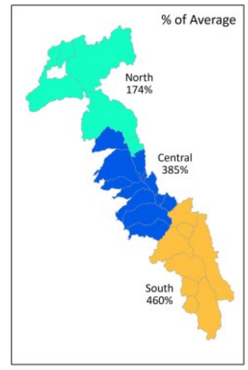
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California

May 23, 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 23, percent of average SWE is highest in the south (460%), then central (385%) and lowest in the north (174%). 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**.

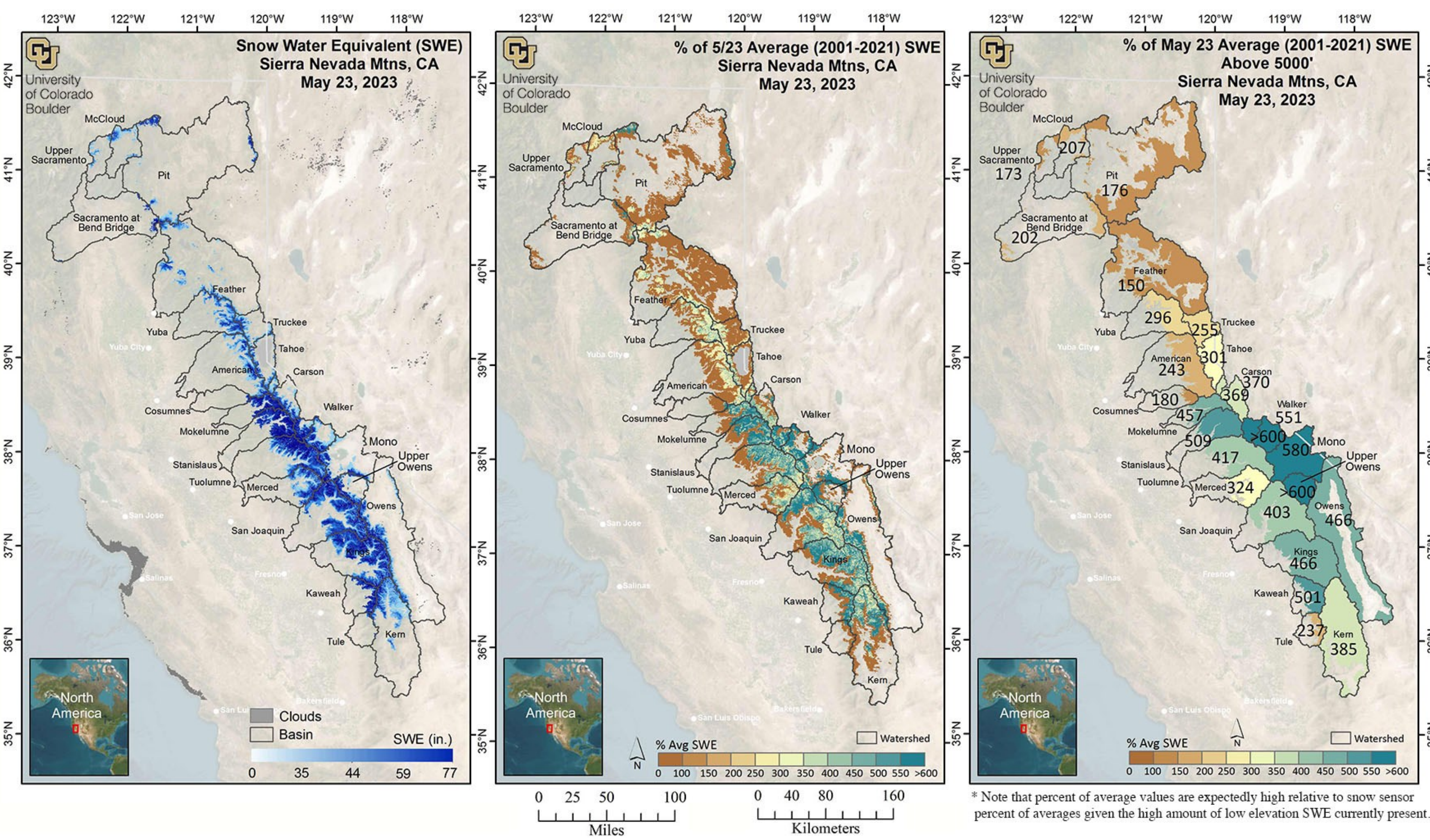

Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for May 23, 2023 (left), and percent of average (2001-2021) SWE for May 23, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all 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 17 were recording zero (shown in black, red and yellow, respectively, in Figure 5, left map). We used 11 CoCoRaHS observations.

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.

