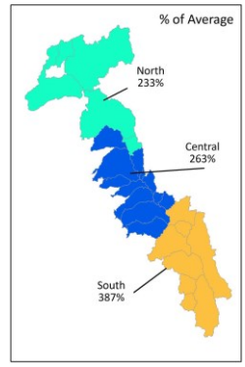
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California
March 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 March 1, percent of average SWE is highest in the south (387%), then central (263%) and lowest in the north (233%). This snow year has 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**.

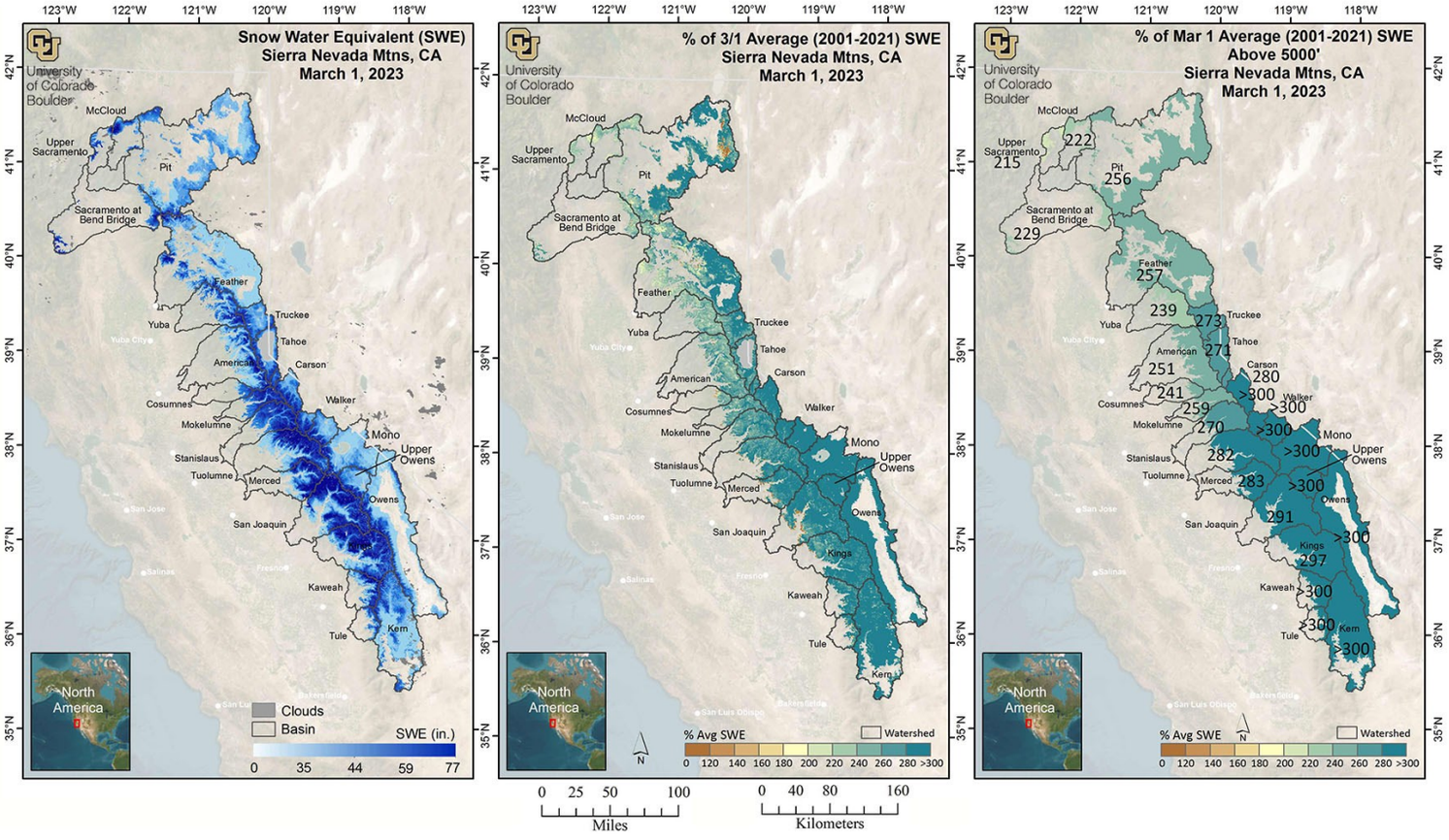

Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for March 1, 2023 (left), and percent of average (2001-2021) SWE for March 1, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all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

102 snow pillow sites in the Sierra Nevada network were recording SWE values out of a total of 127 sites, 26 were offline, and we used 43 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.

