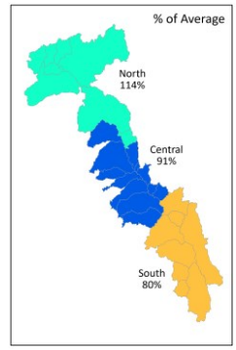
Real-Time Spatial Estimates of Snow-Water Equivalent (SWE)

Sierra Nevada Mountains, California

March 31, 2025



Team: Noah Molotch[1,2], Leanne Lestak[1], Emma Tyrrell[1] and Kehan Yang[1]
[1]Institute of Arctic and Alpine Research, University of Colorado Boulder
[2] Jet Propulsion Laboratory, California Institute of Technology
Contact: Leanne.Lestak@colorado.edu

Summary of current conditions

This year we've added the Trinity basin to our model runs. 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. Figure 2 contains 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**.

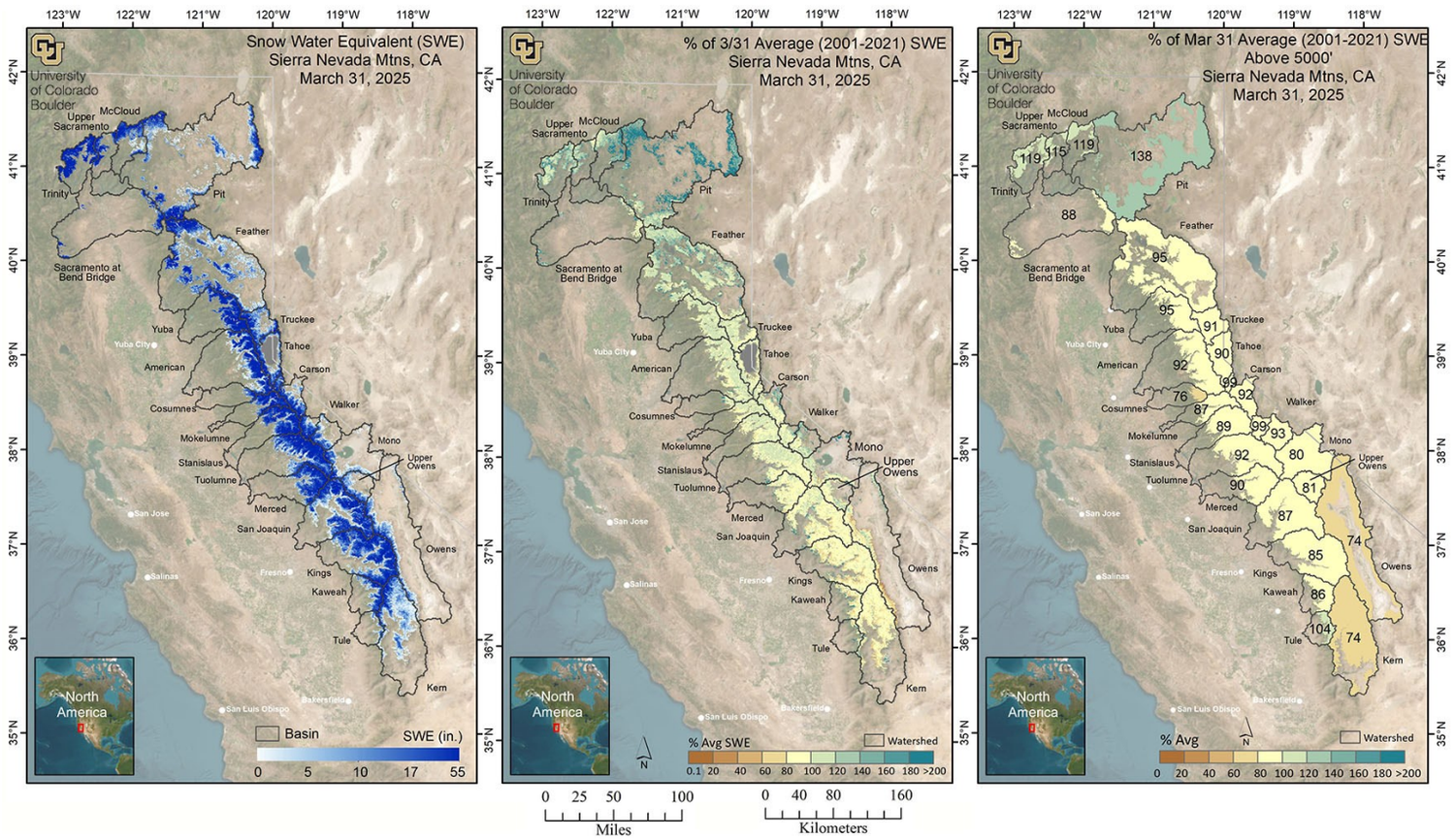


Figure 1. Estimated SWE and % of Average SWE across the Sierra Nevada, Current Report. SWE amounts (left), and percent of average (2001-2021) SWE for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000'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

Location of Reports and Excel Format Tables

https://github.com/CU-Mountain-Hydrology/SierraNevada

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 entire Western United States is available and is distributed to water managers across the western U.S. Note that SWE estimates in the northern basins may be low given recent and persistent cloud cover. See the forthcoming March 1 report which will contain cloud-free imagery.