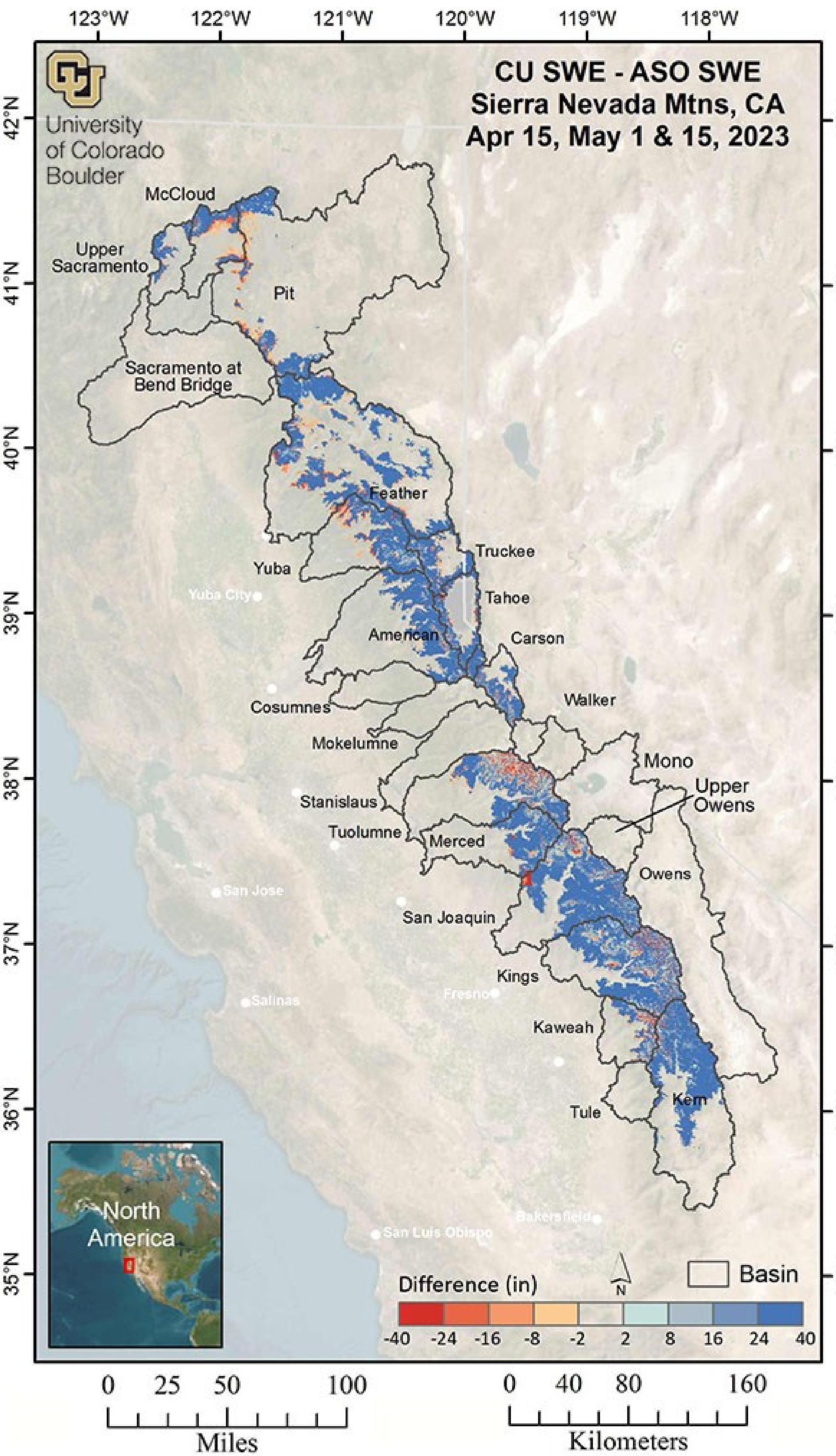

Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the April 15 and May 1 and 15, 2023 CU SWE model run and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins. Red colors show where CU SWE is lower than ASO SWE and blue colors show where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

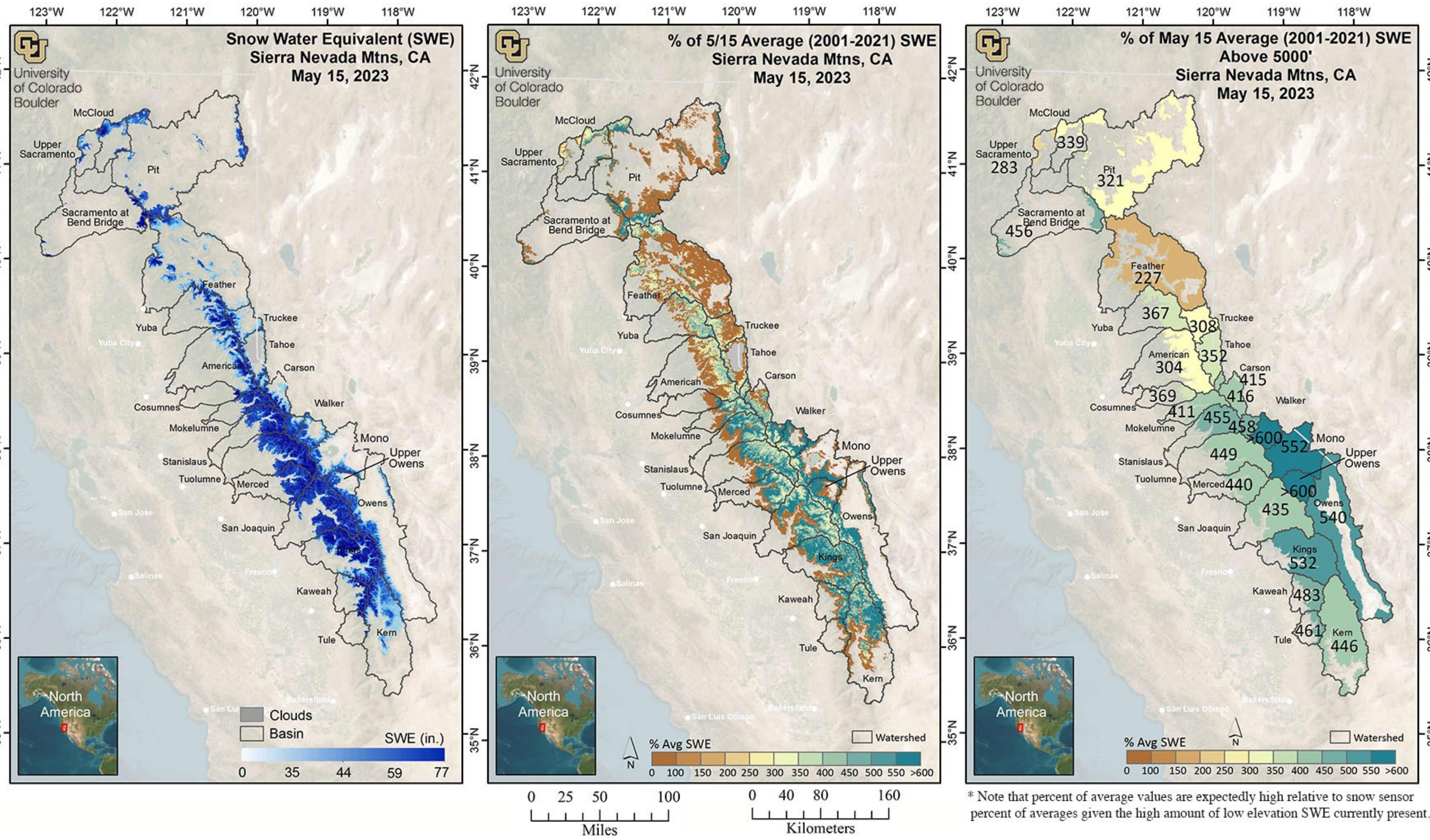

Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for May 15, 2023 (left), and percent of average (2001-2021) SWE for May 15, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all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