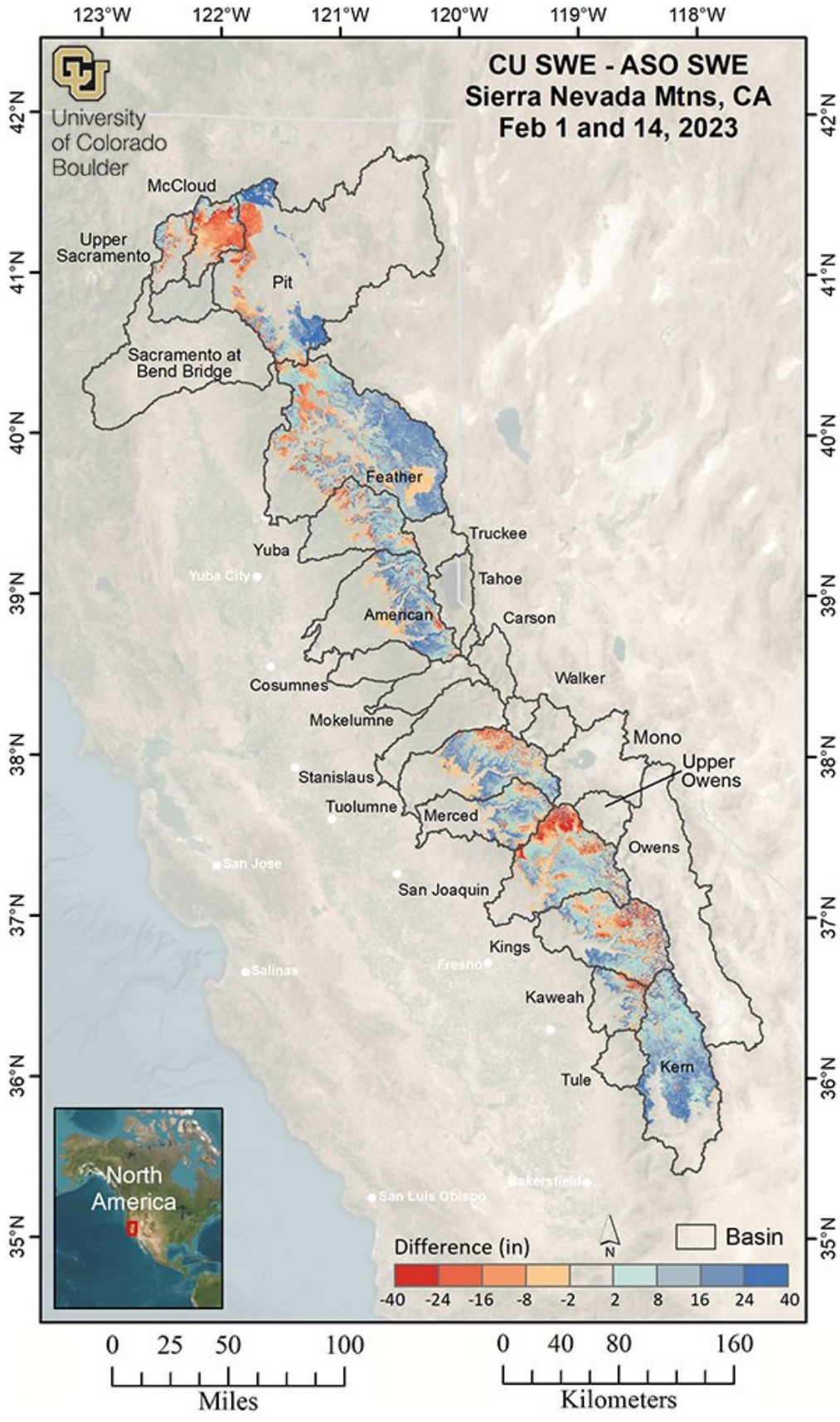

Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the February 1 and February 14, 2023 CU SWE model run and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins. Red colors show where CU SWE is lower than ASO SWE and blue colors show where 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.

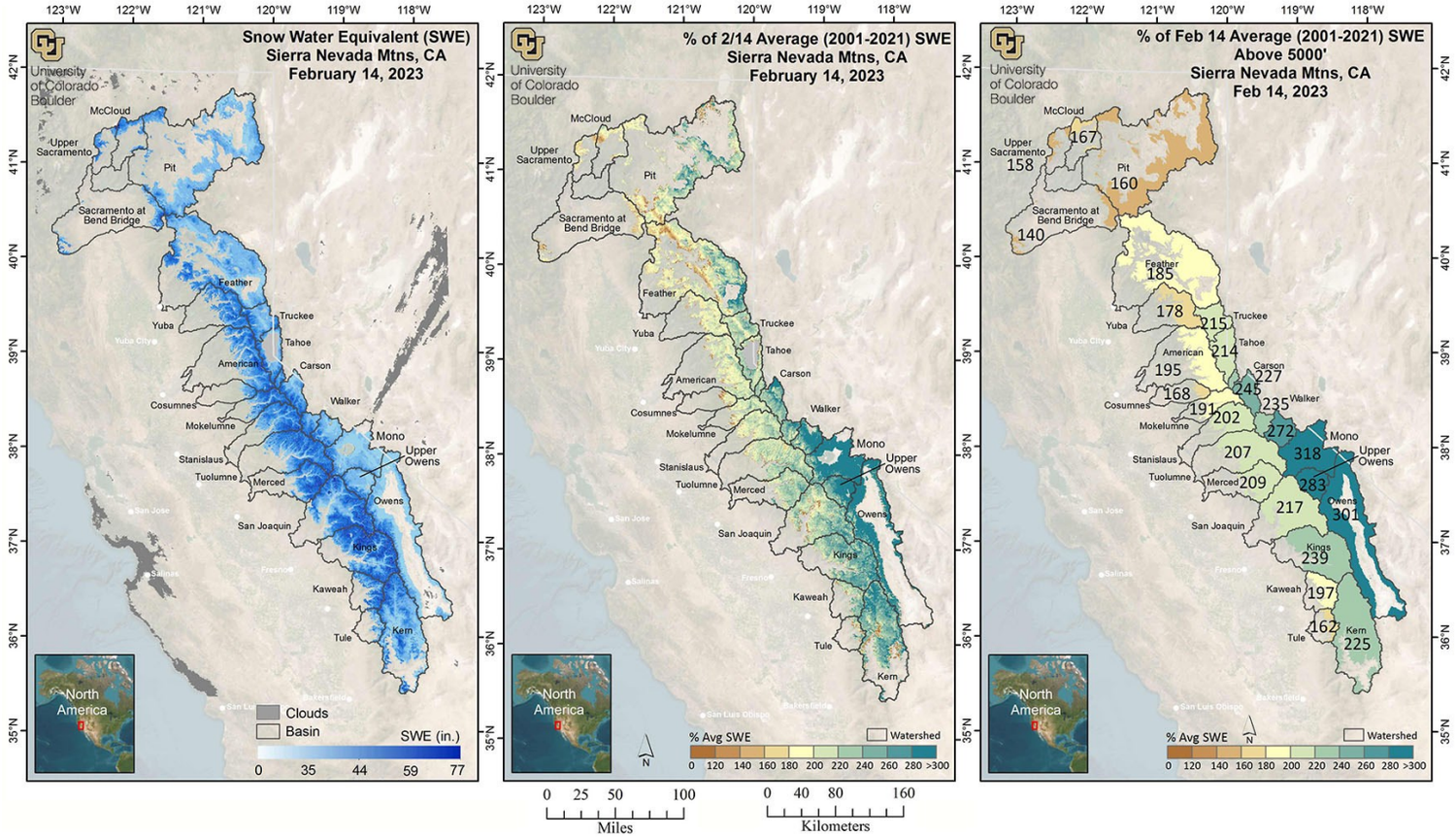

Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for February 14, 2023 (left), and percent of average (2001-2021) SWE for February 14, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

