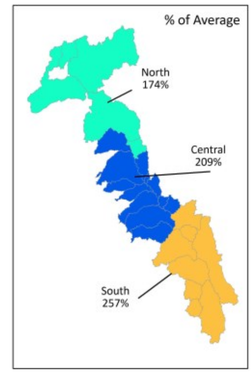
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California

February 14, 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 Feb 14, percent of average SWE is highest in the south (257%), then central (209%) and lowest in the north (174%). This is a time of year when sporadic percent of average especially in low-elevation areas 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**.

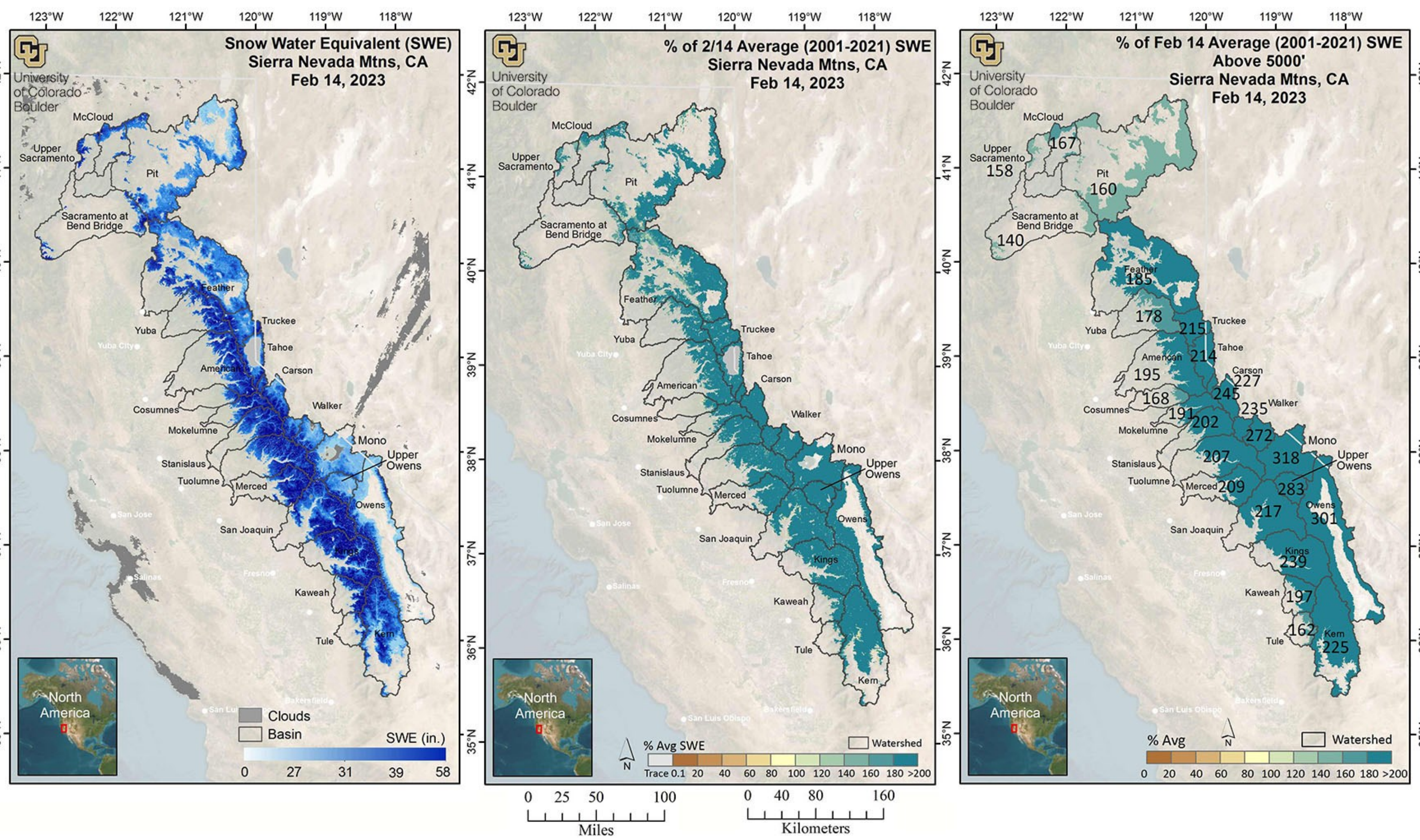

Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for February 14, 2023 (left), and percent of average (2001-2021) SWE for February 14, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

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

112 snow pillow sites in the Sierra Nevada network were recording SWE values out of a total of 127 sites, and 15 were offline (shown in black and red 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.

