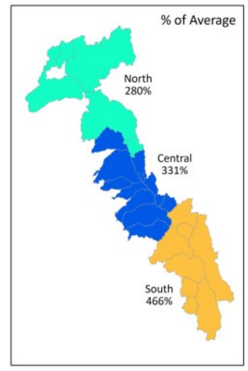
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California

May 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 (466%), then central (331%) and lowest in the north (280%). 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](#)**.

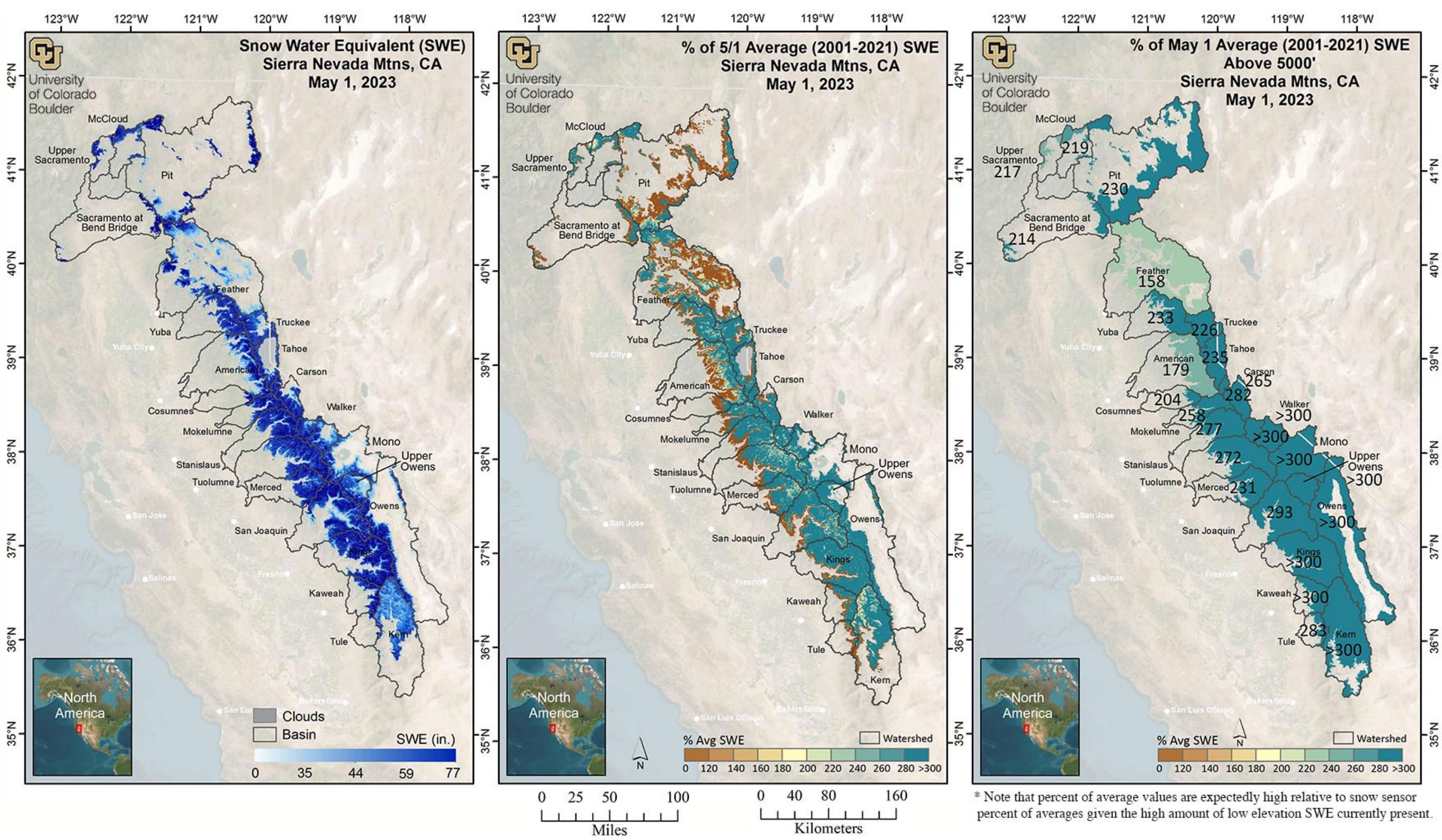

Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for May 1, 2023 (left), and percent of average (2001-2021) SWE for May 1, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model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

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

89 snow pillow sites in the Sierra Nevada network were recording SWE values out of a total of 128 sites, 39 were offline, and 4 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.