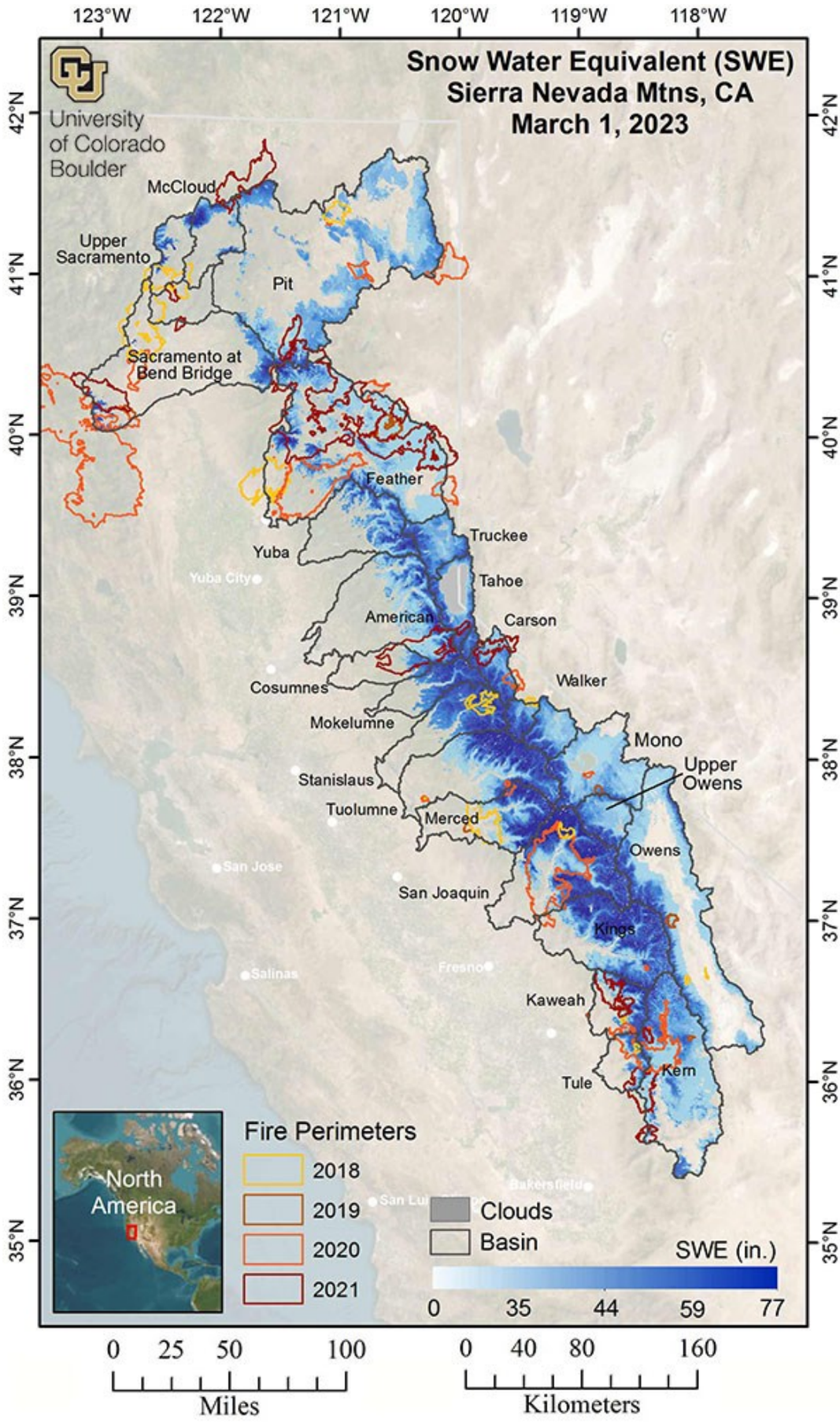

Figure 4. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts for March 1, 2023 are shown with fire perimeters from 2018-2021 (colored from yellow to red).

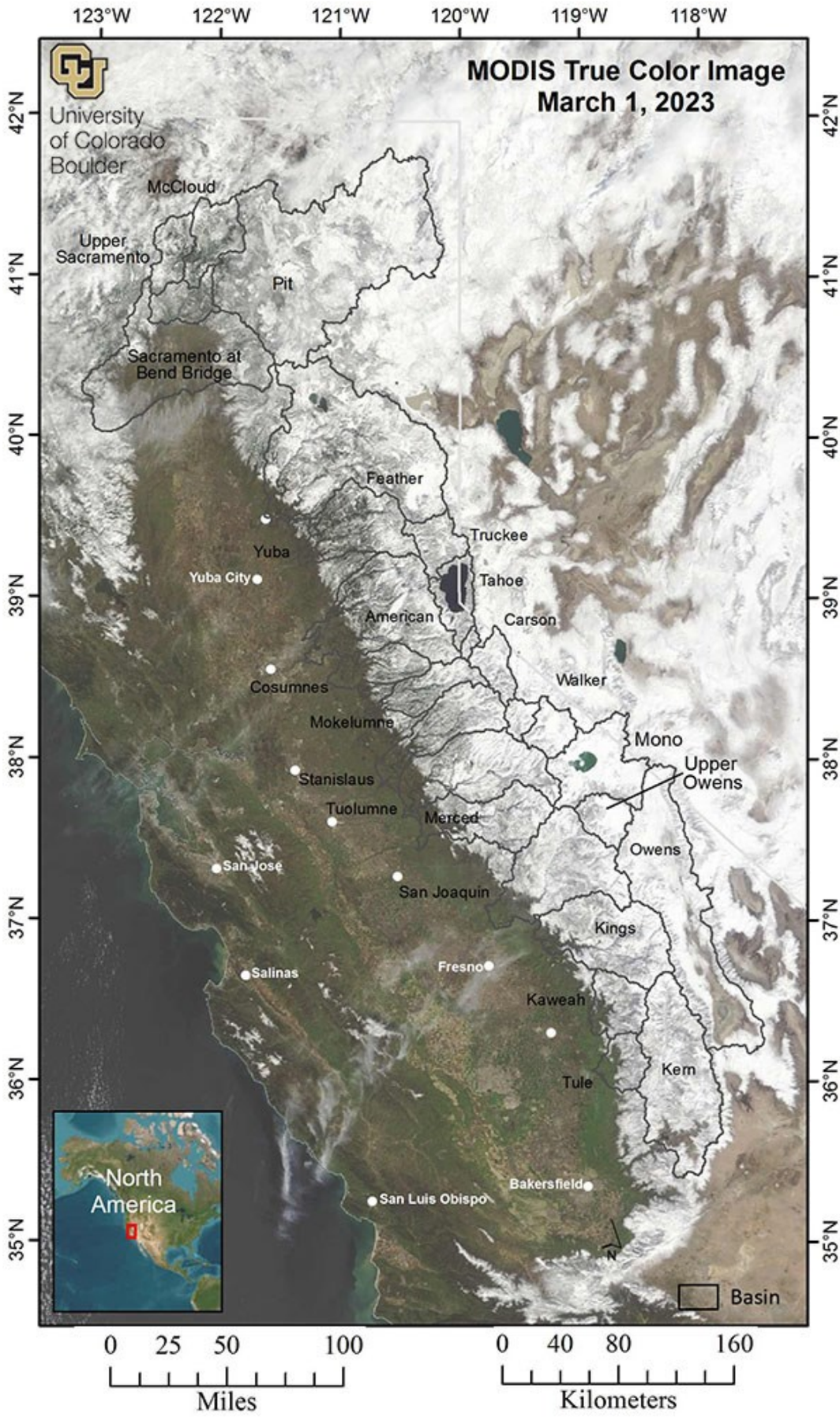

Figure 5. MODIS image, Sierra Nevada. A mostly cloud-free true color MODIS image, showing the image that was used for the March 1, 2023 regression model run. Due to clouds we used portions of 2 MODSCAG images, a Rittger SnowToday image (Rittger, et.al. 2019) and a NORSC SNODAS image.