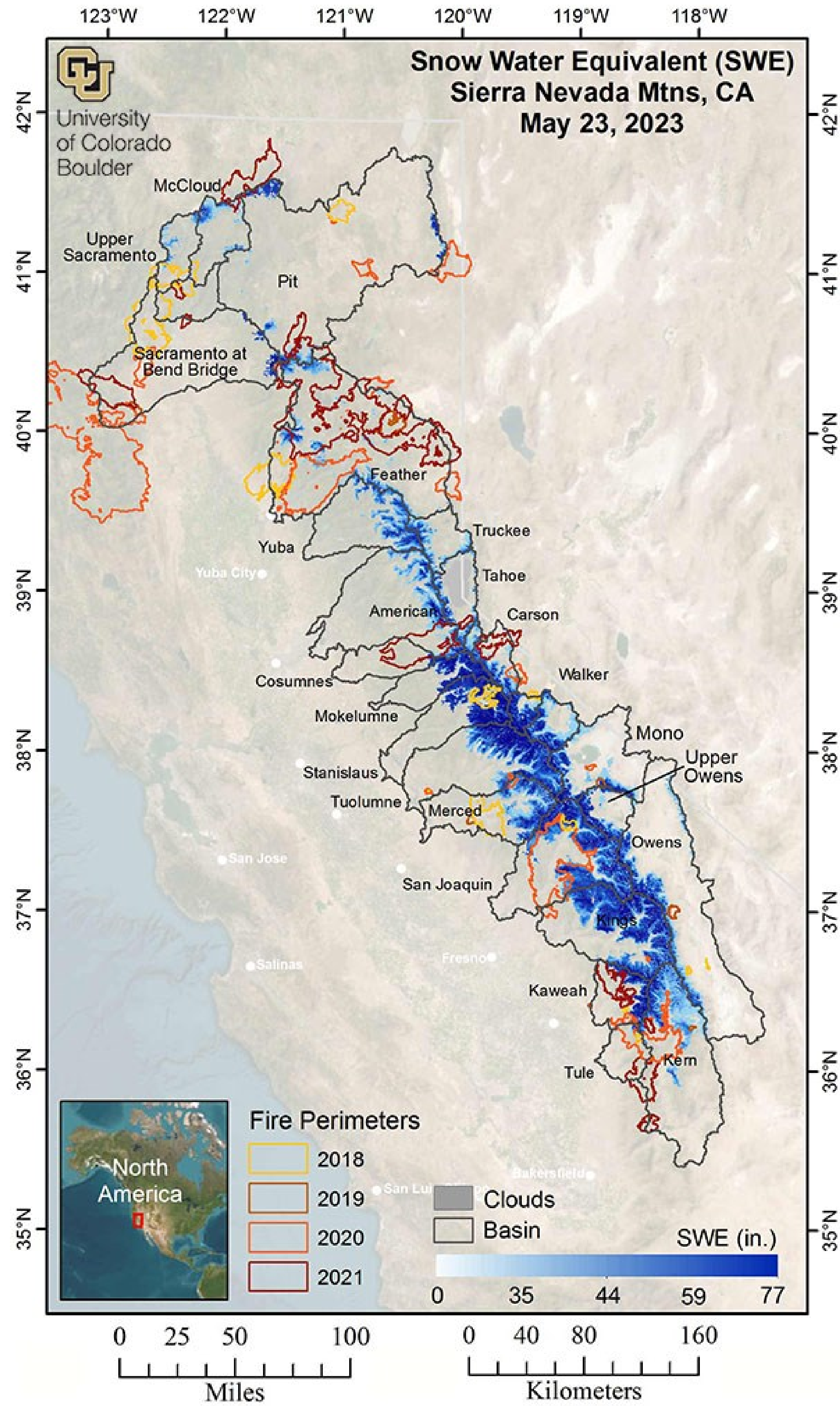

Figure 4. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts for May 23, 2023 are shown with fire perimeters from 2018-2021 (colored from yellow to red).

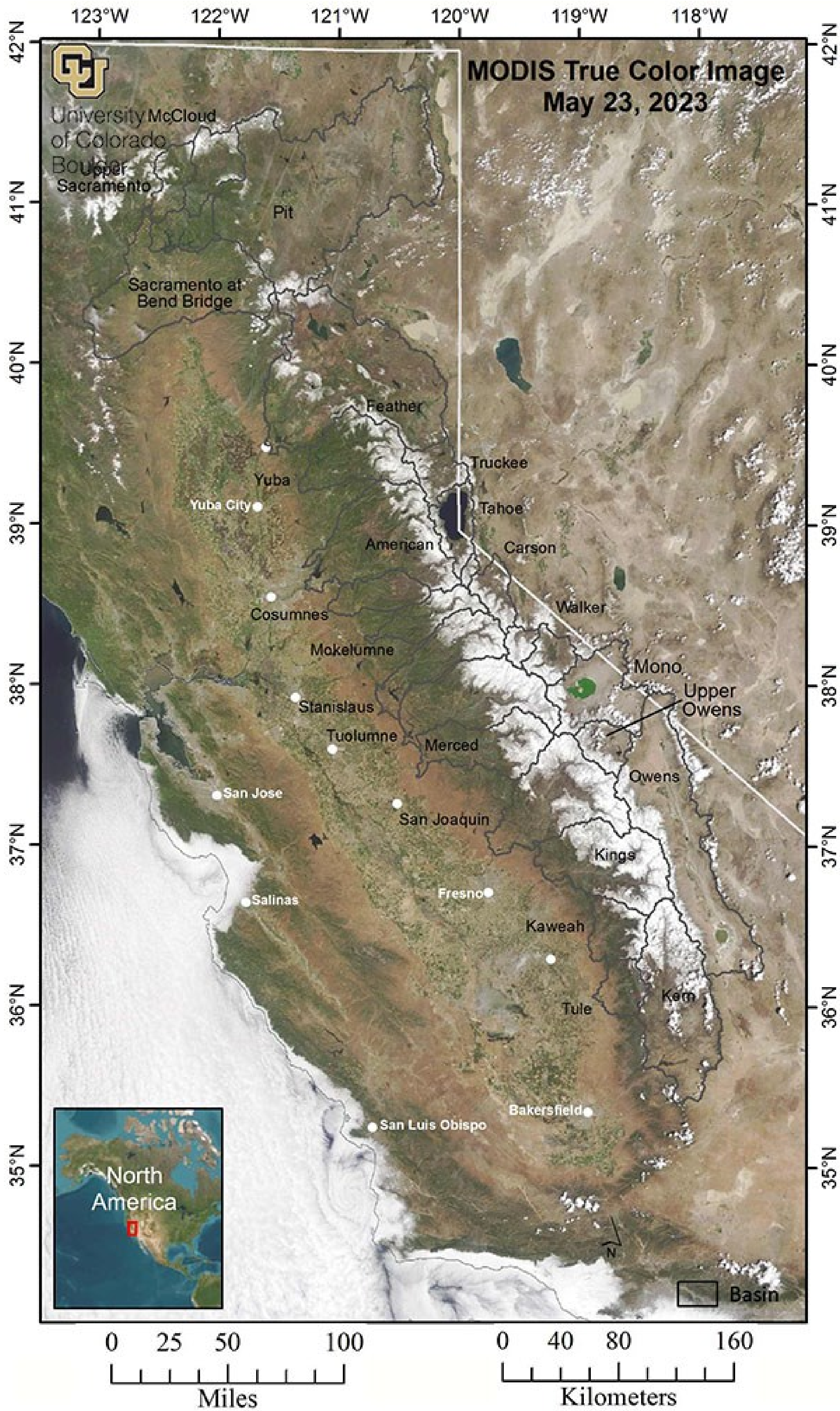

Figure 5. MODIS image, Sierra Nevada. A mostly cloud-free true color MODIS image, showing the image that used for the May 23, 2023 regression model run.