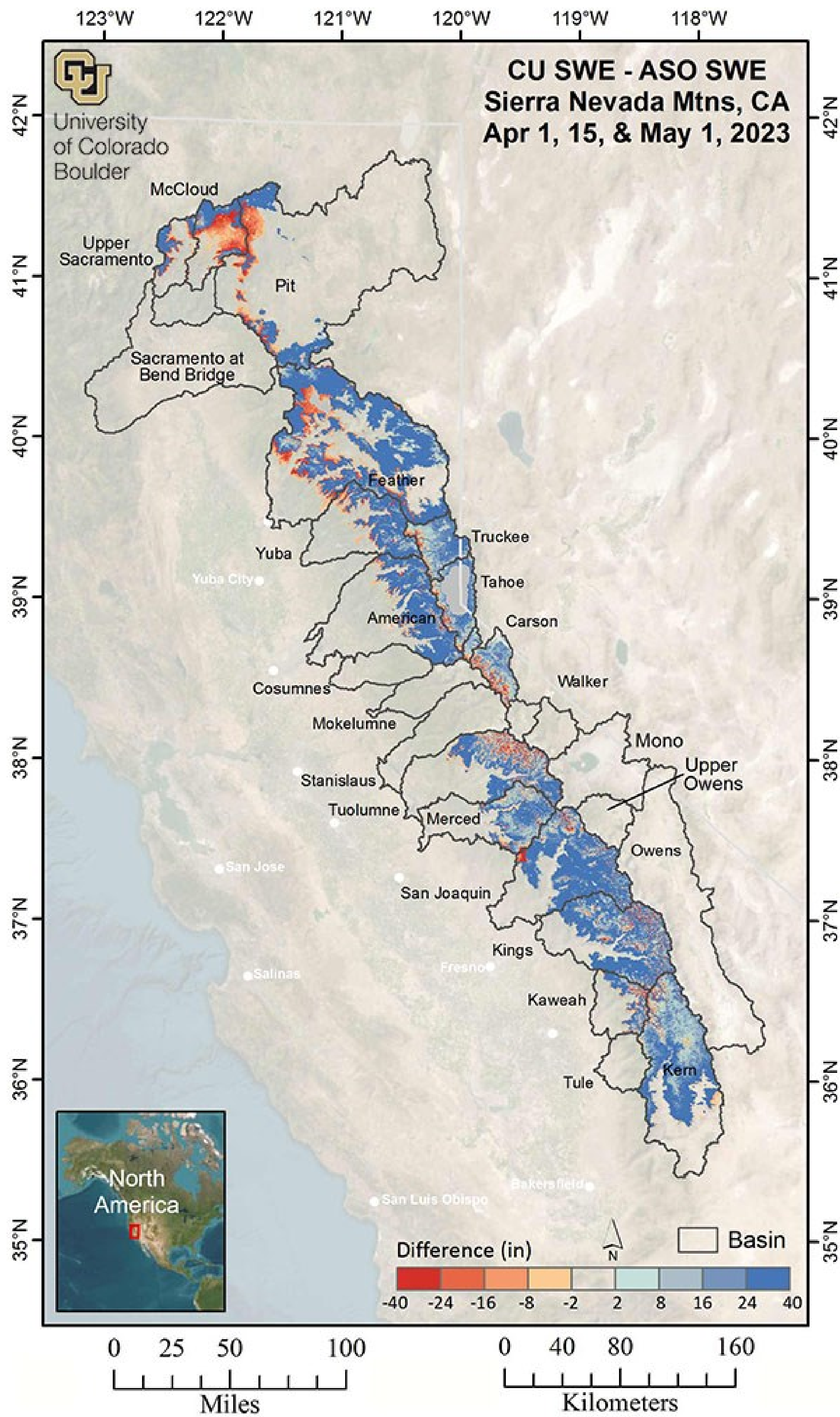

Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the April 1, 15 and May 1, 2023 CU SWE model run and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins. Red colors show where CU SWE is lower than ASO SWE and blue colors show where CU SWE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

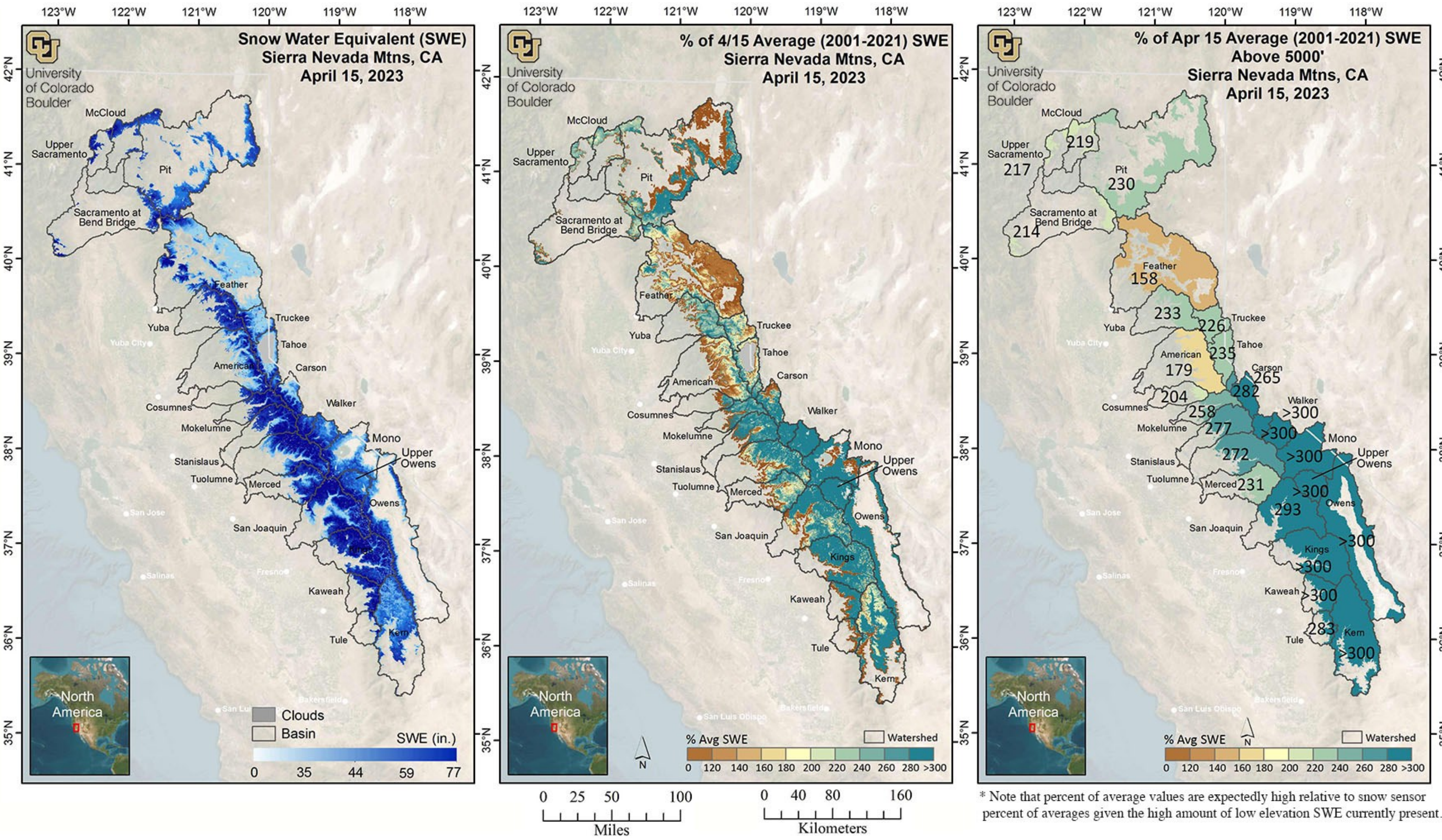

Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for April 15, 2023 (left), and percent of average (2001-2021) SWE for April 15, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across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