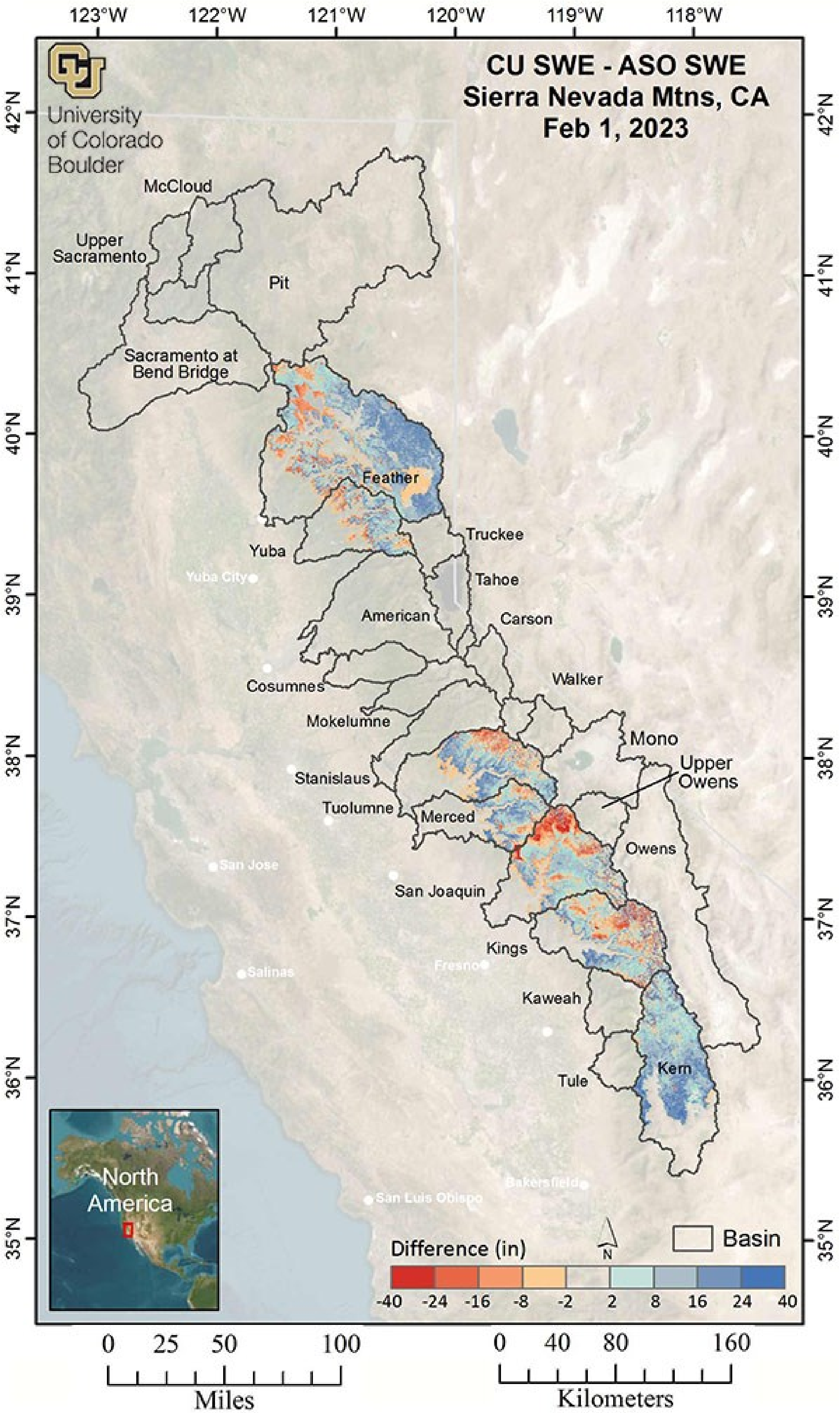

Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the February 1, 2023 CU SWE model run and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins. Red colors show where CU SWE is lower than ASO SWE and blue colors show where CU SWE is higher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

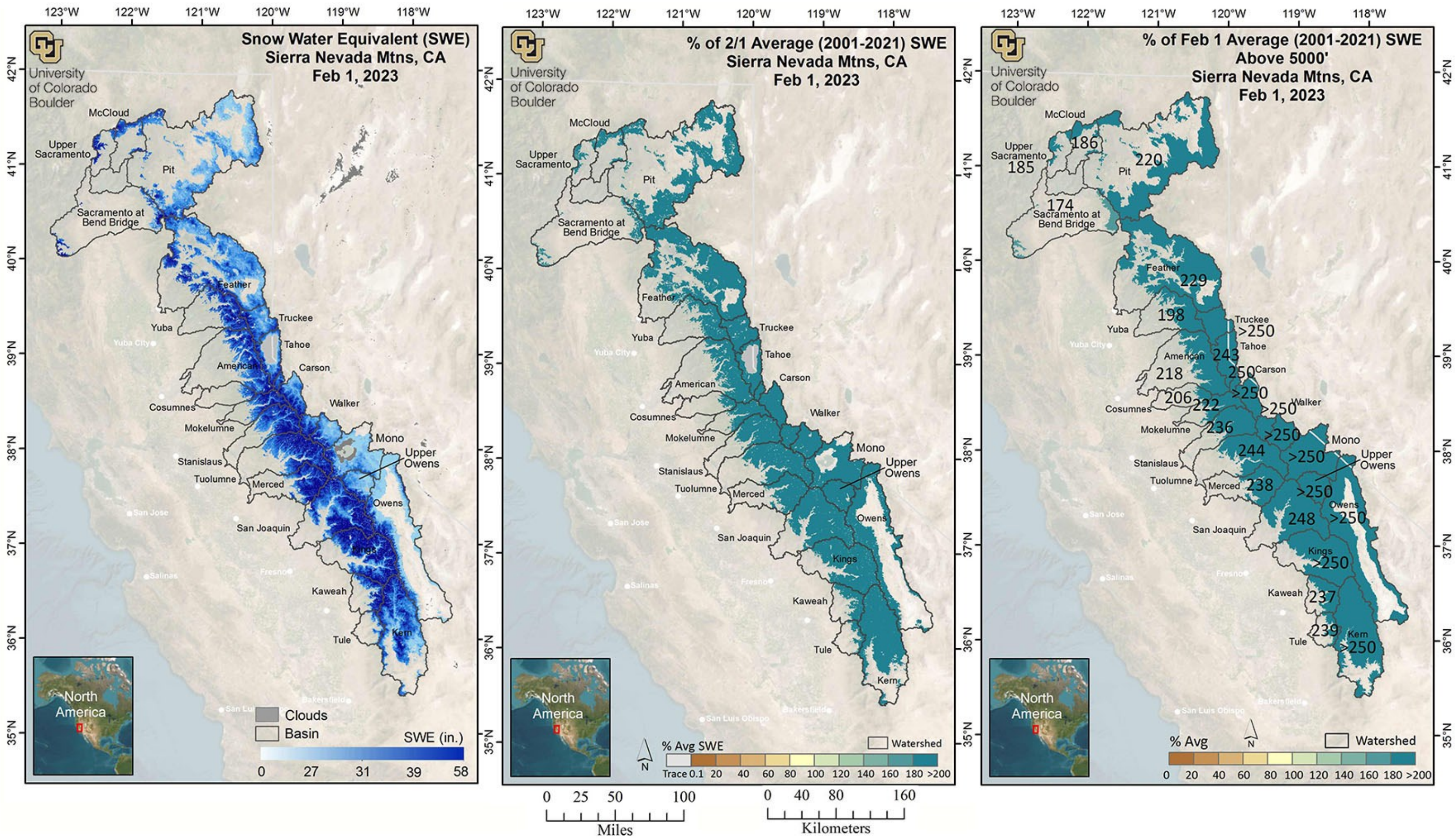

Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts for February 1, 2023 (left), and percent of average (2001-2021) SWE for February 1, 2023 for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across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