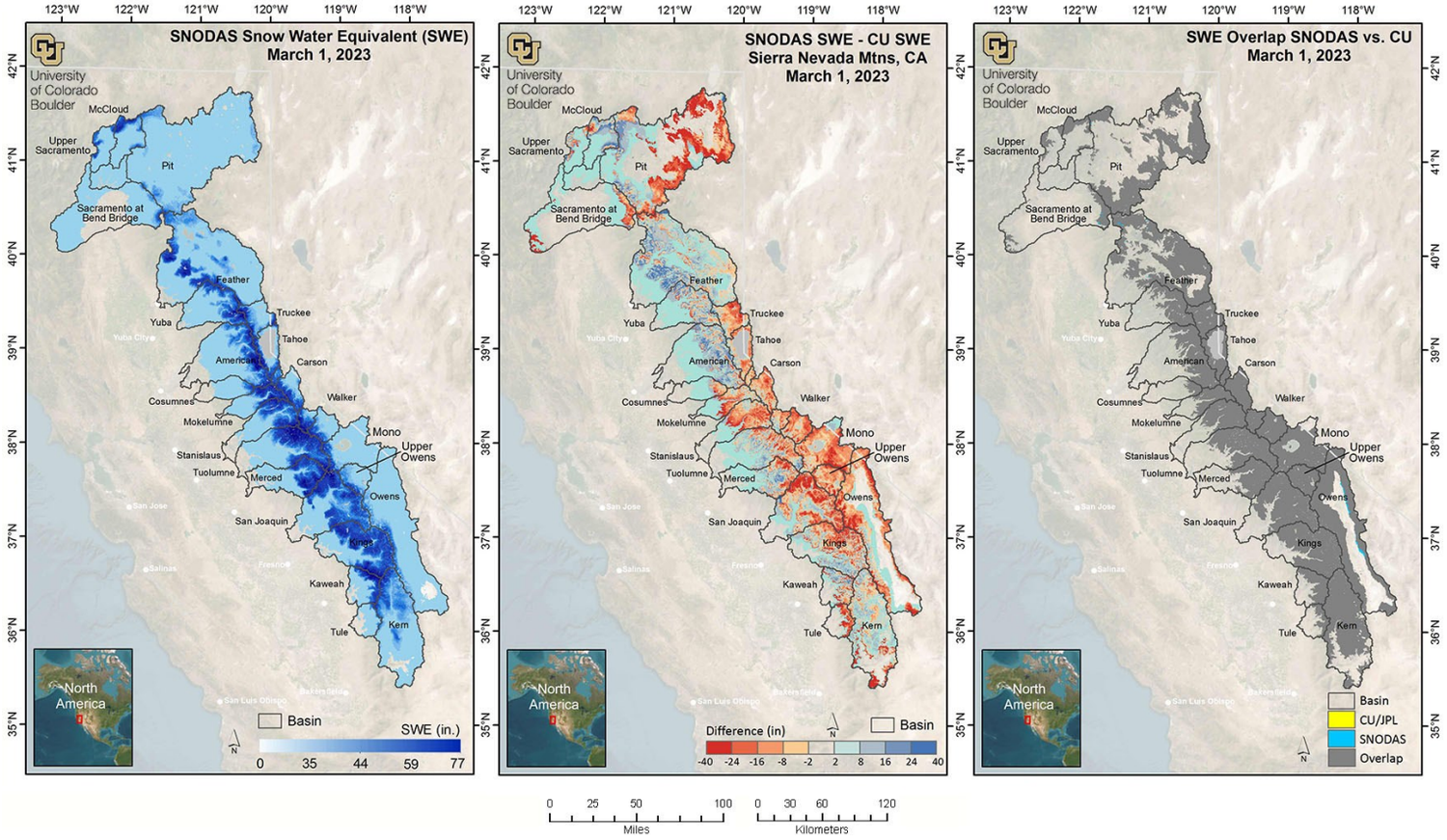

Figure 6. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE for March 1st from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows the difference between the March 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. 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.

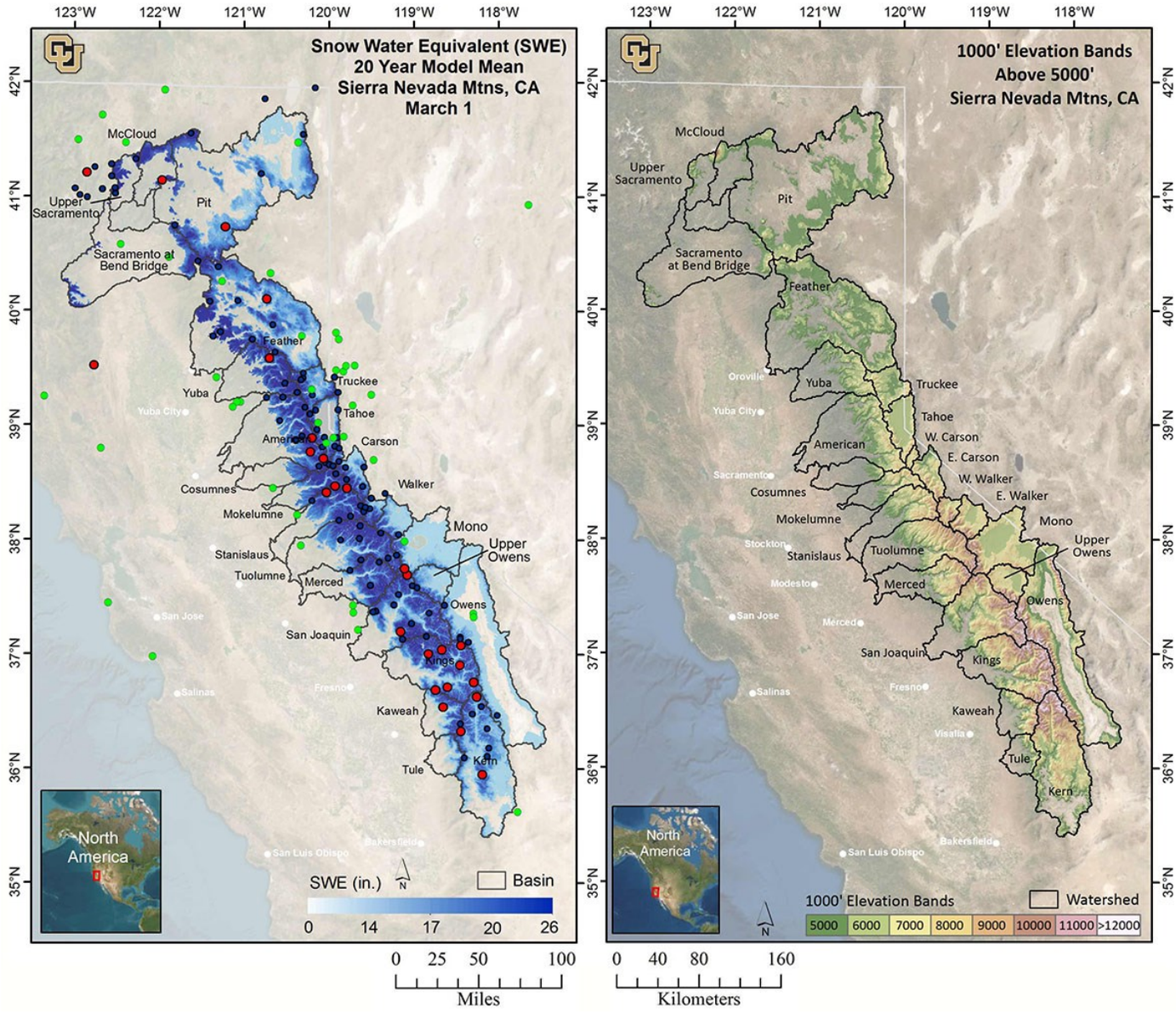

Figure 7. Historical average March 1st and Elevation Bands for the Sierra Nevada. Average SWE (2001-2021) for March 1st (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and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