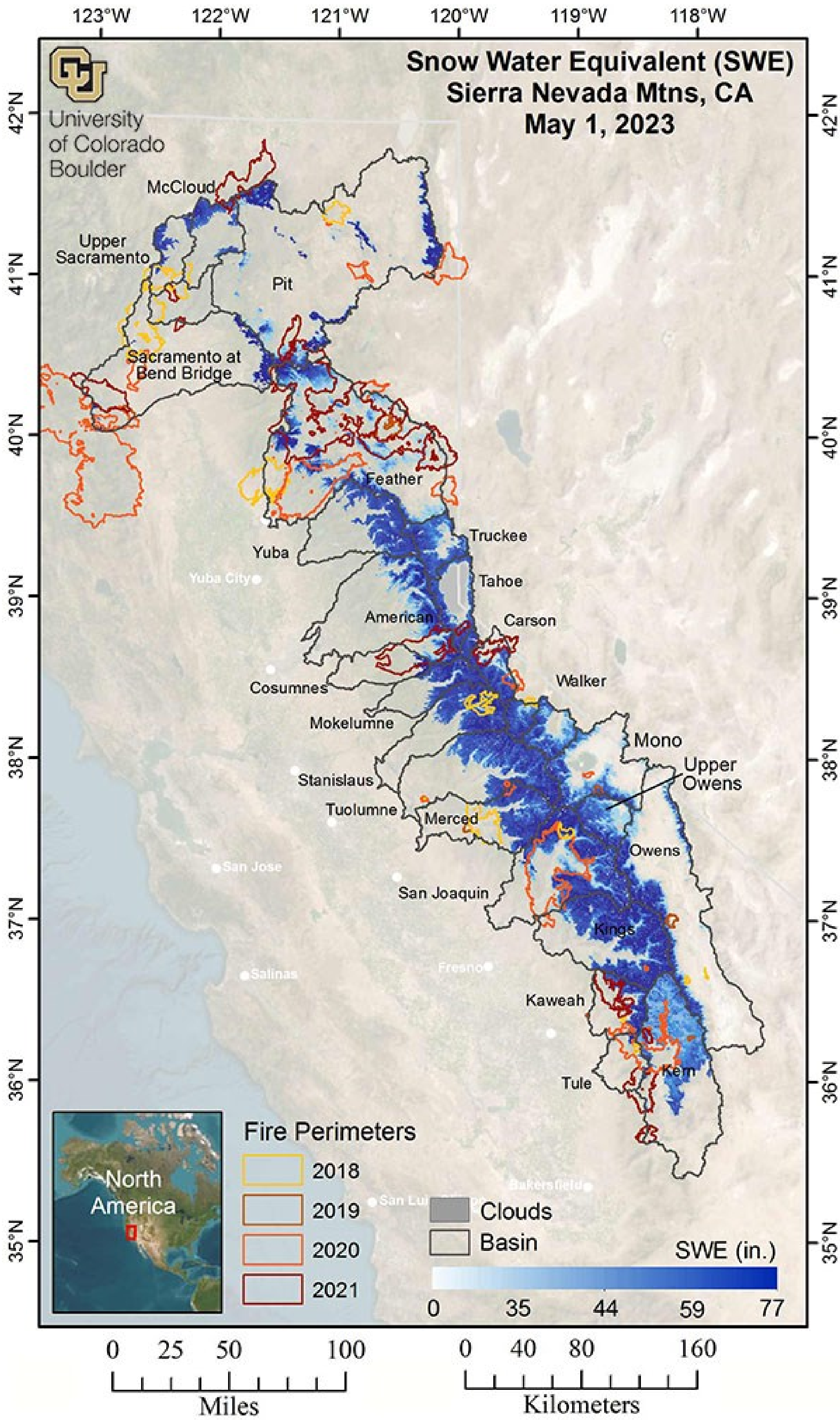

Figure 4. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts for May 1, 2023 are shown with fire perimeters from 2018-2021 (colored from yellow to red).

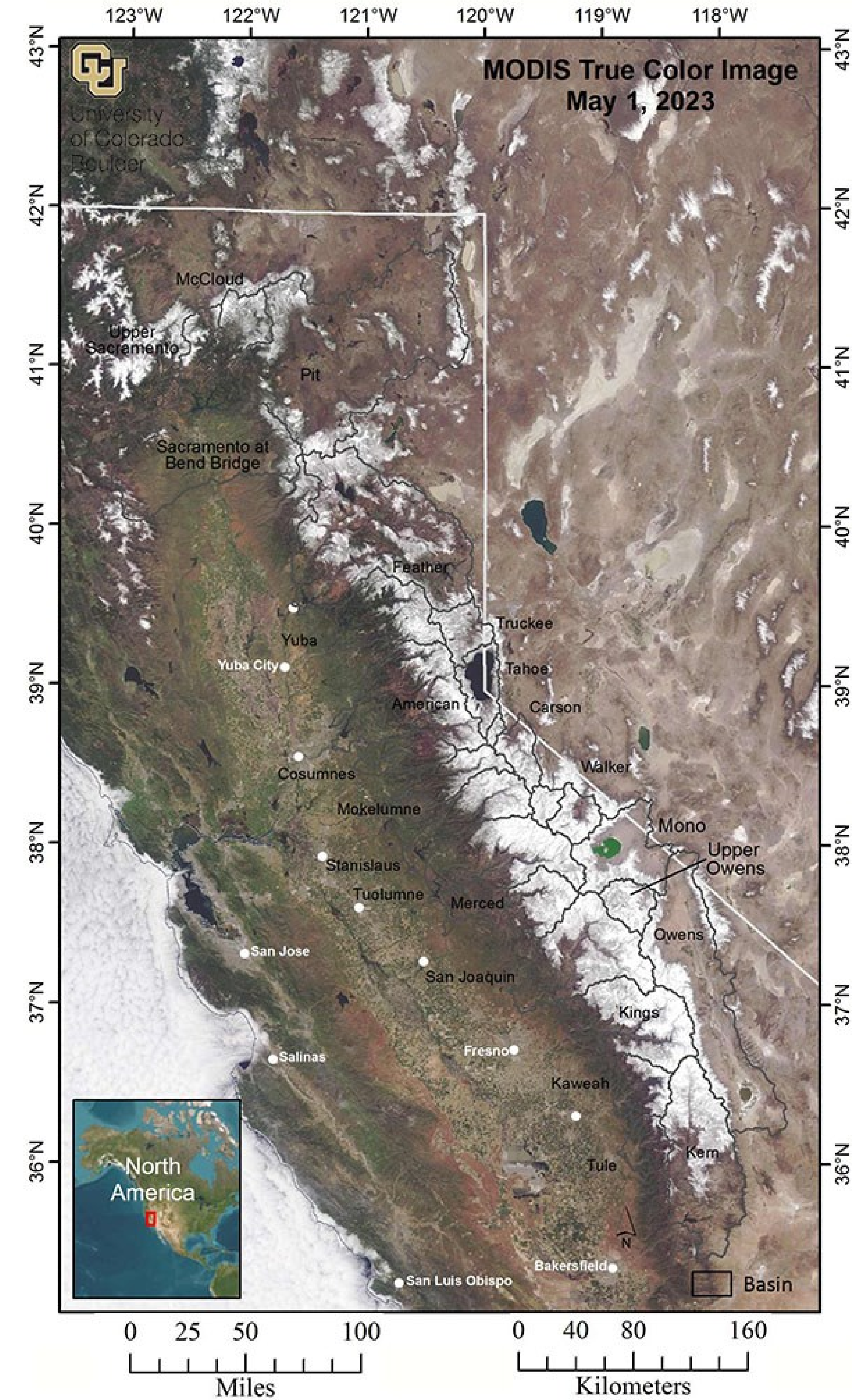

Figure 5. MODIS image, Sierra Nevada. A cloud-free true color MODIS image, showing the image that used for the May 1, 2023 regression model run.