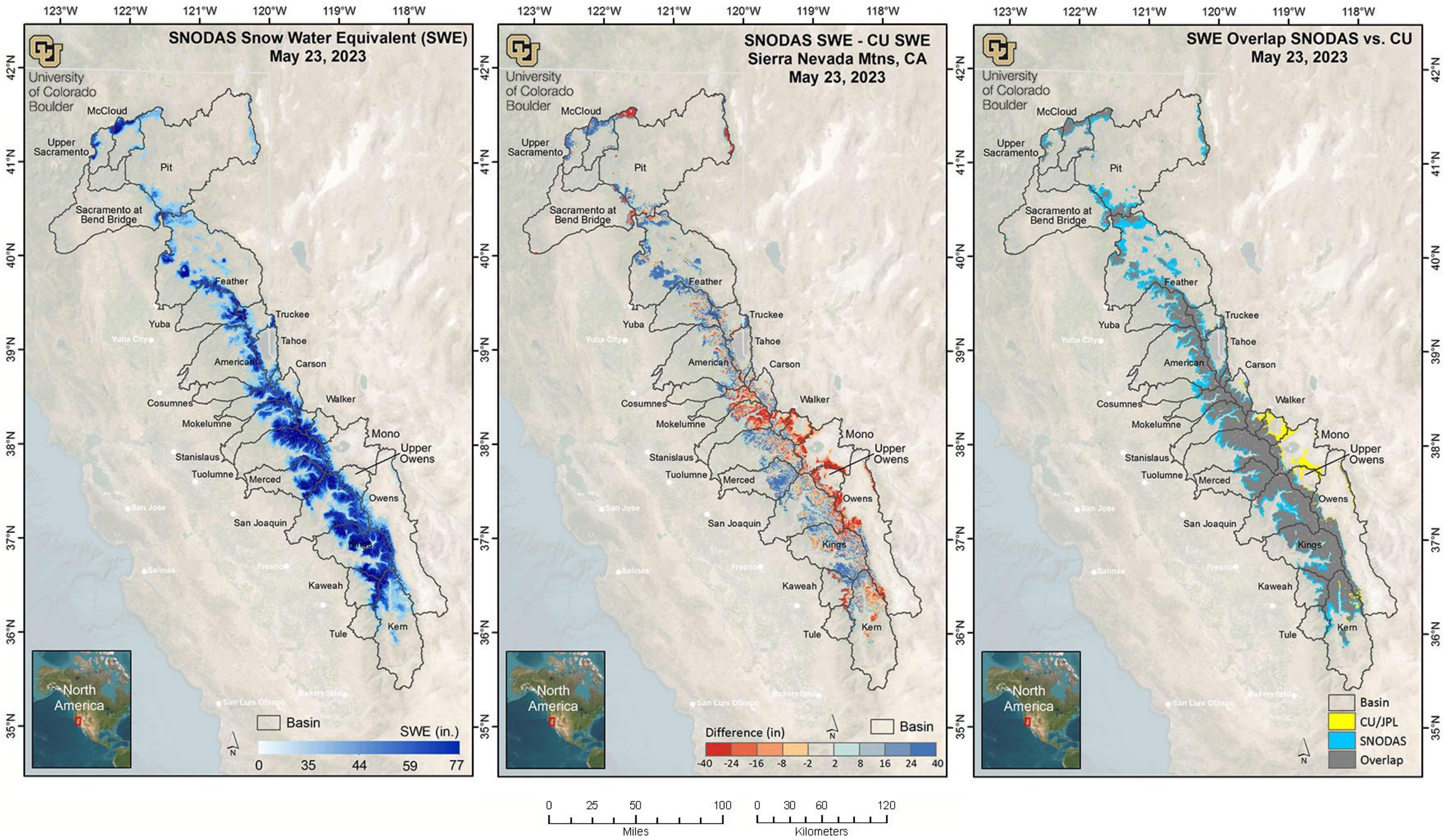

Figure 6. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE for May 23rd from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows the difference between the May 23rd 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.

