123	7	0.8	0.0	0.4	691	352.3	NA	NA	0.7
	7000-8000'	>300†	152	15.4	2.4	13.0	42,523	335.5	8.9 (1)	0.0 (1)	4.2
	8000-9000'	>300†	502	41.3	18.2	72.7	314,604	324.8	38.5 (2)	26.5 (3)	16.8
	9000-10,000'	>300†	578	37.0	35.0	96.8	359,179	192.7	50.1 (1)	44.6 (1)	38.0
	10,000-11,000'	272	527	37.7	49.5	99.3	350,913	132.9	NA	44.4 (2)	51.3
	11,000-12,000'	270	443	49.5	56.6	96.1	286,595	94.9	69.0 (1)	71.5 (1)	61.8
	12,000-13,000	273	355	55.8	50.2	89.8	102,295	38.2	NA	NA	53.7
	>13,000'	>300†	293	64.1	41.4	83.3	14,025	6.3	NA	NA	38.1

Basin	Elevation Band	5/1/23 % 5/1 Avg.	5/15/23 % 5/15 Avg.	5/1/23 SWE (in)	5/15/23 SWE (in)	5/15/23 % SCA	5/15/23‡ Vol (af)	5/15/23 Area (mi2)	5/1/23 Pillows	5/15/23 Pillows	5/15/23 SNODAS* (in)
Truckee§	5000-6000'	>300†	28	8.7	0.3	1.8	1,245	69.7	NA	NA	0.8
	6000-7000'	>300†	235	42.3	8.9	51.2	104,533	220.5	32.7 (5)	24.7 (5)	13.1
	7000-8000'	>300†	357	59.5	37.6	95.5	240,342	119.7	NA	NA	44.8
	8000-9000'	270	348	62.9	52.7	100.0	86,319	30.7	NA	NA	66.4
	9000-10,000'	237	323	55.4	49.4	100.0	20,945	8.0	NA	NA	74.6
	10,000-11,000'	205	289	52.6	49.2	100.0	1,098	0.4	NA	NA	72.0
Tahoe§	6000-7000'	>300†	170	25.7	5.6	28.3	38,714	129.6	28.0 (2)	24.6 (2)	8.9
	7000-8000'	>300†	363	53.1	30.5	80.3	184,087	113.2	49.2 (4)	44.1 (4)	36.5
	8000-9000'	>300†	402	64.5	53.7	97.9	209,044	73.0	44.5 (1)	39.5 (1)	49.7
	9000-10,000'	286	409	69.2	65.5	98.6	59,466	17.0	NA	NA	56.2
	10,000-11,000'	255	376	64.8	63.2	93.2	2,587	0.8	NA	NA	54.0
W. Carson§	5000-6000'	0	0	0.0	0.0	0.0	0	0.2	NA	NA	0.0
	6000-7000'	>300†	27	8.5	0.4	6.1	51	2.2	NA	NA	7.5
	7000-8000'	>300†	376	57.9	25.2	94.6	43,149	32.2	NA	NA	36.7
	8000-9000'	>300†	441	65.7	50.4	99.7	74,983	27.9	61.4 (2)	58.1 (2)	44.2
	9000-10,000'	297	423	68.0	63.2	96.1	23,741	7.0	NA	NA	49.3
	10,000-11,000'	>300†	529	70.1	74.8	97.9	2,504	0.6	NA	NA	51.4
E. Carson§	5000-6000'	16	0	0.0	0.0	0.0	0	50.1	NA	NA	0.0
	6000-7000'	>300†	46	11.7	0.6	9.5	2,409	75.6	0.0 (1)	0.0 (1)	2.2
	7000-8000'	>300†	370	45.9	17.7	69.3	98,551	104.3	NA	NA	22.2
	8000-9000'	>300†	460	61.7	48.6	98.0	263,122	101.5	55.4 (4)	51.5 (4)	49.0
	9000-10,000'	293	442	68.7	68.9	98.5	133,948	36.5	NA	NA	63.1
	>10,000'	268	383	71.3	68.9	97.3	40,499	11.0	NA	NA	60.7
W. Walker	6000-7000'	>300†	364	15.0	1.9	4.8	746	7.4	NA	NA	0.5
	7000-8000'	>300†	>600†	39.0	25.3	55.7	55,012	40.7	22.3 (1)	9.9 (1)	9.7