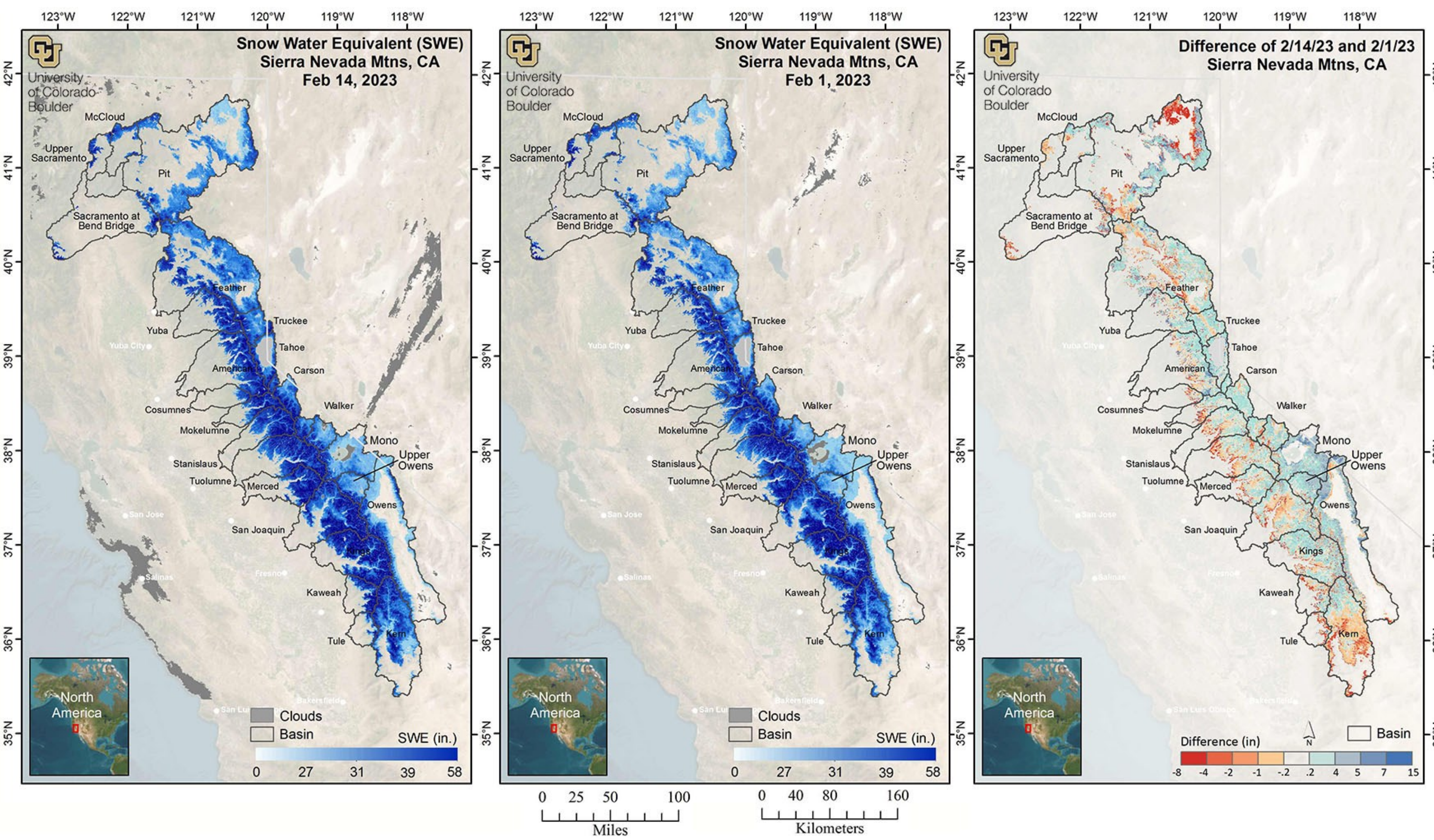

Figure 4. Estimated SWE across the Sierra Nevada, February 14, 2023. SWE amounts for February 14, 2023 (left), February 1, 2023 (middle) and the difference between February 14th and February 1st (right).

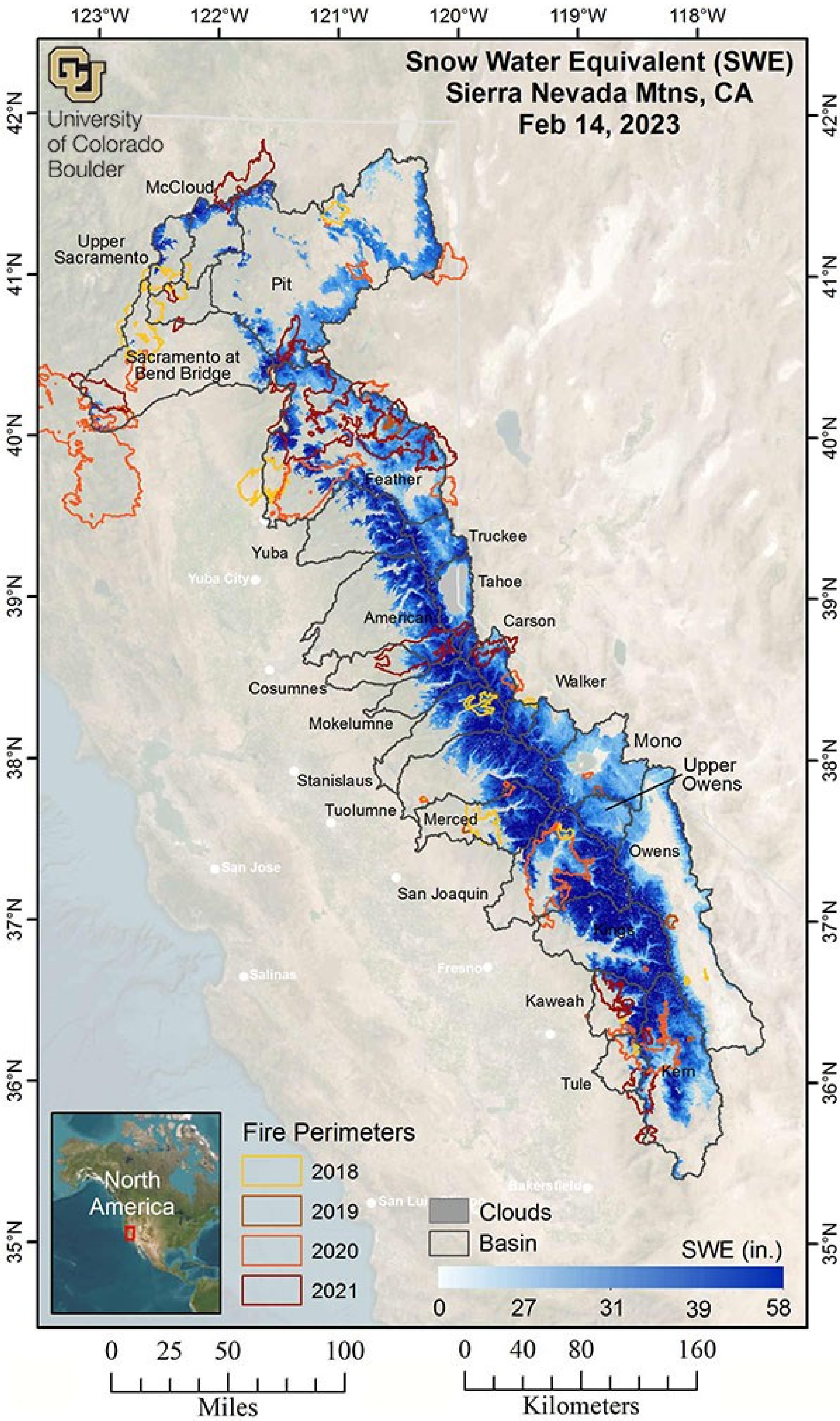

Figure 5. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts for February 14, 2023 are shown with fire perimeters from 2018-2021 (colored from yellow to red).