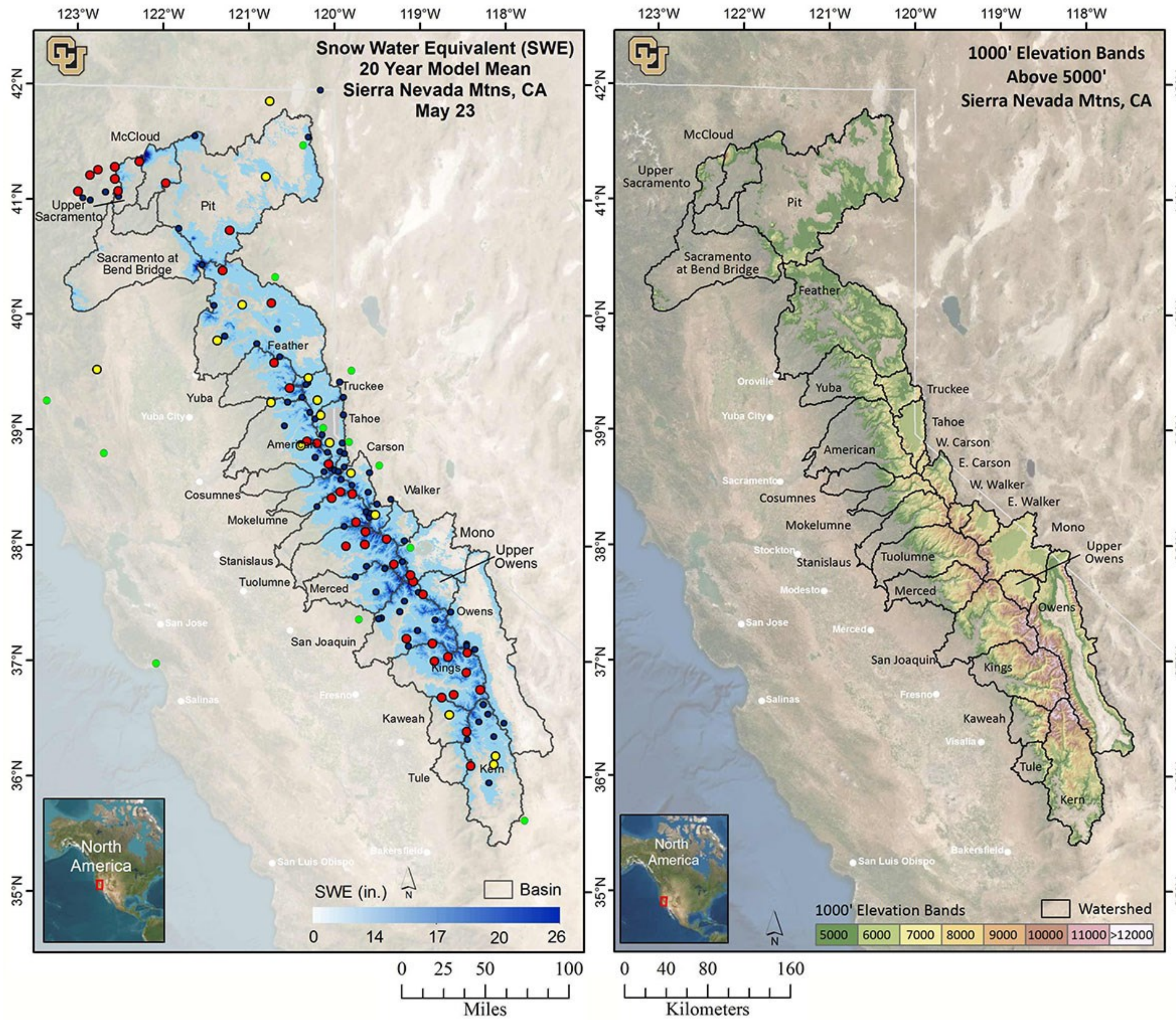

Figure 7. Historical average May 23rd and Elevation Bands for the Sierra Nevada. Average SWE (2001-2021) for May 23rd (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and Table 2. Map on left shows snow pillow sensor sites recording SWE on May 23rd (black), sites that were offline are shown in red, and sites recording zero are shown in yellow. CoCoRaHS observations are shown in green. 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 23, 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.
- 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.

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 15th percent of May 15th average SWE, May 23rd percent of May 23rd average SWE (between 2001-2021 as derived from the regression model), May 15th mean SWE, May 23rd mean SWE, May 23rd percent of snow-covered area, May 23rd 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 15th snow pillow data, and May 23rd snow pillow data for those areas collected, summarized for each basin. The last column shows May 23rd mean SWE from SNODAS*.*

Basin	5/15/23 % 5/15 Avg.	5/23/23 % 5/23 Avg.	5/15/23 SWE (in)	5/23/23 SWE (in)	5/23/23 % SCA	5/23/23‡ Vol (af)	Area (mi2) > 5000'	5/15/23 Pillows	5/23/23 Pillows	5/23/23 SNODAS* (in)
Upper Sacramento§	283	173	36.6	17.3	65.1	117,779	127.8	49.1 (1)	16.0 (1)	35.4
McCloud§	339	207	44.6	21.6	74.5	204,874	178.0	NA	NA	42.6
Pit§	321	176	10.3	4.2	10.8	516,198	2286.8	24.1 (4)	14.0 (4)	4.5
Sac at Bend Bridge	456	202	40.3	13.1	22.8	170,849	243.8	NA	NA	12.4
Feather§	227	150	11.8	5.8	16.9	698,794	2,267.8	44.3 (5)	29.3 (5)	12.6
Yuba§	367	296	38.0	24.3	64.7	719,074	554.0	55.2 (2)	42.8 (2)	33.6
American§	304	243	26.5	16.9	48.4	762,015	847.8	33.7 (9)	23.7 (10)	22.1
Cosumnes	369	180	21.1	7.9	14.1	39,907	94.3	NA	NA	16.0
Mokelumne	411	457	40.6	37.5	59.8	667,561	334.2	61.2 (1)	54.7 (1)	33.6
Stanislaus	455	509	43.8	40.9	65.3	1,282,021	588.2	62.5 (3)	57.5 (3)	34.0
Tuolumne§	449	417	45.8	35.8	65.6	1,832,558	960.4	66.5 (3)	43.3 (2)	40.5
Merced§	440	324	43.3	26.3	68.1	792,741	565.4	67.3 (2)	48.0 (3)	39.5
San Joaquin§	435	403	42.7	33.7	64.0	2,283,857	1,272.5	51.2 (8)	37.1 (8)	36.6
Kings§	532	466	50.4	37.8	70.2	2,538,810	1,258.3	84.9 (2)	NA	43.9
Kaweah§	483	501	34.8	30.3	50.5	526,502	325.4	38.3 (2)	0.0 (1)	31.9
Tule	461	237	14.7	5.6	10.2	42,944	142.8	NA	NA	7.1
Kern§	446	385	15.9	10.7	27.8	995,348	1,745.8	35.6 (8)	28.2 (8)	11.0
Truckee	308	255	19.0	12.7	39.7	304,195	447.5	24.7 (5)	16.1 (5)	17.1
Tahoe	352	301	27.8	19.2	49.0	341,861	333.8	37.9 (7)	24.6 (7)	20.8
W Carson	415	370	38.6	27.6	80.5	103,128	70.2	58.1 (2)	48.9 (2)	27.8
E Carson	416	369	26.6	18.8	46.4	382,364	380.9	41.2 (5)	31.7 (5)	20.4
W Walker	458	551	44.4	46.1	75.4	466,260	189.7	59.3 (3)	52.0 (3)	38.6
E Walker	>600†	>600†	26.9	25.6	54.2	506,162	371.2	45.8 (1)	36.4 (1)	14.6
Mono	552	580	12.7	10.7	23.0	606,587	1,059.1	NA	NA	5.0
Upper Owens	>600†	>600†	26.8	20.8	37.0	436,780	393.4	NA	NA	11.5
Owens	540	466	12.0	9.3	17.0	916,341	1,854.5	35.3 (5)	25.6 (5)	6.1