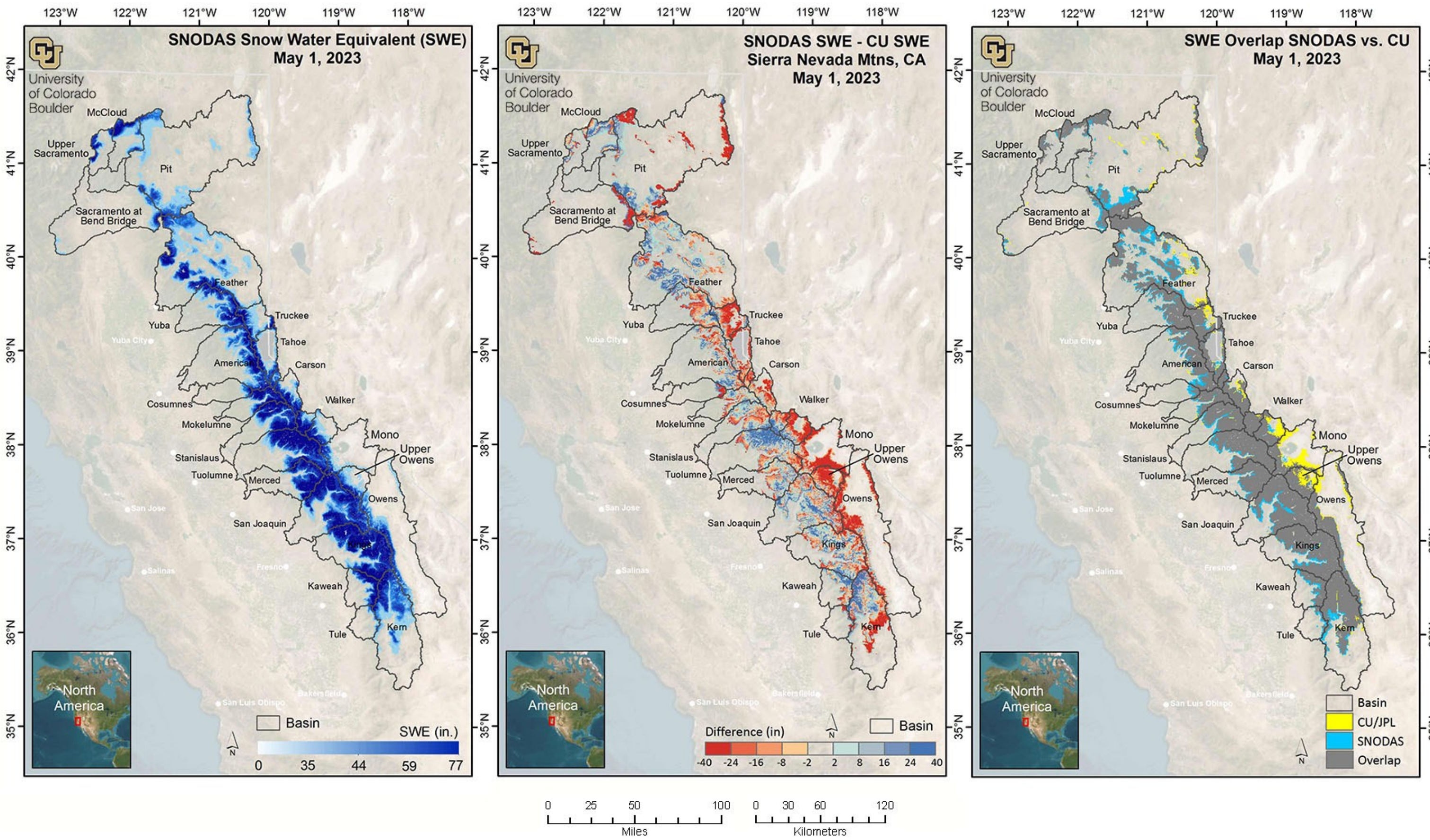

Figure 6. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE for May 1st from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows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