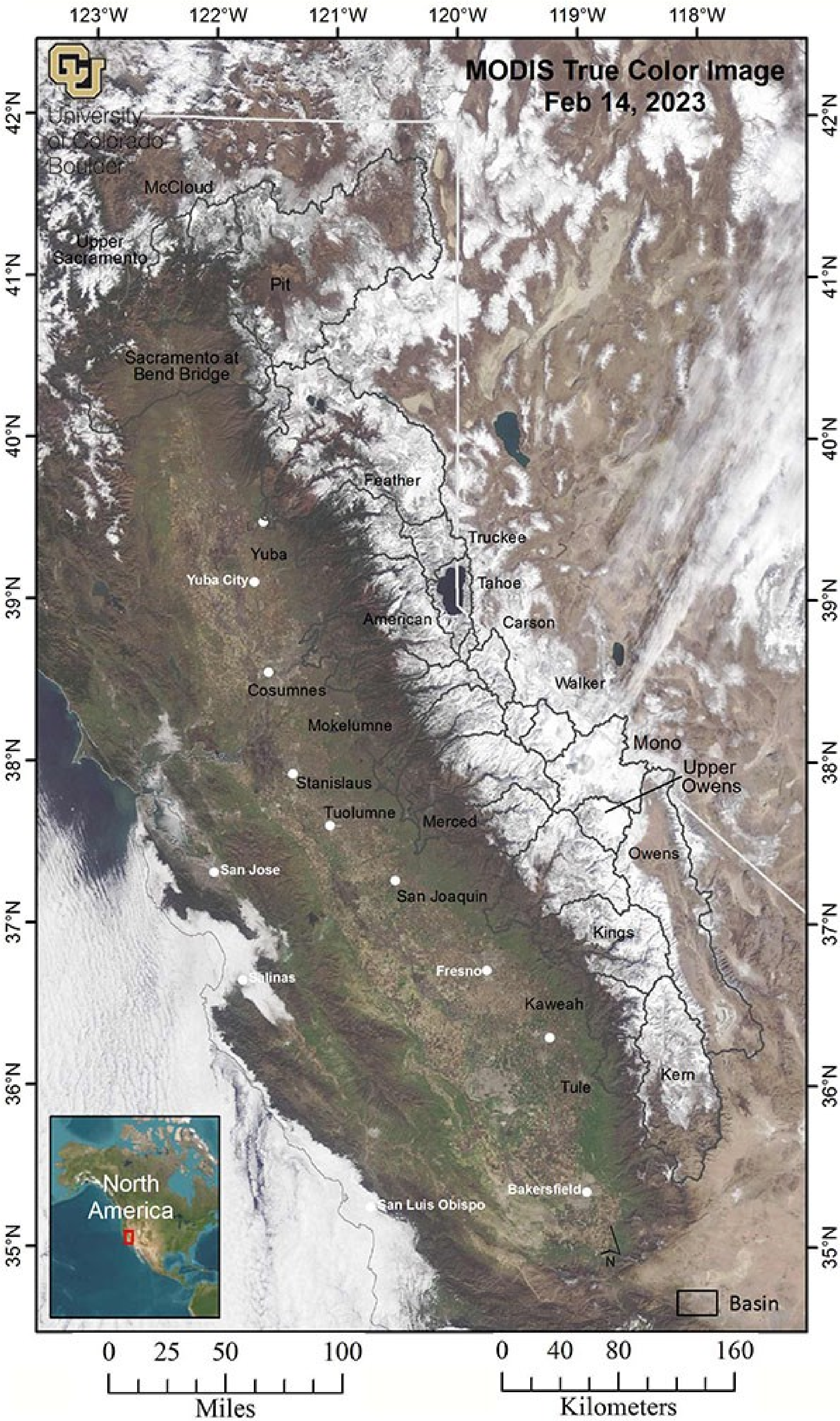

Figure 6. MODIS image, Sierra Nevada. A mostly cloud-free true color MODIS image, showing the image that was used for the February 14, 2023 regression model run.

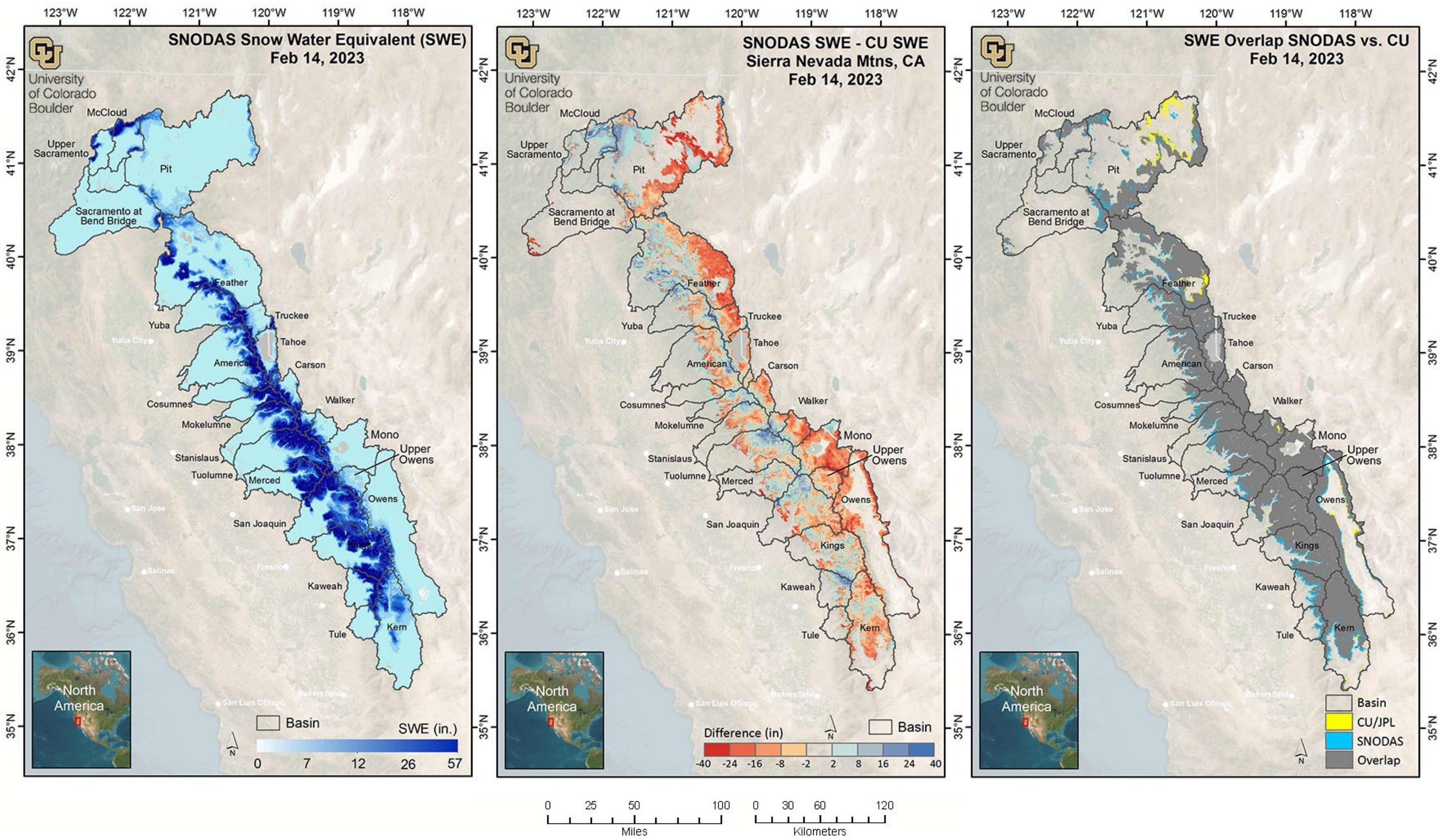

Figure 7. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE for February 14th from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows the difference between the February 14th 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.