§ 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 15th percent of May 15th average SWE, May 23rd percent of May 23rd average SWE (between 2001-2021 as derived from the regression model), May 15th mean SWE, May 23rd mean SWE, May 23rd percent of snow-covered area, May 23rd 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 15th snow pillow data, and May 23rd snow pillow data for those areas collected, summarized for each 1000' elevation band inside each basin. The last column shows May 23rd mean SWE from SNODAS*.*

Basin	Elevation Band	5/15/23 % 5/15 Avg.	5/23/23 % 5/23 Avg.	5/15/23 SWE (in)	5/23/23 SWE (in)	5/23/23 % SCA	5/23/23‡ Vol (af)	5/23/23 Area (mi2)	5/15/23 Pillows	5/23/23 Pillows	5/23/23 SNODAS* (in)
Upper Sacramento§	5000-6000'	315	160	31.2	11.4	50.4	44,225	72.5	49.1 (1)	16.0 (1)	37.3
	6000-7000'	286	198	41.4	22.3	80.2	45,945	38.6	NA	NA	57.1
	7000-8000'	253	195	45.8	29.2	95.9	14,107	9.1	NA	NA	57.1
	8000-9000'	238	173	55.2	35.0	92.8	5,729	3.1	NA	NA	62.6
	9000-10,000'	202	129	59.8	34.7	90.0	3,876	2.1	NA	NA	63.8
	10,000-11,000'	157	103	56.7	34.5	88.4	2,312	1.3	NA	NA	56.5
	> 11,000'	96	78	33.2	25.1	66.0	1,586	1.2	NA	NA	47.5
McCloud§	5000-6000'	419	216	37.1	13.7	64.0	77,150	105.7	NA	NA	42.7
	6000-7000'	352	249	48.5	27.5	86.4	64,081	43.7	NA	NA	66.7
	7000-8000'	327	223	65.0	38.4	97.2	29,155	14.2	NA	NA	70.6
	8000-9000'	286	205	70.3	45.1	97.4	16,279	6.8	NA	NA	75.0
	>9,000'	229	160	67.4	42.6	86.6	7,125	3.1	NA	NA	72.8
Pit§	5000-6000'	224	72	3.4	0.8	2.5	68,270	1,569.5	46.4 (1)	33.2 (1)	3.7
	6000-7000'	353	180	19.2	7.1	19.7	209,432	555.2	17.9 (2)	11.3 (2)	13.5
	7000-8000'	429	281	-	-	56.3	173,719	139.1	14.3 (1)	0.2 (1)	29.5
	>8,000'	406	420	-	-	88.6	58,964	21.3	NA	NA	31.2
Sac at Bend Bridge	5000-6000'	412	94	23.6	3.5	7.4	30,165	163.7	NA	NA	11.8
	6000-7000'	532	258	-	24.7	45.0	80,119	60.9	NA	NA	28.3
	>7,000'	451	317	-	-	82.2	42,151	14.1	NA	NA	49.5
Feather§	5000-6000'	161	72	6.0	1.9	6.9	137,718	1,354.1	62.4 (1)	48.5 (1)	14.9
	6000-7000'	264	190	17.6	9.7	27.5	404,504	784.5	41.7 (3)	27.0 (3)	21.6
	7000-8000'	319	251	35.5	22.1	56.7	147,291	124.7	34.0 (1)	17.3 (1)	35.5
	8000-9000'	336	285	53.0	39.0	77.8	9,281	4.5	NA	NA	41.2
Yuba§	5000-6000'	211	95	13.5	4.3	19.0	46,184	202.7	NA	NA	24.1
	6000-7000'	407	336	44.5	29.5	87.0	360,379	229.2	55.2 (2)	42.8 (2)	46.8
	7000-8000'	419	358	66.1	47.5	98.5	297,949	117.6	NA	NA	69.3
	8000-9000'	420	352	84.8	61.2	96.8	14,563	4.5	NA	NA	96.3
American§	5000-6000'	85	24	3.4	0.6	4.6	10,774	312.6	9.6 (3)	0.9 (3)	9.8
	6000-7000'	277	207	23.6	13.8	58.3	206,500	280.5	47.5 (1)	40.8 (1)	32.5
	7000-8000'	383	311	50.5	34.3	89.3	320,838	175.2	41.1 (3)	29.5 (4)	55.7
	8000-9000'	411	344	-	-	96.1	194,217	70.4	51.7 (2)	37.5 (2)	62.8
	9000-10,000'	399	323	-	-	91.5	29,687	9.1	NA	NA	64.0
Cosumnes	5000-6000'	69	1	2.7	0.0	0.1	135	62.5	NA	NA	10.6
	6000-7000'	>600†	208	48.8	13.5	26.3	17,873	24.9	NA	NA	43.1
	7000-8000'	>600†	532	-	-	96.1	21,899	6.9	NA	NA	64.7
Mokelumne	5000-6000'	135	16	4.4	0.3	1.2	1,571	87.9	NA	NA	5.4
	6000-7000'	496	390	33.9	21.1	41.5	75,603	67.3	NA	NA	37.1
	7000-8000'	461	557	56.9	57.9	94.3	279,948	90.7	NA	NA	62.1
	8000-9000'	399	475	64.3	65.9	97.7	280,321	79.7	61.2 (1)	54.7 (1)	66.9
	9000-10,000'	371	399	69.7	65.3	90.6	30,118	8.6	NA	NA	65.9
Stanislaus	5000-6000'	164	19	4.5	0.3	0.9	1,878	111.7	NA	NA	4.9
	6000-7000'	577	492	35.3	23.9	47.3	177,901	139.3	42.2 (1)	28.0 (1)	34.3
	7000-8000'	520	>600†	53.0	53.2	90.2	428,685	151.2	NA	NA	54.4
	8000-9000'	437	527	63.6	65.8	98.3	416,121	118.6	84.7 (1)	83.3 (1)	64.0
	9000-10,000'	389	456	70.1	71.8	97.2	206,065	53.8	60.7 (1)	61.2 (1)	68.8
	10,000-11,000'	344	396	69.0	70.9	91.0	50,097	13.3	NA	NA	70.1
	> 11,000'	328	363	67.8	68.5	84.8	1,275	0.3	NA	NA	72.0