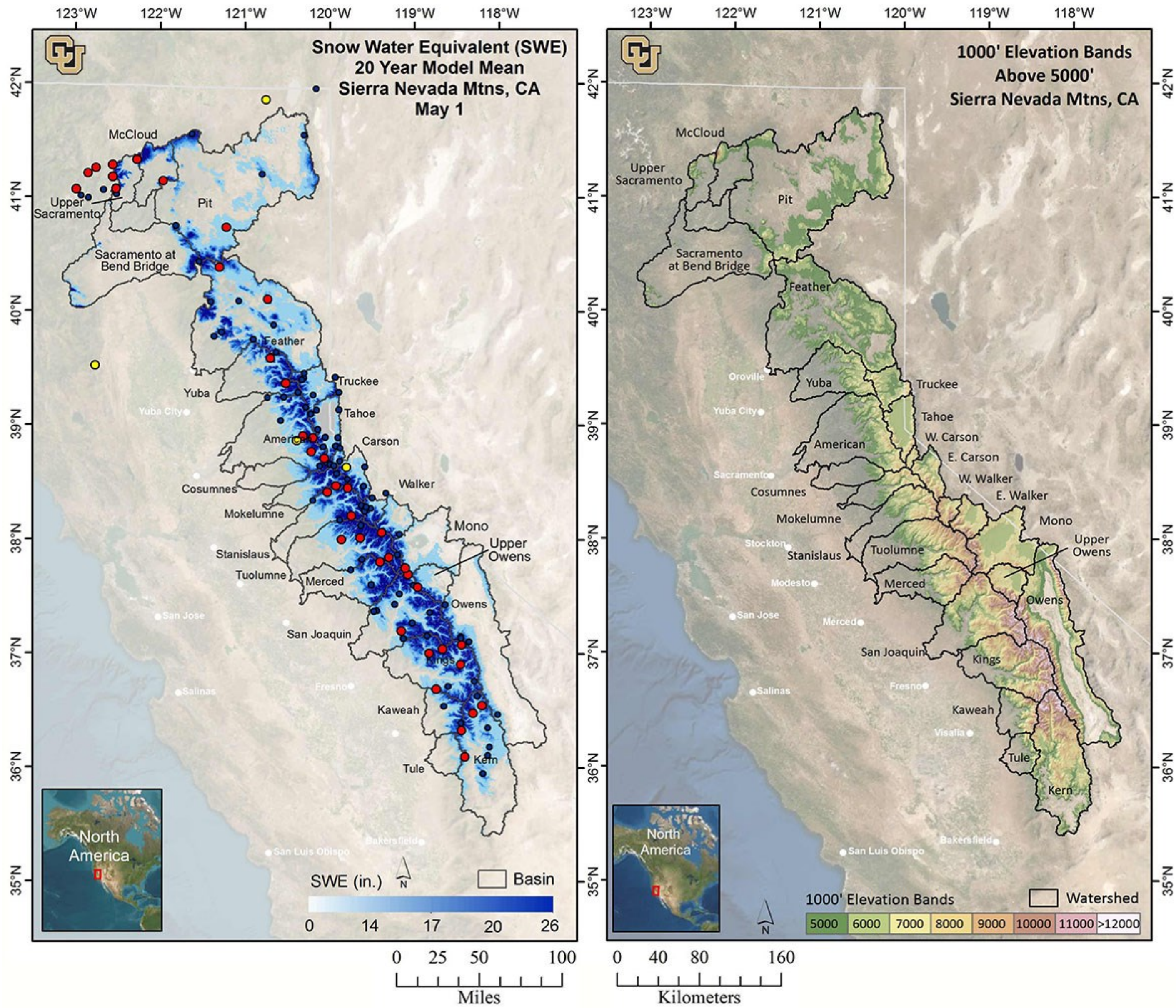

Figure 7. Historical average May 1st and Elevation Bands for the Sierra Nevada. Average SWE (2001-2021) for May 1st (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and Table 2. Map on left shows snow pillow sensor sites recording SWE on May 1st (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 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* May 1, 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.
- 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.
- MISSING SWE VALUES - Data omitted due to inconsistencies with independent SWE estimates.

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

Basin	4/15/23 % 4/15 Avg.	5/1/23 % 5/1 Avg.	4/15/23 SWE (in)	5/1/23 SWE (in)	5/1/23 % SCA	5/1/23‡ Vol (af)	Area (mi2) > 5000'	5/1/23 Surveys	4/15/23 Pillows	5/1/23 Pillows	5/1/23 SNODAS* (in)
Upper Sacramento§	217	257	56.5	53.0	92.9	358,389	126.7	51.5 (2)	83.2 (1)	71.7 (1)	60.1
McCloud§	219	262	54.5	53.1	94.8	500,474	176.9	50.0 (2)	NA	NA	65.0
Pit§	230	>300†	26.4	17.7	32.8	2,156,229	2283.3	12.5 (3)	40.2 (4)	29.4 (4)	15.9
Sac at Bend Bridge	214	>300†	47.8	47.2	58.8	644,246	255.9	10.5 (1)	NA	NA	34.3
Feather§	158	228	24.2	20.5	51.7	2,478,379	2,262.3	40.6 (23)	67.5 (5)	52.6 (5)	32.6
Yuba§	233	292	52.7	49.6	87.4	1,468,100	555.2	64.6 (13)	82.8 (3)	59.6 (2)	58.8
American§	179	253	37.5	37.2	74.6	1,686,307	850.7	39.0 (15)	51.9 (9)	38.9 (9)	49.6
Cosumnes	204	>300†	38.0	34.0	42.4	171,037	94.4	NA	NA	NA	38.2
Mokelumne	258	>300†	55.6	49.3	79.9	882,592	335.9	62.4 (9)	73.2 (1)	65.4 (1)	56.5
Stanislaus	277	>300†	58.3	50.9	83.6	1,606,430	591.3	62.2 (14)	73.7 (3)	63.7 (3)	57.9
Tuolumne§	272	>300†	55.5	47.9	81.5	2,453,472	960.9	64.7 (15)	72.2 (5)	66.0 (3)	61.0
Merced§	231	>300†	47.1	48.4	82.2	1,459,067	565.6	64.2 (5)	69.6 (2)	62.6 (2)	59.0
San Joaquin§	293	>300†	55.5	49.0	81.1	3,324,464	1,272.7	58.6 (8)	69.2 (8)	58.7 (8)	57.5
Kings§	>300†	>300†	61.1	55.5	85.2	3,726,549	1,258.9	68.9 (22)	77.9 (3)	62.0 (3)	62.1
Kaweah§	>300†	>300†	51.6	41.0	66.5	707,935	323.8	55.8 (5)	56.3 (2)	47.2 (2)	54.4
Tule	283	>300†	29.2	18.9	27.9	143,526	142.7	22.5 (2)	NA	NA	22.7
Kern§	>300†	>300†	27.7	22.0	50.9	2,047,420	1,745.7	46.5 (13)	56.0 (7)	41.0 (5)	28.5
Truckee	226	>300†	36.9	43.3	83.7	1,039,261	449.8	70.8 (2)	42.1 (5)	32.7 (5)	38.9
Tahoe	235	>300†	42.1	45.7	80.9	816,196	334.8	NA	54.7 (6)	42.5 (7)	44.5
W Carson	265	>300†	53.5	60.5	95.1	225,961	70.0	67.0 (1)	65.3 (2)	61.4 (2)	52.5
E Carson	282	>300†	41.2	40.0	69.0	813,358	381.4	NA	50.2 (5)	44.3 (5)	37.7
W Walker	>300†	>300†	63.2	54.6	92.1	557,036	191.4	53.5 (1)	67.2 (3)	65.0 (3)	61.3
E Walker	>300†	>300†	49.4	37.7	72.7	756,152	375.6	NA	54.8 (1)	47.3 (1)	31.5
Mono	>300†	>300†	27.7	18.6	40.7	1,060,353	1,066.9	NA	NA	NA	11.8
Upper Owens	>300†	>300†	51.5	42.0	84.0	890,238	397.4	70.0 (3)	NA	NA	31.8
Owens	>300†	>300†	20.9	18.7	30.5	1,856,673	1,862.1	38.0 (7)	49.7 (5)	44.4 (5)	12.5