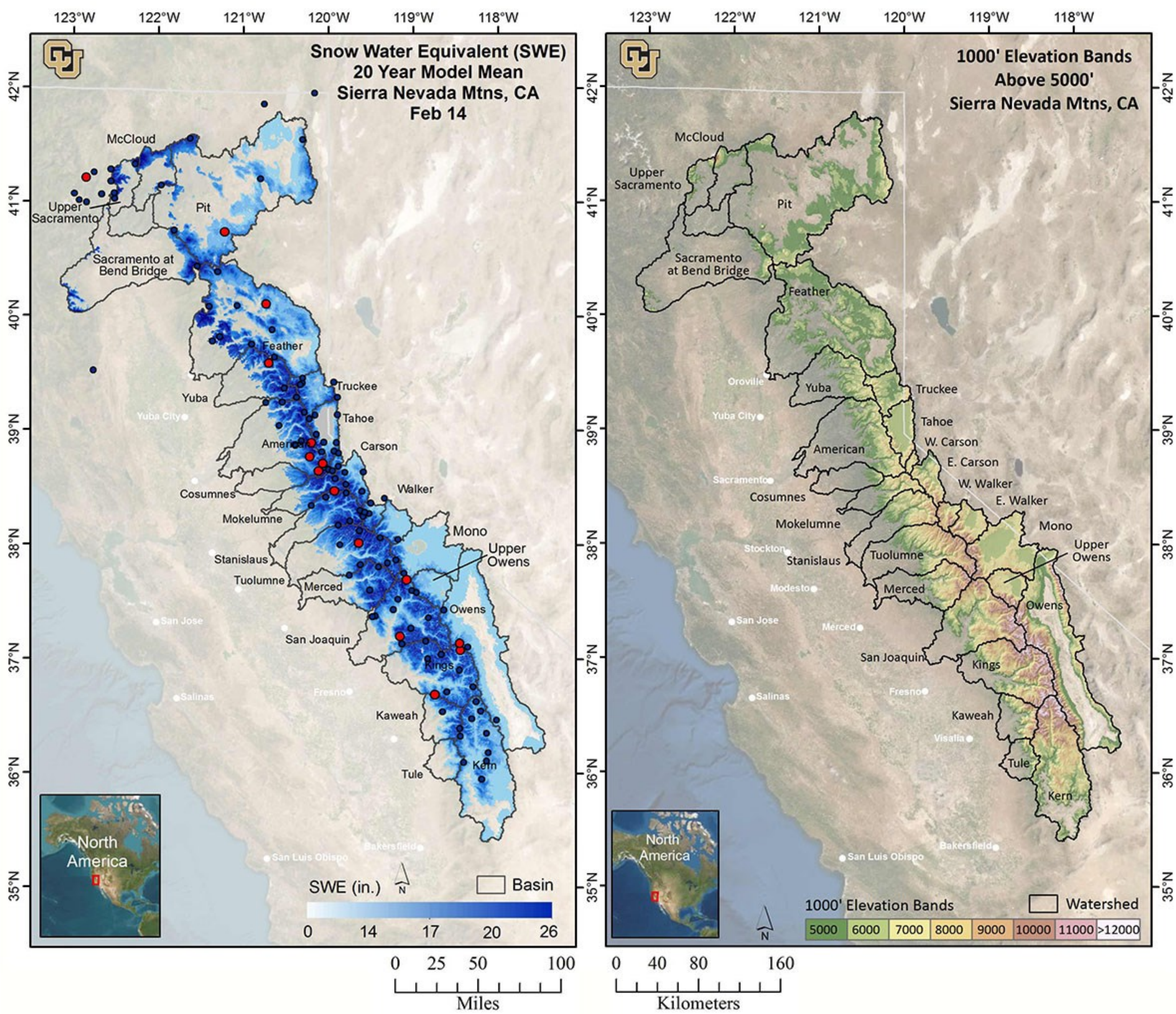

Figure 8. Historical average February 14th and Elevation Bands for the Sierra Nevada. Average SWE (2001-2021) for February 14th (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and Table 2. Map on left shows snow pillow sensor sites recording SWE on February 14th (black) and sites that were offline are shown in red.

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

Basin	2/1/23 % 2/1 Avg.	2/14/23 % 2/14 Avg.	2/1/23 SWE (in)	2/14/23 SWE (in)	2/14/23 % SCA	2/14/23‡ Vol (af)	Area (mi2) > 5000'	2/1 thru 2/14/23 Chg. in SWE (in)	2/1/23 Pillows	2/14/23 Pillows	2/14/23 SNODAS* (in)
Upper Sacramento	185	158	34.3	32.1	95.1	216,375	126.4	-2.2	36.9 (2)	40.1 (2)	33.2
McCloud	186	167	32.2	32.7	93.8	304,880	174.8	0.5	44.6 (1)	32.8 (1)	40.5
Pit	220	160	19.3	19.0	78.9	2,318,380	2287.7	-0.3	20.9 (4)	23.0 (4)	10.2
Sac at Bend Bridge	174	140	27.5	25.1	79.6	341,110	255.3	-2.4	NA	NA	18.6
Feather	229	185	26.3	15.6§	92.7	1,888,576	2,271.1	-10.7§	34.1 (6)	36.5 (6)	19.8
Yuba	198	178	31.9	32.5	90.3	961,257	554.4	0.6	44.1 (3)	47.7 (3)	33.1
American	218	195	32.2	33.1	94.7	1,503,798	850.8	1.0	30.5 (9)	32.6 (9)	30.2
Cosumnes	206	168	28.2	26.8	86.1	133,213	93.2	-1.4	NA	NA	22.4
Mokelumne	222	191	34.4	33.4	91.5	597,020	335.0	-0.9	43.8 (1)	46.3 (1)	34.0
Stanislaus	236	202	35.0	34.2	94.7	1,076,630	590.5	-0.9	42.4 (6)	42.4 (6)	32.0
Tuolumne	244	207	35.3	34.0	92.0	1,740,838	960.4	-1.3	39.2 (6)	40.8 (6)	34.7
Merced	238	209	34.9	34.6	90.6	1,041,624	565.2	-0.4	40.4 (3)	42.3 (3)	34.3
San Joaquin	248	217	34.7	34.2	92.6	2,311,581	1,265.6	-0.4	38.0 (8)	40.8 (8)	32.1
Kings	>250†	239	35.9	36.6	91.4	2,450,520	1,256.6	0.7	42.5 (6)	44.3 (6)	34.8
Kaweah	237	197	29.2	27.7	74.8	476,106	322.5	-1.5	32.2 (2)	33.2 (2)	31.5
Tule	239	162	21.2	17.4	57.7	132,103	142.3	-3.8	NA	NA	13.6
Kern	>250†	225	25.1	15.3§	75.1	1,427,350	1,745.4	-9.8§	29.0 (9)	30.4 (9)	17.6
Truckee	>250†	215	30.3	31.3	97.4	750,510	449.8	1.0	24.1 (5)	27.2 (4)	23.6
Tahoe	243	214	30.6	32.3	95.2	576,121	334.3	1.7	31.5 (7)	34.0 (7)	28.8
W Carson	250	227	36.0	37.7	99.5	140,615	69.9	1.7	38.4 (2)	41.0 (2)	34.5
E Carson	>250†	245	31.1	32.3	98.2	658,086	382.0	1.2	32.0 (5)	34.3 (5)	25.5
W Walker	>250†	235	34.6	35.0	96.3	357,016	191.4	0.3	39.4 (3)	42.5 (3)	36.3
E Walker	>250†	>250†	27.1	28.5	92.5	550,417	361.9	1.4	28.4 (1)	30.8 (1)	19.0
Mono	>250†	>250†	19.0	22.5	95.1	1,212,478	1,009.6	3.5	45.3 (1)	46.2 (1)	11.3
Upper Owens	>250†	>250†	25.8	28.5	97.6	604,271	397.6	2.7	58.7 (1)	61.1 (1)	21.0
Owens	>250†	>250†	13.3	15.0	55.8	1,488,947	1,860.4	1.7	27.1 (5)	28.0 (4)	8.2

§ 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 1st percent of February 1st average SWE, February 14th percent of February 14th average SWE (between 2001-2021 as derived from the regression model), February 1st mean SWE, February 14th mean SWE, February 14th percent of snow-covered area, February 14th 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 1st snow pillow data, and February 14th snow pillow data for those areas collected, summarized for each 1000' elevation band inside each basin. The last column shows February 14th mean SWE from SNODAS*.*