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* March 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 February 14th percent of February 14th average SWE, March 1st percent of March 1st average SWE (between 2001-2021 as derived from the regression model), February 14th mean SWE, March 1st mean SWE, March 1st percent of snow-covered area, March 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), February 14th snow pillow data, and March 1st snow pillow data for those areas collected, summarized for each basin. The last column shows March 1st mean SWE from SNODAS*.*

Basin	2/14/23 % 2/14 Avg.	3/1/23 % 3/1 Avg.	2/14/23 SWE (in)	3/1/23 SWE (in)	3/1/23 % SCA	3/1/23‡ Vol (af)	Area (mi2) > 5000'	3/1/23 Surveys	2/14/23 Pillows	3/1/23 Pillows	3/1/23 SNODAS* (in)
Upper Sacramento§	158	188	32.1	42.5	100.0	287,999	127.0	NA	40.1 (2)	45.5 (2)	37.6
McCloud§	167	205	32.7	46.2	99.9	436,939	177.2	NA	32.8 (1)	NA	45.4
Pit§	160	235	19.0	26.1	99.1	3,195,612	2292.8	16.0 (1)	23.0 (4)	28.0 (4)	12.6
Sac at Bend Bridge	140	202	25.1	44.9	94.1	610,131	254.8	15.5 (1)	NA	NA	22.8
Feather§	185	235	15.6	22.3	98.0	2,642,317	2,225.4	30.1 (21)	36.5 (6)	44.6 (6)	25.1
Yuba§	178	222	32.5	39.7	99.8	1,173,636	554.6	55.6 (7)	47.7 (3)	56.9 (3)	42.0
American§	195	233	33.1	33.1	99.7	1,501,886	851.5	40.4 (13)	32.6 (9)	39.2 (10)	39.0
Cosumnes	168	220	26.8	40.9	95.4	202,209	92.8	NA	NA	NA	30.9
Mokelumne	191	243	33.4	52.0	99.9	934,317	336.8	48.4 (4)	46.3 (1)	55.2 (1)	42.8
Stanislaus	202	>250†	34.2	52.1	100.0	1,637,001	589.4	60.5 (5)	42.4 (6)	53.4 (4)	40.2
Tuolumne§	207	>250†	34.0	46.2	99.6	2,362,831	958.1	46.4 (11)	40.8 (6)	53.5 (7)	43.8
Merced§	209	>250†	34.6	46.9	100.0	1,414,508	565.9	52.5 (2)	42.3 (3)	52.8 (3)	43.5
San Joaquin§	217	>250†	34.2	53.5	100.0	3,632,224	1,273.7	45.9 (10)	40.8 (8)	51.2 (8)	39.8
Kings§	239	>250†	36.6	49.9	100.0	3,353,500	1,261.0	54.7 (16)	44.3 (6)	54.9 (1)	43.6
Kaweah§	197	>250†	27.7	42.1	100.0	731,193	326.0	36.0 (2)	33.2 (2)	58.5 (1)	39.0
Tule	162	>250†	17.4	39.1	100.0	298,684	143.2	22.0 (1)	NA	NA	18.7
Kern§	225	>250†	15.3	26.2	99.2	2,329,851	1,669.8	33.3 (4)	30.4 (9)	33.7 (6)	23.1
Truckee	215	>250†	31.3	39.8	100.0	956,279	450.2	NA	27.2 (4)	32.4 (5)	30.3
Tahoe	214	>250†	32.3	43.6	100.0	779,231	335.2	39.0 (7)	34.0 (7)	42.5 (7)	36.1
W Carson	227	>250†	37.7	51.3	100.0	192,064	70.2	58.0 (1)	41.0 (2)	48.7 (2)	42.7
E Carson	245	>250†	32.3	42.7	100.0	869,870	382.1	NA	34.3 (5)	42.7 (5)	32.5
W Walker	235	>250†	35.0	50.4	100.0	514,511	191.4	NA	42.5 (3)	51.8 (3)	43.7
E Walker	>250†	>250†	28.5	37.7	100.0	759,562	377.6	NA	30.8 (1)	37.8 (1)	25.0
Mono	>250†	>250†	22.5	26.5	98.6	1,505,680	1,064.0	NA	46.2 (1)	NA	14.8
Upper Owens	>250†	>250†	28.5	37.4	100.0	792,018	396.5	58.3 (3)	61.1 (1)	68.5 (1)	25.0
Owens	>250†	>250†	15.0	22.5	94.0	2,232,008	1,856.1	30.8 (2)	28.0 (4)	33.9 (5)	11.7

§ Note that data for the Kern and Feather River Basins have been bias-corrected using ASO data and therefore the SWE changes do 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 February 14th percent of February 14th average SWE, March 1st percent of March 1st average SWE (between 2001-2021 as derived from the regression model), February 14th mean SWE, March 1st mean SWE, March 1st percent of snow-covered area, March 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), February 14th snow pillow data, and March 1st snow pillow data for those areas collected, summarized for each 1000' elevation band inside each basin. The last column shows March 1st mean SWE from SNODAS*.*