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

Basin	Elevation Band	4/15/23 % 4/15 Avg.	5/1/23 % 5/1 Avg.	4/15/23 SWE (in)	5/1/23 SWE (in)	5/1/23 % SCA	5/1/23‡ Vol (af)	5/1/23 Area (mi2)	5/1/23 Surveys	4/15/23 Pillows	5/1/23 Pillows	5/1/23 SNODAS* (in)
Upper Sacramento§	5000-6000'	226	287	51.8	47.9	88.6	185,479	72.5	NA	83.2 (1)	71.7 (1)	43.0
	6000-7000'	219	261	61.2	59.8	98.9	123,135	38.6	37.0 (1)	NA	NA	61.2
	7000-8000'	195	219	60.8	59.2	100.0	28,405	9.0	66.0 (1)	NA	NA	58.7
	8000-9000'	181	168	65.7	56.2	100.0	7,311	2.4	NA	NA	NA	62.1
	9000-10,000'	201	140	83.4	56.6	96.0	5,054	1.7	NA	NA	NA	61.8
	10,000-11,000'	185	151	86.4	72.7	99.0	4,868	1.3	NA	NA	NA	54.7
	> 11,000'	118	140	52.9	65.4	79.6	4,137	1.2	NA	NA	NA	45.7
McCloud§	5000-6000'	226	>300†	47.9	46.7	92.1	263,875	105.9	47.0 (1)	NA	NA	48.5
	6000-7000'	218	267	56.4	57.0	98.9	132,190	43.5	53.0 (1)	NA	NA	69.9
	7000-8000'	213	229	64.7	63.6	100.0	47,299	13.9	NA	NA	NA	70.8
	8000-9000'	235	218	79.8	72.1	99.1	22,789	5.9	NA	NA	NA	73.9
	>9,000'	265	204	98.0	77.9	97.5	13,043	3.1	NA	NA	NA	71.0
Pit§	5000-6000'	224	236	18.3	6.5	14.3	540,898	1,567.3	NA	64.9 (1)	51.7 (1)	5.8
	6000-7000'	244	>300†	41.7	34.2	66.2	1,011,272	554.9	9.8 (2)	34.4 (2)	24.8 (2)	16.5
	7000-8000'	232	>300†	51.2	-	97.9	-	138.4	18.0 (1)	27.1 (1)	16.4 (1)	32.2
	>8,000'	229	>300†	57.6	-	98.3	-	20.9	NA	NA	NA	32.1
Sac at Bend Bridge	5000-6000'	213	286	40.8	30.2	44.6	272,589	169.0	10.5 (1)	NA	NA	17.7
	6000-7000'	219	>300†	57.8	-	82.7	-	65.3	NA	NA	NA	35.6
	>7,000'	210	>300†	69.2	-	98.5	-	16.5	NA	NA	NA	54.8
Feather§	5000-6000'	136	199	17.9	13.1	38.0	944,508	1,348.2	30.4 (11)	76.8 (1)	66.7 (1)	19.2
	6000-7000'	174	247	31.3	28.7	68.6	1,202,214	785.1	52.3 (9)	70.9 (3)	53.1 (3)	25.8
	7000-8000'	204	259	47.0	47.6	90.4	315,822	124.5	43.2 (3)	48.1 (1)	37.0 (1)	39.0
	8000-9000'	211	275	58.5	66.5	95.6	15,836	4.5	NA	NA	NA	43.6
Yuba§	5000-6000'	205	275	38.1	32.3	68.5	351,159	203.8	41.0 (3)	NA	NA	29.8
	6000-7000'	248	>300†	57.8	56.6	97.6	691,899	229.4	65.6 (6)	67.9 (2)	59.6 (2)	51.2
	7000-8000'	243	273	67.2	65.0	99.7	407,624	117.6	80.8 (4)	112.7 (1)	NA	72.6
	8000-9000'	238	247	77.1	73.2	99.0	17,418	4.5	NA	NA	NA	95.3
American§	5000-6000'	100	125	15.8	9.8	42.6	163,056	313.1	18.5 (2)	31.7 (3)	15.5 (3)	13.9
	6000-7000'	173	253	37.0	38.4	88.6	576,328	281.1	36.7 (7)	54.1 (1)	51.0 (1)	38.6
	7000-8000'	229	>300†	58.1	-	98.1	-	176.8	45.4 (5)	58.0 (3)	46.6 (3)	62.3
	8000-9000'	264	>300†	76.7	-	99.3	-	70.6	64.5 (1)	71.8 (2)	56.5 (2)	68.0
	9000-10,000'	283	299	93.2	-	96.0	-	9.1	NA	NA	NA	69.3
Cosumnes	5000-6000'	159	151	26.3	11.0	17.5	36,598	62.5	NA	NA	NA	13.2
	6000-7000'	273	>300†	59.1	74.4	88.7	98,852	24.9	NA	NA	NA	48.1
	7000-8000'	259	>300†	67.6	-	100.0	-	7.0	NA	NA	NA	71.1
Mokelumne	5000-6000'	187	215	26.9	12.9	31.3	60,232	87.8	0.0 (1)	NA	NA	8.4
	6000-7000'	281	>300†	54.5	50.9	92.1	185,344	68.3	37.0 (1)	NA	NA	45.4
	7000-8000'	276	>300†	66.9	63.7	99.2	309,493	91.1	69.2 (5)	NA	NA	69.0
	8000-9000'	264	286	72.3	68.9	99.4	294,353	80.1	89.5 (2)	73.2 (1)	65.4 (1)	71.1
	9000-10,000'	273	259	83.4	72.5	96.3	33,170	8.6	NA	NA	NA	68.9
Stanislaus	5000-6000'	231	237	30.8	11.7	28.3	69,563	111.7	NA	NA	NA	10.0
	6000-7000'	284	>300†	51.6	48.6	91.0	366,392	141.3	36.8 (3)	58.6 (1)	50.2 (1)	46.5
	7000-8000'	281	>300†	62.2	60.0	98.6	487,329	152.2	55.7 (6)	NA	NA	63.5
	8000-9000'	280	>300†	72.0	67.3	99.8	425,567	118.6	95.0 (3)	95.9 (1)	83.0 (1)	69.8
	9000-10,000'	290	273	84.1	72.4	98.3	207,883	53.8	70.8 (2)	66.7 (1)	58.0 (1)	73.4
	10,000-11,000'	285	236	87.6	68.7	93.2	48,552	13.3	NA	NA	NA	73.5
	> 11,000'	298	209	91.8	61.6	83.0	1,145	0.3	NA	NA	NA	73.2