Basin	Elevation Band	2/1/23 % 2/1 Avg.	2/14/23 % 2/14 Avg.	2/1/23 SWE (in)	2/14/23 SWE (in)	2/14/23 % SCA	2/14/23‡ Vol (af)	2/1/23 Area (mi2)	2/1 thru 2/14/23 Chg. in SWE (in)	2/1/23 Pillows	2/14/23 Pillows	2/14/23 SNODAS* (in)
Upper Sacramento	5000-6000'	193	161	32.7	30.3	92.3	117,054	72.3	-2.4	38.5 (1)	42.4 (1)	29.1
	6000-7000'	189	163	37.2	34.8	99.0	70,895	38.2	-2.5	35.3 (1)	37.8 (1)	39.2
	7000-8000'	169	147	34.5	33.0	100.0	15,711	8.9	-1.5	NA	NA	38.5
	8000-9000'	140	130	33.1	33.0	100.0	4,903	2.8	-0.1	NA	NA	38.9
	9000-10,000'	120	118	32.7	33.3	98.8	3,095	1.7	0.6	NA	NA	37.2
	10,000-11,000'	119	131	37.4	41.1	95.5	2,752	1.3	3.7	NA	NA	32.3
	> 11,000'	107	109	32.4	33.0	78.2	1,966	1.1	0.7	NA	NA	27.5
McCloud	5000-6000'	197	170	30.0	30.0	92.3	168,867	105.5	0.0	44.6 (1)	32.8 (1)	37.1
	6000-7000'	187	172	33.0	34.2	96.5	78,382	43.0	1.2	NA	NA	46.4
	7000-8000'	177	160	34.6	34.9	96.7	26,106	14.0	0.3	NA	NA	45.5
	8000-9000'	178	169	38.8	40.0	99.2	12,940	6.1	1.1	NA	NA	46.0
	>10,000'	177	171	44.0	44.5	94.9	6,119	2.6	0.4	NA	NA	43.3
Pit	5000-6000'	231	154	16.8	16.0	73.1	1,337,409	1,568.7	-0.8	30.0 (1)	34.1 (1)	7.0
	6000-7000'	206	166	23.3	24.1	90.4	714,186	556.7	0.8	18.8 (2)	20.7 (2)	15.3
	7000-8000'	209	178	28.8	29.9	95.6	222,793	139.5	1.1	16.1 (1)	16.5 (1)	23.5
	>8,000'	214	193	33.2	35.7	99.7	40,333	21.2	2.5	NA	NA	21.6
Sac at Bend Bridge	5000-6000'	171	129	24.0	20.9	74.4	188,411	169.1	-3.1	NA	NA	14.5
	6000-7000'	173	150	31.2	30.1	87.2	104,300	65.1	-1.1	NA	NA	24.1
	>7,000'	191	175	41.6	41.2	98.4	35,833	16.3	-0.5	NA	NA	33.3
Feather	5000-6000'	234	183	24.0	12.5§	90.2	905,735	1,356.2	-11.5§	43.7 (1)	46.8 (1)	18.1
	6000-7000'	225	187	29.2	18.9§	96.0	793,164	785.8	-10.2§	33.2 (4)	35.6 (4)	21.4
	7000-8000'	216	188	33.6	27.3§	98.4	181,687	124.6	-6.2§	28.3 (1)	29.9 (1)	27.0
	8000-9000'	206	197	36.8	33.6§	100.0	7,990	4.5	-3.2§	NA	NA	27.9
Yuba	5000-6000'	167	145	22.7	23.1	77.6	250,351	203.4	0.4	NA	NA	22.6
	6000-7000'	214	192	35.7	36.1	96.6	441,251	229.0	0.5	37.6 (2)	40.7 (2)	35.5
	7000-8000'	211	197	39.9	41.3	99.7	258,949	117.6	1.4	57.0 (1)	61.6 (1)	45.7
	8000-9000'	204	193	43.3	45.0	99.1	10,706	4.5	1.7	NA	NA	57.3
American	5000-6000'	213	173	24.8	24.1	87.5	403,295	313.7	-0.6	17.6 (3)	19.8 (3)	17.2
	6000-7000'	224	202	33.8	35.1	98.1	526,791	281.1	1.3	31.3 (2)	33.7 (2)	30.3
	7000-8000'	218	207	38.2	40.6	99.7	382,811	176.8	2.4	38.8 (2)	41.0 (2)	44.4
	8000-9000'	214	209	41.8	44.7	99.4	167,563	70.2	2.9	40.6 (2)	42.6 (2)	49.5
	9000-10,000'	198	208	42.7	48.3	98.7	23,338	9.1	5.5	NA	NA	50.7
Cosumnes	5000-6000'	196	152	24.4	22.5	80.8	73,889	61.5	-1.9	NA	NA	16.4
	6000-7000'	222	189	34.5	33.4	95.3	44,083	24.8	-1.1	NA	NA	31.9
	7000-8000'	216	203	39.5	41.0	99.1	15,242	7.0	1.5	NA	NA	42.0
Mokelumne	5000-6000'	207	134	22.9	17.9	74.3	84,067	87.9	-4.9	NA	NA	10.3
	6000-7000'	233	191	33.2	31.2	93.0	113,893	68.4	-2.0	NA	NA	29.5
	7000-8000'	225	211	39.0	40.4	99.8	195,555	90.7	1.4	NA	NA	46.0
	8000-9000'	223	210	41.8	43.1	99.4	183,073	79.6	1.4	43.8 (1)	46.3 (1)	48.8
	9000-10,000'	215	206	43.8	45.4	98.1	20,432	8.4	1.6	NA	NA	46.8
Stanislaus	5000-6000'	248	152	25.5	19.4	79.2	115,697	111.9	-6.1	NA	NA	9.3
	6000-7000'	239	200	31.6	30.9	96.1	232,734	141.1	-0.7	31.7 (1)	33.6 (1)	26.8
	7000-8000'	236	212	37.1	37.7	99.6	305,151	151.7	0.6	33.8 (1)	31.9 (1)	38.6
	8000-9000'	233	215	41.0	41.9	99.7	264,757	118.3	1.0	49.7 (3)	48.9 (3)	43.1
	9000-10,000'	226	211	43.2	44.0	98.3	126,276	53.8	0.8	39.9 (1)	42.2 (1)	46.2
	10,000-11,000'	219	207	43.1	44.2	94.6	31,245	13.3	1.1	NA	NA	45.4
	> 11,000'	202	197	38.6	41.4	87.4	769	0.3	2.8	NA	NA	43.6