Basin	Elevation Band	2/14/23 % 2/14 Avg.	3/1/23 % 3/1 Avg.	2/14/23 SWE (in)	3/1/23 SWE (in)	3/1/23 % SCA	3/1/23‡ Vol (af)	3/1/23 Area (mi2)	3/1/23 Surveys	2/14/23 Pillows	3/1/23 Pillows	3/1/23 SNODAS* (in)
Upper Sacramento§	5000-6000'	161	192	30.3	38.1	100.0	146,355	72.0	NA	42.4 (1)	49.0 (1)	29.1
	6000-7000'	163	189	34.8	47.0	100.0	95,952	38.3	NA	37.8 (1)	42.0 (1)	39.2
	7000-8000'	147	179	33.0	50.3	100.0	24,328	9.1	NA	NA	NA	38.5
	8000-9000'	130	164	33.0	55.5	100.0	9,087	3.1	NA	NA	NA	38.9
	9000-10,000'	118	158	33.3	55.7	100.0	6,214	2.1	NA	NA	NA	37.2
	10,000-11,000'	131	171	41.1	57.0	100.0	3,815	1.3	NA	NA	NA	32.3
	> 11,000'	109	158	33.0	35.5	100.0	2,247	1.2	NA	NA	NA	27.5
McCloud§	5000-6000'	170	204	30.0	38.2	99.8	214,114	105.0	NA	32.8 (1)	NA	37.1
	6000-7000'	172	204	34.2	51.1	100.0	118,986	43.7	NA	NA	NA	46.4
	7000-8000'	160	214	34.9	71.3	100.0	54,094	14.2	NA	NA	NA	45.5
	8000-9000'	169	220	40.0	68.2	100.0	24,616	6.8	NA	NA	NA	46.0
	>9,000'	171	221	44.5	65.1	100.0	10,902	3.1	NA	NA	NA	43.3
Pit§	5000-6000'	154	>250†	16.0	22.7	99.1	1,901,333	1,570.0	NA	34.1 (1)	43.9 (1)	7.0
	6000-7000'	166	208	24.1	31.4	99.2	939,106	560.1	16.0 (1)	20.7 (2)	23.9 (2)	15.3
	7000-8000'	178	210	29.9	39.8	99.0	296,455	139.6	NA	16.5 (1)	20.4 (1)	23.5
	>8,000'	193	224	35.7	46.7	97.9	53,157	21.3	NA	NA	NA	21.6
Sac at Bend Bridge	5000-6000'	129	198	20.9	40.6	93.6	364,322	168.2	15.5 (1)	NA	NA	14.5
	6000-7000'	150	203	30.1	50.1	95.3	173,394	64.9	NA	NA	NA	24.1
	>7,000'	175	219	41.2	61.6	95.9	54,056	16.5	NA	NA	NA	33.3
Feather§	5000-6000'	183	244	12.5	18.5	97.8	1,306,721	1,325.0	26.0 (11)	46.8 (1)	56.6 (1)	18.1
	6000-7000'	187	225	18.9	26.0	98.2	1,071,961	771.9	34.3 (7)	35.6 (4)	44.1 (4)	21.4
	7000-8000'	188	219	27.3	38.3	99.1	253,282	124.0	35.5 (3)	29.9 (1)	34.8 (1)	27.0
	8000-9000'	197	221	33.6	43.5	94.5	10,352	4.5	NA	NA	NA	27.9
Yuba§	5000-6000'	145	216	23.1	27.9	99.4	302,055	203.1	43.0 (1)	NA	NA	22.6
	6000-7000'	192	224	36.1	40.8	100.0	499,856	229.5	52.9 (4)	40.7 (2)	48.5 (2)	35.5
	7000-8000'	197	227	41.3	56.7	100.0	355,610	117.6	67.3 (2)	61.6 (1)	73.7 (1)	45.7
	8000-9000'	193	221	45.0	67.7	100.0	16,115	4.5	NA	NA	NA	57.3
American§	5000-6000'	173	229	24.1	16.8	99.3	280,918	313.3	26.0 (2)	19.8 (3)	27.5 (3)	17.2
	6000-7000'	202	233	35.1	31.0	99.9	465,373	281.3	37.5 (6)	33.7 (2)	37.9 (2)	30.3
	7000-8000'	207	237	40.6	49.4	100.0	466,300	176.9	47.0 (4)	41.0 (2)	44.9 (3)	44.4
	8000-9000'	209	239	44.7	66.2	100.0	249,909	70.8	60.5 (1)	42.6 (2)	49.4 (2)	49.5
	9000-10,000'	208	237	48.3	80.8	100.0	39,386	9.1	NA	NA	NA	50.7
Cosumnes	5000-6000'	152	212	22.5	36.2	94.4	117,440	60.9	NA	NA	NA	16.4
	6000-7000'	189	230	33.4	47.9	97.4	63,615	24.9	NA	NA	NA	31.9
	7000-8000'	203	238	41.0	56.9	97.4	21,155	7.0	NA	NA	NA	42.0
Mokelumne	5000-6000'	134	228	17.9	37.9	99.8	178,518	88.4	NA	NA	NA	10.3
	6000-7000'	191	237	31.2	47.7	99.7	174,064	68.4	NA	NA	NA	29.5
	7000-8000'	211	248	40.4	57.8	100.0	281,121	91.2	44.5 (3)	NA	NA	46.0
	8000-9000'	210	>250†	43.1	63.1	100.0	269,502	80.1	60.0 (1)	46.3 (1)	55.2 (1)	48.8
	9000-10,000'	206	246	45.4	67.5	100.0	31,112	8.6	NA	NA	NA	46.8
Stanislaus	5000-6000'	152	243	19.4	37.1	100.0	217,678	110.0	NA	NA	NA	9.3
	6000-7000'	200	245	30.9	46.0	99.9	345,946	141.2	NA	33.6 (1)	42.5 (1)	26.8
	7000-8000'	212	>250†	37.7	54.5	99.9	442,785	152.2	58.0 (2)	31.9 (1)	NA	38.6
	8000-9000'	215	>250†	41.9	61.6	100.0	389,200	118.6	66.8 (2)	48.9 (3)	60.8 (2)	43.1
	9000-10,000'	211	>250†	44.0	66.6	100.0	191,194	53.8	53.0 (1)	42.2 (1)	49.5 (1)	46.2
	10,000-11,000'	207	>250†	44.2	69.2	100.0	48,869	13.3	NA	NA	NA	45.4
	> 11,000'	197	>250†	41.4	71.4	100.0	1,328	0.3	NA	NA	NA	43.6