Basin	Elevation Band	5/15/23 % 5/15 Avg.	5/23/23 % 5/23 Avg.	5/15/23 SWE (in)	5/23/23 SWE (in)	5/23/23 % SCA	5/23/23‡ Vol (af)	5/23/23 Area (mi2)	5/15/23 Pillows	5/23/23 Pillows	5/23/23 SNODAS* (in)
Tuolumne§	5000-6000'	69	2	1.4	0.0	0.2	226	179.6	NA	NA	3.7
	6000-7000'	>600†	235	30.7	7.7	32.6	60,472	147.2	NA	NA	31.2
	7000-8000'	550	461	49.5	33.7	82.7	282,565	157.3	55.3 (1)	43.0 (1)	56.3
	8000-9000'	466	484	60.4	54.0	95.5	497,258	172.8	96.8 (1)	NA	67.2
	9000-10,000'	430	455	68.2	63.0	97.2	617,570	183.8	47.4 (1)	43.7 (1)	75.2
	10,000-11,000'	394	394	70.0	61.7	92.5	299,878	91.1	NA	NA	69.9
	11,000-12,000'	387	299	71.0	49.4	79.9	67,612	25.7	NA	NA	55.3
	> 12,000'	366	245	74.1	44.7	67.3	6,977	2.9	NA	NA	43.8
Merced§	5000-6000'	49	4	0.9	0.0	0.2	156	75.2	NA	NA	0.8
	6000-7000'	460	139	20.8	4.2	21.9	18,349	82.6	NA	NA	21.1
	7000-8000'	594	309	48.6	19.5	77.1	147,489	141.9	NA	34.0 (1)	48.3
	8000-9000'	460	371	56.6	38.6	95.9	256,219	124.6	67.3 (2)	55.0 (2)	65.1
	9000-10,000'	390	366	59.2	48.2	99.1	225,906	87.9	NA	NA	69.9
	10,000-11,000'	352	314	65.5	51.7	96.9	110,013	39.9	NA	NA	73.5
	11,000-12,000'	320	254	68.7	49.3	87.6	31,015	11.8	NA	NA	69.6
	> 12,000'	293	184	73.7	42.0	81.9	3,595	1.6	NA	NA	61.7
San Joaquin§	5000-6000'	30	0	0.4	0.0	0.0	12	144.4	NA	NA	1.6
	6000-7000'	432	198	15.4	4.8	14.4	47,627	186.8	34.4 (2)	16.5 (2)	22.2
	7000-8000'	594	404	38.9	20.7	53.4	245,550	222.2	56.0 (4)	39.2 (4)	41.7
	8000-9000'	524	485	55.3	43.2	91.0	467,452	203.0	NA	NA	58.0
	9000-10,000'	436	448	59.6	52.9	97.6	584,076	207.1	68.9 (1)	61.2 (1)	63.7
	10,000-11,000'	388	404	62.1	57.1	95.6	492,286	161.7	48.2 (1)	45.8 (1)	64.8
	11,000-12,000'	354	370	61.9	58.1	88.3	368,555	119.0	NA	NA	52.0
	12,000-13,000	312	308	58.5	51.9	75.2	74,711	27.0	NA	NA	36.5
	> 13,000	290	291	51.3	45.9	65.1	3,588	1.5	NA	NA	22.7
Kings§	5000-6000'	21	0	0.2	0.0	0.0	13	101.2	NA	NA	0.5
	6000-7000'	331	167	9.5	3.1	12.2	22,979	136.8	NA	NA	11.2
	7000-8000'	579	499	32.8	20.5	59.6	192,910	176.8	NA	NA	35.3
	8000-9000'	>600†	529	54.9	39.6	85.4	466,359	221.0	NA	NA	60.6
	9000-10,000'	572	511	66.2	50.9	94.6	602,305	221.7	80.9 (1)	NA	70.0
	10,000-11,000'	539	475	73.0	57.0	94.2	584,545	192.2	88.9 (1)	NA	70.8
	11,000-12,000'	492	436	75.9	61.2	88.8	507,299	155.3	NA	NA	67.5
	12,000-13,000	403	383	66.4	57.6	80.2	151,036	49.2	NA	NA	55.8
	>13,000'	368	368	57.1	51.8	64.4	11,364	4.1	NA	NA	43.6
Kaweah§	5000-6000'	0	0	0.0	0.0	0.0	0	61.4	NA	NA	0.3
	6000-7000'	147	78	4.2	1.6	3.9	5,094	60.7	1.8 (1)	0.0 (1)	11.0
	7000-8000'	434	541	26.8	24.2	48.7	80,415	62.2	NA	NA	33.4
	8000-9000'	549	>600†	54.7	51.1	89.4	157,175	57.7	NA	NA	53.9
	9000-10,000'	554	543	70.6	60.7	96.5	140,997	43.6	74.9 (1)	NA	77.0
	10,000-11,000'	520	491	79.2	67.1	96.1	110,855	31.0	NA	NA	84.3
	>11,000'	509	444	85.6	68.2	92.1	31,967	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'	36	2	0.9	0.0	0.1	73	41.6	NA	NA	2.9
	7000-8000'	444	107	25.3	4.3	9.5	6,104	26.8	NA	NA	20.8
	8000-9000'	>600†	403	68.5	28.9	52.4	22,589	14.6	NA	NA	37.0
	9000-10,000'	>600†	548	84.5	58.6	94.7	14,179	4.5	NA	NA	63.9
Kern§	5000-6000'	16	0	0.0	0.0	0.0	0	257.9	NA	NA	0.0
	6000-7000'	7	0	0.0	0.0	0.0	0	357.8	NA	NA	0.7
	7000-8000'	152	27	2.4	0.2	0.8	4,006	338.7	0.0 (1)	0.0 (1)	4.2
	8000-9000'	502	362	18.2	7.9	27.3	136,839	325.8	26.5 (3)	18.5 (3)	16.8
	9000-10,000'	578	503	35.0	24.5	76.4	252,969	193.2	44.6 (1)	36.6 (1)	38.0
	10,000-11,000'	527	458	49.5	38.2	94.6	271,036	133.1	44.4 (2)	39.3 (2)	51.3
	11,000-12,000'	443	390	56.6	45.1	89.7	228,182	94.8	71.5 (1)	54.5 (1)	61.8
	12,000-13,000	355	338	50.2	43.6	75.5	88,838	38.2	NA	NA	53.7
	>13,000'	293	311	41.4	39.8	62.2	13,478	6.3	NA	NA	38.1