Basin	Elevation Band	2/1/23 % 2/1 Avg.	2/14/23 % 2/14 Avg.	2/1/23 SWE (in)	2/14/23 SWE (in)	2/14/23 % SCA	2/14/23‡ Vol (af)	2/1/23 Area (mi2)	2/1 thru 2/14/23 Chg. in SWE (in)	2/1/23 Pillows	2/14/23 Pillows	2/14/23 SNODAS* (in)
Tuolumne	5000-6000'	>250†	148	23.7	16.2	70.1	155,007	179.3	-7.5	NA	NA	8.0
	6000-7000'	>250†	206	30.7	29.1	94.8	228,088	147.1	-1.6	24.6 (1)	25.2 (1)	25.5
	7000-8000'	243	219	36.7	37.0	98.8	310,294	157.2	0.3	41.5 (1)	44.6 (1)	38.6
	8000-9000'	237	219	38.8	39.9	98.9	368,578	173.2	1.1	44.7 (2)	46.5 (2)	44.9
	9000-10,000'	235	215	40.9	41.1	97.1	402,592	183.8	0.2	39.7 (2)	41.1 (2)	47.9
	10,000-11,000'	235	216	42.9	42.9	95.6	208,793	91.2	0.0	NA	NA	47.3
	11,000-12,000'	238	222	43.9	44.2	91.1	60,630	25.7	0.2	NA	NA	41.4
	> 12,000'	227	214	43.8	43.9	84.7	6,855	2.9	0.1	NA	NA	35.2
Merced	5000-6000'	209	106	17.3	11.1	48.8	44,245	74.8	-6.2	NA	NA	5.2
	6000-7000'	233	187	27.3	25.8	87.7	113,808	82.8	-1.5	NA	NA	22.7
	7000-8000'	245	217	36.0	36.0	98.6	271,903	141.8	0.0	31.6 (1)	33.0 (1)	38.3
	8000-9000'	241	224	40.1	41.3	99.8	274,537	124.7	1.2	44.8 (2)	47.0 (2)	42.6
	9000-10,000'	244	230	41.8	43.6	99.8	204,561	87.9	1.8	NA	NA	42.8
	10,000-11,000'	237	225	45.2	46.1	97.0	98,130	39.9	0.9	NA	NA	49.1
	11,000-12,000'	223	220	46.4	48.3	91.6	30,388	11.8	1.9	NA	NA	50.6
	> 12,000'	199	200	45.8	47.4	84.7	4,053	1.6	1.5	NA	NA	47.4
San Joaquin	5000-6000'	224	128	17.1	12.7	60.2	97,299	144.1	-4.5	NA	NA	5.3
	6000-7000'	>250†	205	27.2	25.7	93.9	255,678	186.6	-1.5	37.3 (2)	40.0 (2)	23.0
	7000-8000'	247	211	31.7	31.2	98.3	362,303	217.7	-0.5	38.8 (4)	42.4 (4)	35.6
	8000-9000'	245	219	37.0	37.1	98.4	398,486	201.4	0.1	NA	NA	38.2
	9000-10,000'	250	234	40.7	41.8	99.0	461,707	206.9	1.2	40.7 (1)	41.6 (1)	39.2
	10,000-11,000'	>250†	239	43.2	44.2	97.8	381,673	161.7	1.1	33.7 (1)	35.0 (1)	42.7
	11,000-12,000'	>250†	237	45.0	45.3	93.0	286,698	118.8	0.2	NA	NA	36.6
	12,000-13,000	244	228	45.6	45.0	85.5	64,551	26.9	-0.7	NA	NA	26.4
	> 13,000	230	219	39.7	40.8	83.7	3,187	1.5	1.1	NA	NA	16.6
Kings	5000-6000'	182	94	11.6	7.9	40.5	42,108	100.2	-3.7	NA	NA	5.6
	6000-7000'	>250†	208	25.7	23.9	87.8	174,180	136.8	-1.8	NA	NA	17.6
	7000-8000'	>250†	232	32.2	32.6	97.8	307,080	176.6	0.4	NA	NA	33.4
	8000-9000'	>250†	244	37.1	38.8	99.0	455,810	220.2	1.7	41.2 (1)	43.1 (1)	41.4
	9000-10,000'	>250†	>250†	40.5	42.6	99.1	503,347	221.3	2.2	43.8 (2)	46.6 (2)	43.9
	10,000-11,000'	>250†	>250†	42.9	44.7	97.7	460,775	193.1	1.8	42.0 (3)	43.2 (3)	43.8
	11,000-12,000'	>250†	>250†	44.6	45.9	92.4	380,460	155.3	1.3	NA	NA	38.9
	12,000-13,000	>250†	243	44.8	44.9	86.5	117,861	49.2	0.2	NA	NA	30.7
	>13,000'	248	234	41.1	41.3	82.7	8,900	4.0	0.2	NA	NA	23.1
Kaweah	5000-6000'	119	28	6.8	2.1	11.4	6,911	60.5	-4.7	NA	NA	5.3
	6000-7000'	236	156	22.9	18.2	69.1	58,109	59.9	-4.7	18.0 (1)	19.4 (1)	17.7
	7000-8000'	250	211	31.9	30.9	92.2	100,814	61.2	-1.0	NA	NA	33.2
	8000-9000'	>250†	234	37.5	38.7	98.2	118,783	57.5	1.2	NA	NA	42.4
	9000-10,000'	>250†	238	40.7	42.1	97.8	98,165	43.7	1.4	46.4 (1)	47.0 (1)	51.6
	10,000-11,000'	>250†	235	43.5	43.8	93.8	72,219	30.9	0.3	NA	NA	53.9
	>11,000'	>250†	236	44.3	45.0	92.1	21,105	8.8	0.7	NA	NA	46.2
Tule	5000-6000'	173	42	7.7	2.7	15.1	7,945	54.4	-4.9	NA	NA	2.3
	6000-7000'	>250†	155	23.6	17.4	70.4	38,706	41.7	-6.2	NA	NA	9.8
	7000-8000'	>250†	216	32.4	31.0	94.3	44,441	26.8	-1.4	NA	NA	24.9
	8000-9000'	>250†	238	38.7	39.4	99.2	31,030	14.8	0.6	NA	NA	35.7
	9000-10,000'	>250†	235	39.9	41.3	98.2	9,980	4.5	1.4	NA	NA	48.5
Kern	5000-6000'	198	64	5.3	0.8§	13.2	10,688	256.6	-4.5§	NA	NA	1.8
	6000-7000'	>250†	163	16.7	5.2§	53.5	100,067	357.8	-11.5§	NA	NA	7.2
	7000-8000'	>250†	225	25.7	11.4§	91.2	206,498	339.5	-14.3§	22.7 (2)	23.1 (2)	15.2
	8000-9000'	>250†	247	32.1	21.3§	99.6	370,690	325.8	-10.8§	30.8 (3)	32.5 (3)	24.7
	9000-10,000'	>250†	>250†	33.8	26.9§	99.7	277,026	193.2	-6.9§	36.6 (1)	38.6 (1)	32.1
	10,000-11,000'	>250†	>250†	37.1	31.2§	99.2	221,530	133.1	-5.9§	25.8 (2)	26.5 (2)	32.5
	11,000-12,000'	>250†	>250†	41.9	33.4§	93.6	168,885	94.9	-8.5§	34.6 (1)	38.4 (1)	31.1
	12,000-13,000	>250†	244	42.1	30.8§	84.8	62,830	38.2	-11.3§	NA	NA	24.7
	>13,000'	246	227	37.5	27.0§	78.9	9,136	6.3	-10.5§	NA	NA	16.7