Basin	Elevation Band	2/14/23 % 2/14 Avg.	3/1/23 % 3/1 Avg.	2/14/23 SWE (in)	3/1/23 SWE (in)	3/1/23 % SCA	3/1/23‡ Vol (af)	3/1/23 Area (mi2)	3/1/23 Surveys	2/14/23 Pillows	3/1/23 Pillows	3/1/23 SNODAS* (in)
Tuolumne§	5000-6000'	148	246	16.2	12.9	98.8	122,107	178.0	NA	NA	NA	8.0
	6000-7000'	206	>250†	29.1	26.7	99.7	208,662	146.8	36.4 (5)	25.2 (1)	33.4 (1)	25.5
	7000-8000'	219	>250†	37.0	46.6	99.6	388,906	156.4	NA	44.6 (1)	60.8 (2)	38.6
	8000-9000'	219	>250†	39.9	63.2	99.7	582,956	172.9	59.0 (2)	46.5 (2)	55.5 (2)	44.9
	9000-10,000'	215	>250†	41.1	68.2	100.0	668,235	183.8	52.5 (4)	41.1 (2)	54.3 (2)	47.9
	10,000-11,000'	216	>250†	42.9	63.0	100.0	307,627	91.5	NA	NA	NA	47.3
	11,000-12,000'	222	>250†	44.2	54.2	100.0	74,595	25.8	NA	NA	NA	41.4
	> 12,000'	214	>250†	43.9	62.4	100.0	9,743	2.9	NA	NA	NA	35.2
Merced§	5000-6000'	106	210	11.1	11.6	100.0	46,566	75.2	NA	NA	NA	5.2
	6000-7000'	187	>250†	25.8	23.5	100.0	103,948	82.9	NA	NA	NA	22.7
	7000-8000'	217	>250†	36.0	42.5	100.0	322,318	142.1	NA	33.0 (1)	41.4 (1)	38.3
	8000-9000'	224	>250†	41.3	61.8	100.0	410,703	124.7	52.5 (2)	47.0 (2)	58.5 (2)	42.6
	9000-10,000'	230	>250†	43.6	70.0	100.0	328,194	87.9	NA	NA	NA	42.8
	10,000-11,000'	225	>250†	46.1	71.4	100.0	151,856	39.9	NA	NA	NA	49.1
	11,000-12,000'	220	>250†	48.3	70.6	100.0	44,357	11.8	NA	NA	NA	50.6
	> 12,000'	200	>250†	47.4	76.7	100.0	6,566	1.6	NA	NA	NA	47.4
San Joaquin§	5000-6000'	128	226	12.7	16.1	100.0	123,700	144.4	NA	NA	NA	5.3
	6000-7000'	205	>250†	25.7	29.5	100.0	294,040	187.0	NA	40.0 (2)	49.6 (2)	23.0
	7000-8000'	211	>250†	31.2	45.2	100.0	535,870	222.3	35.5 (3)	42.4 (4)	52.6 (4)	35.6
	8000-9000'	219	>250†	37.1	66.0	100.0	714,845	203.1	51.5 (1)	NA	NA	38.2
	9000-10,000'	234	>250†	41.8	73.4	100.0	812,694	207.5	58.5 (2)	41.6 (1)	56.9 (1)	39.2
	10,000-11,000'	239	>250†	44.2	72.6	100.0	627,260	162.0	50.8 (3)	35.0 (1)	43.3 (1)	42.7
	11,000-12,000'	237	>250†	45.3	67.4	100.0	427,888	119.0	31.0 (1)	NA	NA	36.6
	12,000-13,000	228	>250†	45.0	63.6	100.0	91,498	27.0	NA	NA	NA	26.4
	> 13,000	219	>250†	40.8	56.7	100.0	4,427	1.5	NA	NA	NA	16.6
Kings§	5000-6000'	94	>250†	7.9	15.8	100.0	85,517	101.3	NA	NA	NA	5.6
	6000-7000'	208	>250†	23.9	22.6	100.0	165,689	137.2	NA	NA	NA	17.6
	7000-8000'	232	>250†	32.6	39.7	100.0	375,447	177.3	39.3 (2)	NA	NA	33.4
	8000-9000'	244	>250†	38.8	55.1	100.0	649,768	221.1	57.3 (6)	43.1 (1)	NA	41.4
	9000-10,000'	>250†	>250†	42.6	61.6	100.0	729,380	221.8	58.9 (5)	46.6 (2)	54.9 (1)	43.9
	10,000-11,000'	>250†	>250†	44.7	62.4	100.0	643,596	193.4	52.3 (2)	43.2 (3)	NA	43.8
	11,000-12,000'	>250†	>250†	45.9	64.1	100.0	531,558	155.6	53.5 (1)	NA	NA	38.9
	12,000-13,000	243	>250†	44.9	61.1	100.0	160,339	49.2	NA	NA	NA	30.7
	>13,000'	234	>250†	41.3	55.6	100.0	12,205	4.1	NA	NA	NA	23.1
Kaweah§	5000-6000'	28	>250†	2.1	22.8	100.0	74,596	61.4	NA	NA	NA	5.3
	6000-7000'	156	>250†	18.2	20.9	100.0	67,927	60.8	23.0 (1)	19.4 (1)	NA	17.7
	7000-8000'	211	>250†	30.9	36.2	100.0	120,567	62.5	NA	NA	NA	33.2
	8000-9000'	234	>250†	38.7	53.4	100.0	164,680	57.8	49.0 (1)	NA	NA	42.4
	9000-10,000'	238	>250†	42.1	64.5	100.0	150,383	43.7	NA	47.0 (1)	58.5 (1)	51.6
	10,000-11,000'	235	>250†	43.8	72.8	100.0	120,199	31.0	NA	NA	NA	53.9
	>11,000'	236	>250†	45.0	70.1	100.0	32,840	8.8	NA	NA	NA	46.2
Tule	5000-6000'	42	>250†	2.7	28.2	100.0	82,996	55.2	NA	NA	NA	2.3
	6000-7000'	155	>250†	17.4	38.9	100.0	86,809	41.8	22.0 (1)	NA	NA	9.8
	7000-8000'	216	>250†	31.0	49.2	100.0	70,448	26.8	NA	NA	NA	24.9
	8000-9000'	238	>250†	39.4	56.2	100.0	44,293	14.8	NA	NA	NA	35.7
	9000-10,000'	235	>250†	41.3	58.5	100.0	14,138	4.5	NA	NA	NA	48.5
Kern§	5000-6000'	64	>250†	0.8	16.9	97.6	213,489	236.7	NA	NA	NA	1.8
	6000-7000'	163	>250†	5.2	15.2	98.7	268,161	331.4	NA	NA	NA	7.2
	7000-8000'	225	>250†	11.4	17.8	99.5	308,281	324.2	NA	23.1 (2)	29.0 (2)	15.2
	8000-9000'	247	>250†	21.3	30.3	99.6	510,351	316.3	31.3 (2)	32.5 (3)	36.9 (2)	24.7
	9000-10,000'	>250†	>250†	26.9	37.3	99.8	377,190	189.4	NA	38.6 (1)	NA	32.1
	10,000-11,000'	>250†	>250†	31.2	42.9	100.0	302,575	132.4	35.5 (1)	26.5 (2)	35.2 (2)	32.5
	11,000-12,000'	>250†	>250†	33.4	47.7	99.9	241,218	94.9	35.0 (1)	38.4 (1)	NA	31.1
	12,000-13,000	244	>250†	30.8	46.3	99.9	94,367	38.2	NA	NA	NA	24.7
	>13,000'	227	>250†	27.0	42.0	100.0	14,220	6.3	NA	NA	NA	16.7