	8000-9000'	>300†	>600†	54.9	48.3	96.3	124,030	48.1	55.6 (1)	50.7 (1)	43.9
	9000-10,000'	>300†	386	64.0	54.0	96.8	187,682	65.2	117.1 (1)	117.5 (1)	71.9
	10,000-11,000'	247	300	65.5	54.0	92.5	78,548	27.3	NA	NA	72.9
	> 11,000'	245	294	62.8	50.2	85.4	5,972	2.2	NA	NA	62.8
E. Walker	6000-7000'	>300†	250	3.5	0.1	0.3	370	57.4	NA	NA	0.0
	7000-8000'	>300†	>600†	28.6	13.9	33.4	87,443	117.8	NA	NA	3.0
	8000-9000'	>300†	>600†	47.3	36.9	81.9	189,191	96.2	NA	NA	16.9
	9000-10,000'	>300†	477	58.9	47.4	93.2	144,671	57.2	47.3 (1)	45.8 (1)	47.5
	10,000-11,000'	274	328	61.2	48.8	89.2	90,449	34.7	NA	NA	59.3
	>11,000'	239	288	56.2	44.4	79.3	20,953	8.9	NA	NA	52.3
Mono	6000-7000'	>300†	27	0.4	0.0	0.3	402	319.7	NA	NA	0.0
	7000-8000'	>300†	>600†	10.5	4.2	10.9	93,319	412.4	NA	NA	0.3
	8000-9000'	>300†	>600†	35.7	25.3	61.8	249,797	185.3	NA	NA	3.9
	9000-10,000'	>300†	592	57.9	47.4	93.9	163,868	64.9	NA	NA	28.0
	10,000-11,000'	>300†	365	63.0	50.7	93.2	131,079	48.5	NA	NA	54.9
	11,000-12,000'	260	296	62.1	48.7	83.9	68,513	26.4	NA	NA	51.1
	> 12,000'	245	279	61.9	48.9	79.2	11,464	4.4	NA	NA	41.3
Upper Owens	6000-7000'	>300†	8	16.6	0.0	0.0	49	66.0	NA	NA	0.1
	7000-8000'	>300†	>600†	33.1	14.4	32.3	116,153	151.2	NA	NA	2.8
	8000-9000'	>300†	>600†	49.9	42.5	87.2	181,916	80.3	NA	NA	20.6
	9000-10,000'	>300†	532	59.6	48.6	90.4	114,322	44.1	NA	NA	37.5
	10,000-11,000'	>300†	419	68.8	53.1	92.8	98,054	34.6	NA	NA	49.6
	11,000-12,000'	>300†	344	77.2	54.1	87.1	46,650	16.2	NA	NA	44.7
	> 12,000'	>300†	319	76.5	47.7	80.0	9,749	3.8	NA	NA	29.8
Owens	5000-6000'	0	0	0.0	0.0	0.0	0	443.7	NA	NA	0.0
	6000-7000'	>300†	164	0.2	0.0	0.2	827	352.1	NA	NA	0.0
	7000-8000'	>300†	>600†	4.8	1.3	4.0	21,906	328.3	NA	NA	0.4
	8000-9000'	>300†	>600†	13.0	8.9	23.3	89,749	188.4	NA	NA	5.6
	9000-10,000'	>300†	>600†	35.5	25.8	61.4	211,518	154.0	43.8 (3)	38.4 (3)	17.1
	10,000-11,000'	>300†	>600†	57.4	38.8	84.6	347,866	168.1	45.3 (2)	30.7 (2)	29.2
	11,000-12,000'	>300†	433	71.6	45.4	84.6	328,745	135.7	NA	NA	35.5
	12,000-13,000	>300†	348	76.0	45.2	81.0	163,611	67.9	NA	NA	29.2
	>13,000'	>300†	305	70.7	40.1	77.1	23,388	10.9	NA	NA	21.8

- Data omitted due to inconsistencies with independent SWE estimates.
§ 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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