Basin	Elevation Band	2/1/23 % 2/1 Avg.	2/14/23 % 2/14 Avg.	2/1/23 SWE (in)	2/14/23 SWE (in)	2/14/23 % SCA	2/14/23‡ Vol (af)	2/1/23 Area (mi2)	2/1 thru 2/14/23 Chg. in SWE (in)	2/1/23 Pillows	2/14/23 Pillows	2/14/23 SNODAS* (in)
Truckee	5000-6000'	>250†	232	21.2	23.0	96.9	85,575	69.9	1.8	NA	NA	7.9
	6000-7000'	>250†	213	28.1	28.7	96.6	338,381	221.3	0.6	24.1 (5)	27.2 (4)	18.8
	7000-8000'	238	213	36.6	37.7	98.2	240,608	119.7	1.1	NA	NA	35.0
	8000-9000'	228	209	39.7	41.7	100.0	67,865	30.5	1.9	NA	NA	43.5
	9000-10,000'	232	206	39.1	40.5	99.9	17,185	8.0	1.4	NA	NA	46.9
	10,000-11,000'	233	198	40.5	40.1	97.7	896	0.4	-0.3	NA	NA	44.3
Tahoe	6000-7000'	>250†	209	22.7	24.3	90.1	169,094	130.7	1.6	24.8 (2)	26.7 (2)	17.5
	7000-8000'	242	215	32.9	34.5	98.2	208,138	113.0	1.6	34.4 (4)	37.4 (4)	32.9
	8000-9000'	233	216	38.8	40.7	99.5	158,332	72.9	1.9	33.0 (1)	35.1 (1)	39.8
	9000-10,000'	225	214	40.1	42.8	99.6	38,720	16.9	2.7	NA	NA	41.5
	10,000-11,000'	237	220	43.3	44.9	97.3	1,836	0.8	1.6	NA	NA	34.6
W. Carson	5000-6000'	>250†	222	20.7	16.6	70.3	185	0.2	-4.1	NA	NA	11.3
	6000-7000'	>250†	>250†	25.1	27.2	98.6	3,039	2.1	2.2	NA	NA	24.0
	7000-8000'	>250†	228	33.2	35.0	99.7	60,006	32.2	1.8	NA	NA	33.2
	8000-9000'	245	225	38.8	40.2	99.7	59,592	27.8	1.3	38.4 (2)	41.0 (2)	36.1
	9000-10,000'	235	226	41.4	43.8	99.4	16,449	7.0	2.4	NA	NA	37.9
	10,000-11,000'	240	219	38.6	40.1	98.5	1,343	0.6	1.5	NA	NA	34.8
E. Carson	5000-6000'	>250†	>250†	19.5	19.5	92.8	52,271	50.3	0.0	NA	NA	8.1
	6000-7000'	>250†	>250†	24.0	25.1	97.6	104,368	78.1	1.1	15.9 (1)	17.1 (1)	13.8
	7000-8000'	>250†	240	30.8	32.2	99.1	179,679	104.7	1.4	NA	NA	23.4
	8000-9000'	>250†	232	37.4	38.9	99.8	210,805	101.5	1.5	36.0 (4)	38.6 (4)	37.8
	9000-10,000'	245	228	42.0	43.3	99.9	83,967	36.3	1.3	NA	NA	42.4
	>10,000'	243	230	44.3	45.9	98.3	26,995	11.0	1.7	NA	NA	38.6
W. Walker	6000-7000'	>250†	>250†	22.8	24.6	96.1	10,264	7.8	1.9	NA	NA	12.5
	7000-8000'	>250†	>250†	25.3	26.1	97.0	56,766	40.7	0.9	21.9 (1)	25.2 (1)	17.5
	8000-9000'	>250†	240	32.4	33.3	97.3	85,382	48.1	0.9	33.8 (1)	35.6 (1)	35.9
	9000-10,000'	>250†	227	39.6	39.8	96.9	138,284	65.2	0.2	62.5 (1)	66.8 (1)	47.3
	10,000-11,000'	238	215	43.5	42.5	93.3	61,746	27.3	-1.0	NA	NA	45.5
	> 11,000'	246	202	43.1	38.4	84.4	4,574	2.2	-4.7	NA	NA	38.9
E. Walker	6000-7000'	>250†	>250†	17.9	20.4	88.2	54,497	50.1	2.5	NA	NA	11.4
	7000-8000'	>250†	>250†	21.8	23.5	92.7	147,240	117.3	1.7	NA	NA	8.6
	8000-9000'	>250†	>250†	27.9	29.3	95.2	148,412	95.0	1.4	NA	NA	19.0
	9000-10,000'	>250†	243	36.2	36.4	94.6	109,305	56.3	0.2	28.4 (1)	30.8 (1)	34.3
	10,000-11,000'	>250†	225	41.1	39.9	90.1	73,254	34.5	-1.3	NA	NA	39.4
	>11,000'	247	211	40.7	37.8	82.2	17,709	8.8	-2.9	NA	NA	34.7
Mono	6000-7000'	>250†	>250†	11.9	17.8	89.1	250,822	264.1	5.9	NA	NA	7.2
	7000-8000'	>250†	>250†	15.0	18.8	97.5	418,397	416.2	3.9	NA	NA	7.1
	8000-9000'	>250†	>250†	22.1	25.4	98.0	251,046	185.5	3.3	NA	NA	9.9
	9000-10,000'	>250†	>250†	32.3	34.9	98.6	120,556	64.7	2.6	NA	NA	25.6
	10,000-11,000'	>250†	245	39.5	40.8	95.5	105,095	48.3	1.3	45.3 (1)	46.2 (1)	42.6
	11,000-12,000'	>250†	225	42.2	40.8	87.6	57,360	26.4	-1.4	NA	NA	39.8
	> 12,000'	243	216	41.6	39.9	84.1	9,201	4.3	-1.7	NA	NA	34.9
Upper Owens	6000-7000'	>250†	>250†	16.3	21.4	96.8	75,209	66.0	5.1	NA	NA	15.3
	7000-8000'	>250†	>250†	21.0	24.1	98.5	195,969	152.7	3.1	NA	NA	16.0
	8000-9000'	>250†	>250†	28.0	30.3	98.9	129,685	80.3	2.3	NA	NA	21.3
	9000-10,000'	>250†	>250†	34.7	36.3	98.3	85,263	44.1	1.5	58.7 (1)	61.1 (1)	28.4
	10,000-11,000'	>250†	>250†	39.3	40.0	96.3	73,733	34.6	0.7	NA	NA	36.9
	11,000-12,000'	>250†	239	43.7	42.5	89.9	36,673	16.2	-1.2	NA	NA	34.8
	> 12,000'	>250†	220	40.7	37.8	83.2	7,740	3.8	-2.8	NA	NA	25.1
Owens	5000-6000'	>250†	72	0.6	0.3	3.0	8,132	443.5	-0.2	NA	NA	0.4
	6000-7000'	>250†	>250†	4.7	6.3	37.4	120,039	359.0	1.6	NA	NA	2.9
	7000-8000'	>250†	>250†	9.9	13.2	68.9	236,210	334.3	3.4	NA	NA	5.7
	8000-9000'	>250†	>250†	14.5	18.2	86.6	183,298	189.1	3.7	NA	NA	9.4
	9000-10,000'	>250†	>250†	23.6	26.4	94.8	216,841	153.8	2.8	28.3 (3)	29.3 (3)	15.8
	10,000-11,000'	>250†	>250†	30.9	33.1	96.1	295,768	167.3	2.2	25.3 (2)	24.2 (1)	21.4
	11,000-12,000'	>250†	>250†	37.6	37.6	89.7	271,088	135.2	0.0	NA	NA	22.4
	12,000-13,000	>250†	245	39.1	38.1	83.6	137,069	67.5	-1.0	NA	NA	17.4
	>13,000'	>250†	230	35.5	35.6	80.9	20,501	10.8	0.0	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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