Basin	Elevation Band	2/14/23 % 2/14 Avg.	3/1/23 % 3/1 Avg.	2/14/23 SWE (in)	3/1/23 SWE (in)	3/1/23 % SCA	3/1/23‡ Vol (af)	3/1/23 Area (mi2)	3/1/23 Surveys	2/14/23 Pillows	3/1/23 Pillows	3/1/23 SNODAS* (in)
Truckee	5000-6000'	232	>250†	23.0	27.2	100.0	101,335	69.9	NA	NA	NA	7.9
	6000-7000'	213	>250†	28.7	36.1	100.0	425,748	221.4	NA	27.2 (4)	32.4 (5)	18.8
	7000-8000'	213	239	37.7	48.9	100.0	312,567	119.7	NA	NA	NA	35.0
	8000-9000'	209	237	41.7	55.8	100.0	91,401	30.7	NA	NA	NA	43.5
	9000-10,000'	206	243	40.5	56.4	100.0	23,916	8.0	NA	NA	NA	46.9
	10,000-11,000'	198	246	40.1	58.8	100.0	1,312	0.4	NA	NA	NA	44.3
Tahoe	6000-7000'	209	>250†	24.3	32.0	100.0	224,209	131.3	25.3 (3)	26.7 (2)	34.4 (2)	17.5
	7000-8000'	215	>250†	34.5	46.3	100.0	279,224	113.2	39.0 (3)	37.4 (4)	46.2 (4)	32.9
	8000-9000'	216	246	40.7	56.1	100.0	218,583	73.0	80.0 (1)	35.1 (1)	43.7 (1)	39.8
	9000-10,000'	214	246	42.8	60.2	100.0	54,601	17.0	NA	NA	NA	41.5
	10,000-11,000'	220	>250†	44.9	63.9	100.0	2,614	0.8	NA	NA	NA	34.6
W. Carson	5000-6000'	222	>250†	16.6	28.9	100.0	322	0.2	NA	NA	NA	11.3
	6000-7000'	>250†	>250†	27.2	37.1	100.0	4,415	2.2	NA	NA	NA	24.0
	7000-8000'	228	>250†	35.0	46.6	100.0	79,874	32.2	NA	NA	NA	33.2
	8000-9000'	225	>250†	40.2	55.4	100.0	82,447	27.9	58.0 (1)	41.0 (2)	48.7 (2)	36.1
	9000-10,000'	226	250	43.8	61.5	100.0	23,098	7.0	NA	NA	NA	37.9
	10,000-11,000'	219	244	40.1	57.0	100.0	1,907	0.6	NA	NA	NA	34.8
E. Carson	5000-6000'	>250†	>250†	19.5	24.8	100.0	66,517	50.3	NA	NA	NA	8.1
	6000-7000'	>250†	>250†	25.1	31.0	100.0	129,084	78.1	NA	17.1 (1)	22.7 (1)	13.8
	7000-8000'	240	>250†	32.2	41.6	100.0	231,975	104.7	NA	NA	NA	23.4
	8000-9000'	232	>250†	38.9	52.7	100.0	285,170	101.5	NA	38.6 (4)	47.7 (4)	37.8
	9000-10,000'	228	>250†	43.3	61.0	100.0	118,649	36.5	NA	NA	NA	42.4
	>10,000'	230	>250†	45.9	65.5	100.0	38,476	11.0	NA	NA	NA	38.6
W. Walker	6000-7000'	>250†	>250†	24.6	29.1	100.0	12,139	7.8	NA	NA	NA	12.5
	7000-8000'	>250†	>250†	26.1	33.1	100.0	71,816	40.7	NA	25.2 (1)	32.1 (1)	17.5
	8000-9000'	240	>250†	33.3	45.9	100.0	117,848	48.1	NA	35.6 (1)	43.2 (1)	35.9
	9000-10,000'	227	>250†	39.8	59.4	100.0	206,497	65.2	NA	66.8 (1)	80.1 (1)	47.3
	10,000-11,000'	215	>250†	42.5	67.5	100.0	98,147	27.3	NA	NA	NA	45.5
	> 11,000'	202	>250†	38.4	67.7	100.0	8,063	2.2	NA	NA	NA	38.9
E. Walker	6000-7000'	>250†	>250†	20.4	21.8	100.0	70,366	60.5	NA	NA	NA	11.4
	7000-8000'	>250†	>250†	23.5	28.0	100.0	179,593	120.2	NA	NA	NA	8.6
	8000-9000'	>250†	>250†	29.3	38.0	100.0	194,801	96.2	NA	NA	NA	19.0
	9000-10,000'	243	>250†	36.4	53.5	100.0	163,045	57.2	NA	30.8 (1)	37.8 (1)	34.3
	10,000-11,000'	225	>250†	39.9	64.6	100.0	119,731	34.7	NA	NA	NA	39.4
	>11,000'	211	>250†	37.8	67.8	100.0	32,026	8.9	NA	NA	NA	34.7
Mono	6000-7000'	>250†	>250†	17.8	17.3	97.0	295,374	320.9	NA	NA	NA	7.2
	7000-8000'	>250†	>250†	18.8	21.0	99.1	464,983	414.5	NA	NA	NA	7.1
	8000-9000'	>250†	>250†	25.4	31.1	99.5	306,137	184.5	NA	NA	NA	9.9
	9000-10,000'	>250†	>250†	34.9	48.1	99.9	166,537	64.9	NA	NA	NA	25.6
	10,000-11,000'	245	>250†	40.8	61.7	100.0	159,776	48.5	NA	46.2 (1)	NA	42.6
	11,000-12,000'	225	>250†	40.8	68.9	100.0	96,822	26.4	NA	NA	NA	39.8
	> 12,000'	216	>250†	39.9	68.5	100.0	16,051	4.4	NA	NA	NA	34.9
Upper Owens	6000-7000'	>250†	>250†	21.4	21.8	100.0	76,715	66.0	NA	NA	NA	15.3
	7000-8000'	>250†	>250†	24.1	28.6	100.0	230,952	151.5	NA	NA	NA	16.0
	8000-9000'	>250†	>250†	30.3	41.6	99.9	178,289	80.3	50.3 (2)	NA	NA	21.3
	9000-10,000'	>250†	>250†	36.3	52.6	100.0	123,678	44.1	74.5 (1)	61.1 (1)	68.5 (1)	28.4
	10,000-11,000'	>250†	>250†	40.0	59.5	100.0	109,834	34.6	NA	NA	NA	36.9
	11,000-12,000'	239	>250†	42.5	68.3	100.0	58,944	16.2	NA	NA	NA	34.8
	> 12,000'	220	>250†	37.8	66.5	100.0	13,606	3.8	NA	NA	NA	25.1
Owens	5000-6000'	72	>250†	0.3	3.9	87.7	91,742	439.2	NA	NA	NA	0.4
	6000-7000'	>250†	>250†	6.3	12.8	94.5	245,318	359.4	NA	NA	NA	2.9
	7000-8000'	>250†	>250†	13.2	19.2	96.3	342,161	333.4	NA	NA	NA	5.7
	8000-9000'	>250†	>250†	18.2	23.1	92.7	232,359	188.4	NA	NA	NA	9.4
	9000-10,000'	>250†	>250†	26.4	33.7	96.0	274,929	153.1	23.5 (1)	29.3 (3)	34.8 (3)	15.8
	10,000-11,000'	>250†	>250†	33.1	43.9	97.9	392,835	167.9	NA	24.2 (1)	32.5 (2)	21.4
	11,000-12,000'	>250†	>250†	37.6	55.1	98.6	398,533	135.6	38.0 (1)	NA	NA	22.4
	12,000-13,000	245	>250†	38.1	60.8	99.0	220,385	67.9	NA	NA	NA	17.4
	>13,000'	230	>250†	35.6	57.8	99.0	33,744	10.9	NA	NA	NA	12.1

§ Note that data for the Kern and Feather River Basins have been bias-corrected using ASO data and therefore the SWE changes do 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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