Basin	Elevation Band	5/15/23 % 5/15 Avg.	5/23/23 % 5/23 Avg.	5/15/23 SWE (in)	5/23/23 SWE (in)	5/23/23 % SCA	5/23/23‡ Vol (af)	5/23/23 Area (mi2)	5/15/23 Pillows	5/23/23 Pillows	5/23/23 SNODAS* (in)
Truckee§	5000-6000'	28	2	0.3	0.0	0.2	55	69.3	NA	NA	0.8
	6000-7000'	235	151	8.9	4.5	20.9	52,720	219.5	24.7 (5)	16.1 (5)	13.1
	7000-8000'	357	311	37.6	26.5	79.6	169,249	119.7	NA	NA	44.8
	8000-9000'	348	310	52.7	40.0	98.9	65,422	30.7	NA	NA	66.4
	9000-10,000'	323	281	49.4	37.6	99.3	15,924	8.0	NA	NA	74.6
	10,000-11,000'	289	245	49.2	36.9	95.2	824	0.4	NA	NA	72.0
Tahoe§	6000-7000'	170	108	5.6	2.6	10.2	17,968	130.2	24.6 (2)	17.2 (2)	8.9
	7000-8000'	363	311	30.5	20.7	61.4	125,013	113.0	44.1 (4)	27.9 (4)	36.5
	8000-9000'	402	352	53.7	39.7	93.7	154,606	73.0	39.5 (1)	26.3 (1)	49.7
	9000-10,000'	409	342	65.5	47.2	93.2	42,480	16.9	NA	NA	56.2
	10,000-11,000'	376	298	63.2	43.8	79.8	1,794	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'	27	0	0.4	0.0	0.0	0	2.2	NA	NA	7.5
	7000-8000'	376	327	25.2	16.0	70.0	27,501	32.2	NA	NA	36.7
	8000-9000'	441	398	50.4	37.7	96.4	56,036	27.9	58.1 (2)	48.9 (2)	44.2
	9000-10,000'	423	376	63.2	47.8	92.6	17,939	7.0	NA	NA	49.3
	10,000-11,000'	529	408	74.8	49.3	84.5	1,651	0.6	NA	NA	51.4
E. Carson§	5000-6000'	0	0	0.0	0.0	0.0	0	49.9	NA	NA	0.0
	6000-7000'	46	3	0.6	0.0	0.4	107	77.8	0.0 (1)	0.0 (1)	2.2
	7000-8000'	370	300	17.7	9.7	38.7	53,987	104.1	NA	NA	22.2
	8000-9000'	460	411	48.6	35.5	90.3	192,363	101.5	51.5 (4)	39.7 (4)	49.0
	9000-10,000'	442	396	68.9	53.2	95.4	103,475	36.5	NA	NA	63.1
	>10,000'	383	348	68.9	55.2	92.2	32,433	11.0	NA	NA	60.7
W. Walker	6000-7000'	364	0	1.9	0.0	0.0	0	7.7	NA	NA	0.5
	7000-8000'	>600†	567	25.3	9.4	32.4	20,348	40.4	9.9 (1)	0.0 (1)	9.7
	8000-9000'	>600†	>600†	48.3	48.8	91.4	124,638	47.9	50.7 (1)	38.9 (1)	43.9
	9000-10,000'	386	531	54.0	-	94.5	219,503	64.5	117.5 (1)	117.1 (1)	71.9
	10,000-11,000'	300	418	54.0	-	87.9	94,792	26.9	NA	NA	72.9
	> 11,000'	294	387	50.2	-	78.1	6,978	2.2	NA	NA	62.8
E. Walker	6000-7000'	250	16	0.1	0.0	0.3	117	57.4	NA	NA	0.0
	7000-8000'	>600†	>600†	13.9	6.9	32.5	43,003	117.6	NA	NA	3.0
	8000-9000'	>600†	>600†	36.9	32.5	80.3	166,576	96.2	NA	NA	16.9
	9000-10,000'	477	>600†	47.4	-	89.9	164,185	57.1	45.8 (1)	36.4 (1)	47.5
	10,000-11,000'	328	455	48.8	-	83.8	107,658	34.2	NA	NA	59.3
	>11,000'	288	387	44.4	-	73.9	24,624	8.7	NA	NA	52.3
Mono	6000-7000'	27	10	0.0	0.0	0.3	193	319.7	NA	NA	0.0
	7000-8000'	>600†	474	4.2	1.1	6.8	25,207	411.8	NA	NA	0.3
	8000-9000'	>600†	>600†	25.3	16.8	51.1	165,230	184.3	NA	NA	3.9
	9000-10,000'	592	>600†	47.4	-	88.8	174,047	64.6	NA	NA	28.0
	10,000-11,000'	365	494	50.7	-	86.1	153,535	48.1	NA	NA	54.9
	11,000-12,000'	296	377	48.7	-	73.6	77,328	26.2	NA	NA	51.1
	> 12,000'	279	300	48.9	47.1	65.7	11,047	4.4	NA	NA	41.3
Upper Owens	6000-7000'	8	0	0.0	0.0	0.0	0	66.0	NA	NA	0.1
	7000-8000'	>600†	>600†	14.4	3.2	10.6	25,328	149.0	NA	NA	2.8
	8000-9000'	>600†	>600†	42.5	33.1	64.9	140,967	79.9	NA	NA	20.6
	9000-10,000'	532	>600†	48.6	48.7	82.6	114,163	43.9	NA	NA	37.5
	10,000-11,000'	419	486	53.1	53.7	81.0	99,088	34.6	NA	NA	49.6
	11,000-12,000'	344	398	54.1	54.9	73.2	47,400	16.2	NA	NA	44.7
	> 12,000'	319	368	47.7	48.1	65.5	9,834	3.8	NA	NA	29.8
Owens	5000-6000'	0	0	0.0	0.0	0.0	0	446.6	NA	NA	0.0
	6000-7000'	164	0	0.0	0.0	0.0	0	358.7	NA	NA	0.0
	7000-8000'	>600†	35	1.3	0.1	0.5	1,236	333.1	NA	NA	0.4
	8000-9000'	>600†	215	8.9	1.5	5.3	14,957	185.7	NA	NA	5.6
	9000-10,000'	>600†	571	25.8	13.6	32.2	109,893	151.3	38.4 (3)	28.5 (3)	17.1
	10,000-11,000'	>600†	>600†	38.8	33.5	65.1	297,783	166.6	30.7 (2)	21.2 (2)	29.2
	11,000-12,000'	433	464	45.4	43.6	70.0	313,069	134.5	NA	NA	35.5
	12,000-13,000	348	371	45.2	43.8	65.4	157,658	67.4	NA	NA	29.2
	>13,000'	305	325	40.1	38.7	60.3	21,745	10.5	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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