Basin	Elevation Band	4/15/23 % 4/15 Avg.	5/1/23 % 5/1 Avg.	4/15/23 SWE (in)	5/1/23 SWE (in)	5/1/23 % SCA	5/1/23‡ Vol (af)	5/1/23 Area (mi2)	5/1/23 Surveys	4/15/23 Pillows	5/1/23 Pillows	5/1/23 SNODAS* (in)
Tuolumne§	5000-6000'	134	237	13.7	7.8	22.3	74,936	179.6	NA	NA	NA	8.1
	6000-7000'	240	>300†	38.7	40.0	85.1	313,922	147.1	40.8 (6)	NA	NA	40.4
	7000-8000'	284	>300†	58.5	52.3	96.2	437,567	157.0	81.8 (2)	72.9 (1)	62.7 (1)	62.1
	8000-9000'	>300†	>300†	74.5	59.0	98.7	544,689	173.2	78.2 (3)	72.2 (2)	87.0 (1)	72.8
	9000-10,000'	>300†	282	80.0	65.5	98.7	642,620	183.8	82.0 (4)	71.8 (2)	48.4 (1)	78.1
	10,000-11,000'	260	265	72.2	68.4	96.6	333,891	91.5	NA	NA	NA	70.2
	11,000-12,000'	209	259	58.7	68.8	88.1	94,701	25.8	NA	NA	NA	54.1
	> 12,000'	236	246	69.9	71.4	80.3	11,147	2.9	NA	NA	NA	42.0
Merced§	5000-6000'	89	69	8.0	1.9	7.4	7,802	75.2	NA	NA	NA	2.3
	6000-7000'	192	>300†	29.6	31.1	71.4	137,044	82.6	41.0 (1)	NA	NA	27.0
	7000-8000'	241	>300†	48.0	54.5	96.4	412,569	141.9	36.0 (1)	54.4 (1)	46.1 (1)	53.8
	8000-9000'	252	>300†	59.3	60.4	99.3	401,865	124.7	81.3 (3)	84.9 (1)	79.1 (1)	68.8
	9000-10,000'	252	290	64.2	64.2	99.6	300,673	87.9	NA	NA	NA	70.9
	10,000-11,000'	243	263	70.3	70.3	98.0	149,476	39.9	NA	NA	NA	72.4
	11,000-12,000'	215	223	68.0	67.7	94.1	42,585	11.8	NA	NA	NA	67.7
	> 12,000'	245	235	85.6	82.4	92.5	7,053	1.6	NA	NA	NA	60.0
San Joaquin§	5000-6000'	95	40	7.1	0.9	10.8	6,712	143.5	NA	NA	NA	5.2
	6000-7000'	243	298	30.5	17.2	60.3	171,122	187.0	28.5 (1)	64.0 (2)	49.7 (2)	30.5
	7000-8000'	295	>300†	49.2	41.1	91.1	487,121	222.3	55.5 (2)	71.5 (4)	60.2 (4)	50.0
	8000-9000'	>300†	>300†	69.3	61.7	99.1	668,255	203.1	NA	NA	NA	63.3
	9000-10,000'	>300†	>300†	77.0	70.4	99.5	778,649	207.5	69.8 (2)	77.6 (1)	72.6 (1)	67.5
	10,000-11,000'	>300†	>300†	77.4	74.5	98.1	643,817	162.0	63.2 (3)	61.8 (1)	56.6 (1)	69.2
	11,000-12,000'	274	>300†	72.3	74.7	93.5	473,993	119.0	NA	NA	NA	57.1
	12,000-13,000	219	235	60.8	62.7	84.1	90,258	27.0	NA	NA	NA	41.2
	> 13,000	223	229	59.9	58.1	79.0	4,537	1.5	NA	NA	NA	27.1
Kings§	5000-6000'	255	168	15.1	2.5	10.6	13,174	100.4	NA	NA	NA	3.0
	6000-7000'	>300†	>300†	42.5	22.2	60.5	161,865	136.5	51.0 (1)	NA	NA	21.4
	7000-8000'	>300†	>300†	55.7	46.4	91.2	438,195	177.2	48.3 (4)	NA	NA	45.7
	8000-9000'	>300†	>300†	64.5	57.9	97.5	682,062	221.0	72.0 (7)	NA	NA	67.2
	9000-10,000'	>300†	>300†	76.8	64.0	98.3	756,823	221.7	78.0 (5)	84.2 (1)	64.5 (2)	74.6
	10,000-11,000'	>300†	>300†	75.0	73.1	97.4	753,211	193.3	74.1 (4)	74.7 (2)	57.0 (1)	74.0
	11,000-12,000'	291	>300†	69.4	82.2	95.1	682,203	155.5	82.0 (1)	NA	NA	67.4
	12,000-13,000	241	>300†	60.5	84.6	90.4	221,862	49.2	NA	NA	NA	54.4
	>13,000'	221	>300†	53.8	78.2	79.1	17,153	4.1	NA	NA	NA	42.4
Kaweah§	5000-6000'	43	1	2.1	0.0	0.1	39	61.0	NA	NA	NA	1.8
	6000-7000'	293	230	33.4	11.3	34.9	36,509	60.3	8.0 (1)	32.6 (1)	17.4 (1)	20.6
	7000-8000'	>300†	>300†	57.7	43.3	89.8	144,235	62.4	NA	NA	NA	45.4
	8000-9000'	>300†	>300†	66.1	59.9	98.6	184,107	57.7	60.7 (3)	NA	NA	62.6
	9000-10,000'	>300†	>300†	84.3	70.1	99.0	161,981	43.3	89.0 (1)	80.0 (1)	77.0 (1)	81.8
	10,000-11,000'	>300†	>300†	88.7	84.8	98.0	137,270	30.3	NA	NA	NA	88.0
	>11,000'	>300†	>300†	87.4	94.2	96.8	43,794	8.7	NA	NA	NA	81.9
Tule	5000-6000'	27	0	1.0	0.0	0.0	4	55.2	NA	NA	NA	0.2
	6000-7000'	224	66	24.5	2.9	10.9	6,384	41.5	21.0 (1)	NA	NA	6.9
	7000-8000'	>300†	>300†	59.4	38.1	63.1	54,341	26.7	24.0 (1)	NA	NA	28.7
	8000-9000'	>300†	>300†	78.0	77.5	94.4	61,080	14.8	NA	NA	NA	45.2
	9000-10,000'	>300†	>300†	78.1	89.8	99.7	21,717	4.5	NA	NA	NA	71.1
Kern§	5000-6000'	101	0	0.6	0.0	0.0	0	257.9	NA	NA	NA	0.0
	6000-7000'	>300†	123	10.7	0.8	3.7	15,678	357.2	NA	NA	NA	2.5
	7000-8000'	>300†	>300†	33.1	15.4	37.0	278,861	339.1	NA	26.0 (1)	8.9 (1)	8.7
	8000-9000'	>300†	>300†	42.0	41.3	91.4	717,739	325.8	41.7 (3)	58.1 (3)	38.5 (2)	25.9
	9000-10,000'	254	>300†	37.0	37.0	99.0	381,364	193.2	40.7 (3)	65.2 (1)	50.1 (1)	45.4
	10,000-11,000'	215	272	37.7	37.7	99.1	267,709	133.1	51.2 (5)	54.4 (1)	NA	54.3
	11,000-12,000'	234	270	49.4	49.5	96.1	250,578	94.9	50.8 (2)	72.1 (1)	69.0 (1)	59.2
	12,000-13,000	245	273	55.7	55.8	88.3	113,786	38.2	NA	NA	NA	48.8
	>13,000'	267	>300†	61.9	64.1	75.9	21,706	6.3	NA	NA	NA	33.6

Basin	Elevation Band	4/15/23 % 4/15 Avg.	5/1/23 % 5/1 Avg.	4/15/23 SWE (in)	5/1/23 SWE (in)	5/1/23 % SCA	5/1/23‡ Vol (af)	5/1/23 Area (mi2)	5/1/23 Surveys	4/15/23 Pillows	5/1/23 Pillows	5/1/23 SNODAS* (in)
Truckee§	5000-6000'	213	>300†	15.0	8.7	32.9	32,191	69.7	NA	NA	NA	2.7
	6000-7000'	215	>300†	30.5	42.3	89.8	499,340	221.3	59.0 (1)	42.1 (5)	32.7 (5)	18.6
	7000-8000'	241	>300†	53.5	59.5	98.7	380,078	119.7	82.5 (1)	NA	NA	50.0
	8000-9000'	237	270	63.5	62.9	99.9	102,982	30.7	NA	NA	NA	67.8
	9000-10,000'	206	237	55.4	55.4	99.4	23,495	8.0	NA	NA	NA	69.9
	10,000-11,000'	184	205	52.6	52.6	96.5	1,174	0.4	NA	NA	NA	65.4
Tahoe§	6000-7000'	191	>300†	22.5	25.7	58.0	179,248	130.8	NA	41.4 (2)	28.0 (2)	13.8
	7000-8000'	240	>300†	46.2	53.1	95.4	320,354	113.2	NA	63.0 (3)	49.2 (4)	42.7
	8000-9000'	262	>300†	64.3	64.5	98.6	251,146	73.0	NA	56.6 (1)	44.5 (1)	54.1
	9000-10,000'	251	286	68.8	69.2	97.3	62,799	17.0	NA	NA	NA	59.7
	10,000-11,000'	229	255	64.8	64.8	90.7	2,650	0.8	NA	NA	NA	53.5
W. Carson§	5000-6000'	4	0	0.2	0.0	0.0	0	0.2	NA	NA	NA	0.0
	6000-7000'	150	>300†	13.6	8.5	24.8	949	2.1	NA	NA	NA	16.2
	7000-8000'	267	>300†	47.3	57.9	96.9	99,345	32.2	NA	NA	NA	43.2
	8000-9000'	274	>300†	61.7	65.7	98.9	97,763	27.9	67.0 (1)	65.3 (2)	61.4 (2)	47.6
	9000-10,000'	242	297	62.7	68.0	95.6	25,556	7.0	NA	NA	NA	52.5
	10,000-11,000'	252	>300†	64.4	70.1	94.4	2,347	0.6	NA	NA	NA	53.1
E. Carson§	5000-6000'	51	16	1.0	0.0	0.2	34	50.2	NA	NA	NA	0.0
	6000-7000'	204	>300†	15.7	11.7	32.3	48,877	78.0	NA	8.6 (1)	0.0 (1)	4.7
	7000-8000'	299	>300†	42.8	45.9	88.2	256,053	104.6	NA	NA	NA	27.2
	8000-9000'	>300†	>300†	64.5	61.7	98.8	332,766	101.1	NA	60.6 (4)	55.4 (4)	53.1
	9000-10,000'	284	293	73.3	68.7	98.0	133,724	36.5	NA	NA	NA	66.0
	>10,000'	238	268	67.7	71.3	93.8	41,904	11.0	NA	NA	NA	62.3
W. Walker	6000-7000'	>300†	>300†	35.4	15.0	48.7	6,265	7.8	NA	NA	NA	6.1
	7000-8000'	>300†	>300†	48.1	39.0	88.0	84,643	40.7	NA	34.6 (1)	22.3 (1)	18.9
	8000-9000'	>300†	>300†	56.5	54.9	97.9	140,952	48.1	53.5 (1)	56.1 (1)	55.6 (1)	53.0
	9000-10,000'	>300†	>300†	72.8	64.0	96.4	222,460	65.2	NA	110.9 (1)	117.1 (1)	77.0
	10,000-11,000'	292	247	81.4	65.5	91.2	95,243	27.3	NA	NA	NA	75.7
	> 11,000'	287	245	78.0	62.8	84.0	7,474	2.2	NA	NA	NA	65.0
E. Walker	6000-7000'	>300†	>300†	33.5	3.5	11.7	10,864	58.8	NA	NA	NA	1.7
	7000-8000'	>300†	>300†	43.7	28.6	71.8	183,178	120.0	NA	NA	NA	6.3
	8000-9000'	>300†	>300†	46.1	47.3	93.1	242,825	96.2	NA	NA	NA	23.4
	9000-10,000'	>300†	>300†	62.2	58.9	94.7	179,708	57.2	NA	54.8 (1)	47.3 (1)	53.8
	10,000-11,000'	>300†	274	77.0	61.2	88.3	113,048	34.7	NA	NA	NA	63.5
	>11,000'	>300†	239	77.2	56.2	76.9	26,529	8.9	NA	NA	NA	56.1
Mono	6000-7000'	>300†	>300†	7.3	0.4	2.0	7,316	320.1	NA	NA	NA	0.1
	7000-8000'	>300†	>300†	24.9	10.5	32.9	234,310	417.1	NA	NA	NA	1.0
	8000-9000'	>300†	>300†	38.5	35.7	86.1	353,779	185.6	NA	NA	NA	5.9
	9000-10,000'	>300†	>300†	57.1	57.9	96.5	200,367	64.9	NA	NA	NA	31.7
	10,000-11,000'	>300†	>300†	74.2	63.0	92.6	162,829	48.5	NA	NA	NA	55.9
	11,000-12,000'	>300†	260	79.6	62.1	82.5	87,241	26.4	NA	NA	NA	50.3
	> 12,000'	289	245	76.5	61.9	74.4	14,511	4.4	NA	NA	NA	39.6
Upper Owens	6000-7000'	>300†	>300†	39.1	16.6	64.9	58,266	66.0	NA	NA	NA	3.6
	7000-8000'	>300†	>300†	44.2	33.1	82.9	269,250	152.5	NA	NA	NA	6.4
	8000-9000'	>300†	>300†	52.4	49.9	93.8	213,458	80.3	59.5 (2)	NA	NA	25.4
	9000-10,000'	>300†	>300†	65.6	59.6	93.9	140,027	44.1	91.0 (1)	NA	NA	42.6
	10,000-11,000'	>300†	>300†	73.1	68.8	91.6	126,940	34.6	NA	NA	NA	55.9
	11,000-12,000'	>300†	>300†	77.7	77.2	85.8	66,655	16.2	NA	NA	NA	50.3
	> 12,000'	>300†	>300†	72.7	76.5	76.5	15,642	3.8	NA	NA	NA	35.7
Owens	5000-6000'	0	0	0.0	0.0	0.0	0	446.7	NA	NA	NA	0.0
	6000-7000'	>300†	>300†	1.0	0.2	0.7	3,058	358.2	NA	NA	NA	0.0
	7000-8000'	>300†	>300†	12.6	4.8	17.2	84,349	332.6	NA	NA	NA	1.2
	8000-9000'	>300†	>300†	24.9	13.0	35.7	130,734	188.9	24.0 (1)	NA	NA	8.6
	9000-10,000'	>300†	>300†	44.2	35.5	72.0	291,092	153.6	38.7 (3)	49.4 (3)	43.8 (3)	21.6
	10,000-11,000'	>300†	>300†	54.3	57.4	89.5	513,989	167.9	35.0 (2)	50.1 (2)	45.3 (2)	33.6
	11,000-12,000'	>300†	>300†	63.4	71.6	85.3	517,154	135.4	56.0 (1)	NA	NA	37.0
	12,000-13,000	>300†	>300†	66.3	76.0	78.5	275,008	67.9	NA	NA	NA	29.9
	>13,000'	288	>300†	61.6	70.7	70.4	41,289	10.9	NA	NA	NA	21.4

- 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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