The spatial SWE-fusion 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
- Fractional snow-covered area (fSCA) data from recent cloud-free satellite images or model
- Physiographic information (elevation, latitude, upwind mountain barriers, slope, etc.)
- Historical daily SWE patterns (1985-2021) retrospectively generated using historical fSCA 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 uncertainties of the SWE product.

Data availability for this report

There are a total of 134 snow pillow sites in the Sierra Nevada network that are used by the SWE-fusion model and when applicable there are typically 10-20 CoCoRaHS measurements that can be used. Sites that are recording SWE, offline sites, sites recording zero, and CoCoRaHS measurements are shown in Figure 6, on the left map (shown in black, red, yellow, and green respectively).

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 fSCA 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.

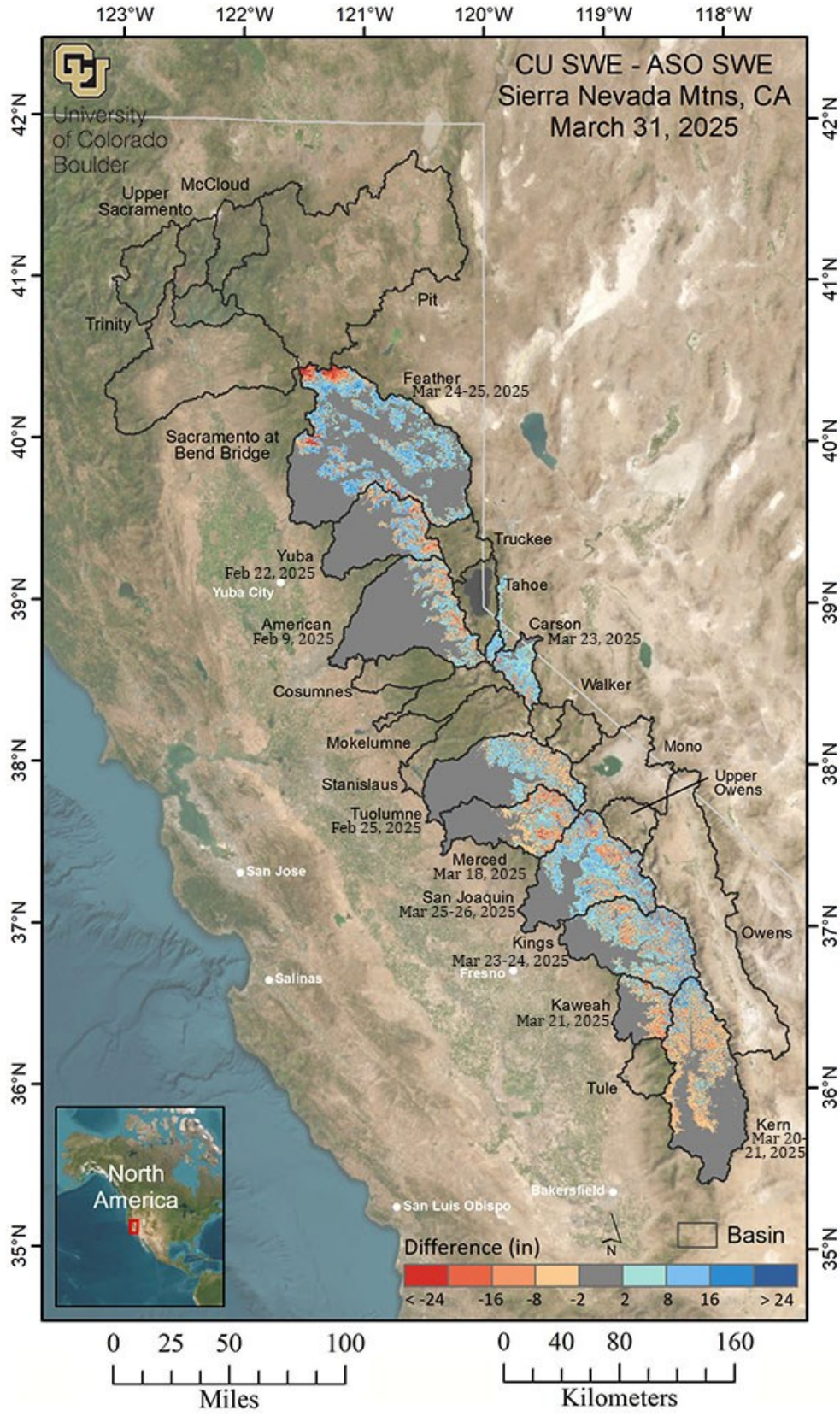


Figure 2. Comparison to ASO, Sierra Nevada. The difference in SWE amounts between the CU SWE-fusion model runs and Airborne Snow Observatories (ASO) lidar-derived SWE are shown for available basins flown this year. The date referenced to each basin, corresponds to the most recent ASO flight date where data has been released and is then compared to the CU SWE-fusion model run is that closest to the ASO flight date. Red colors show where CU SWE is lower than ASO SWE and blue colors show where CU SWE is higher than ASO SWE. This map will be updated as new ASO data becomes available. ASO data from current and sometimes past years are used to bias-correct our model data.

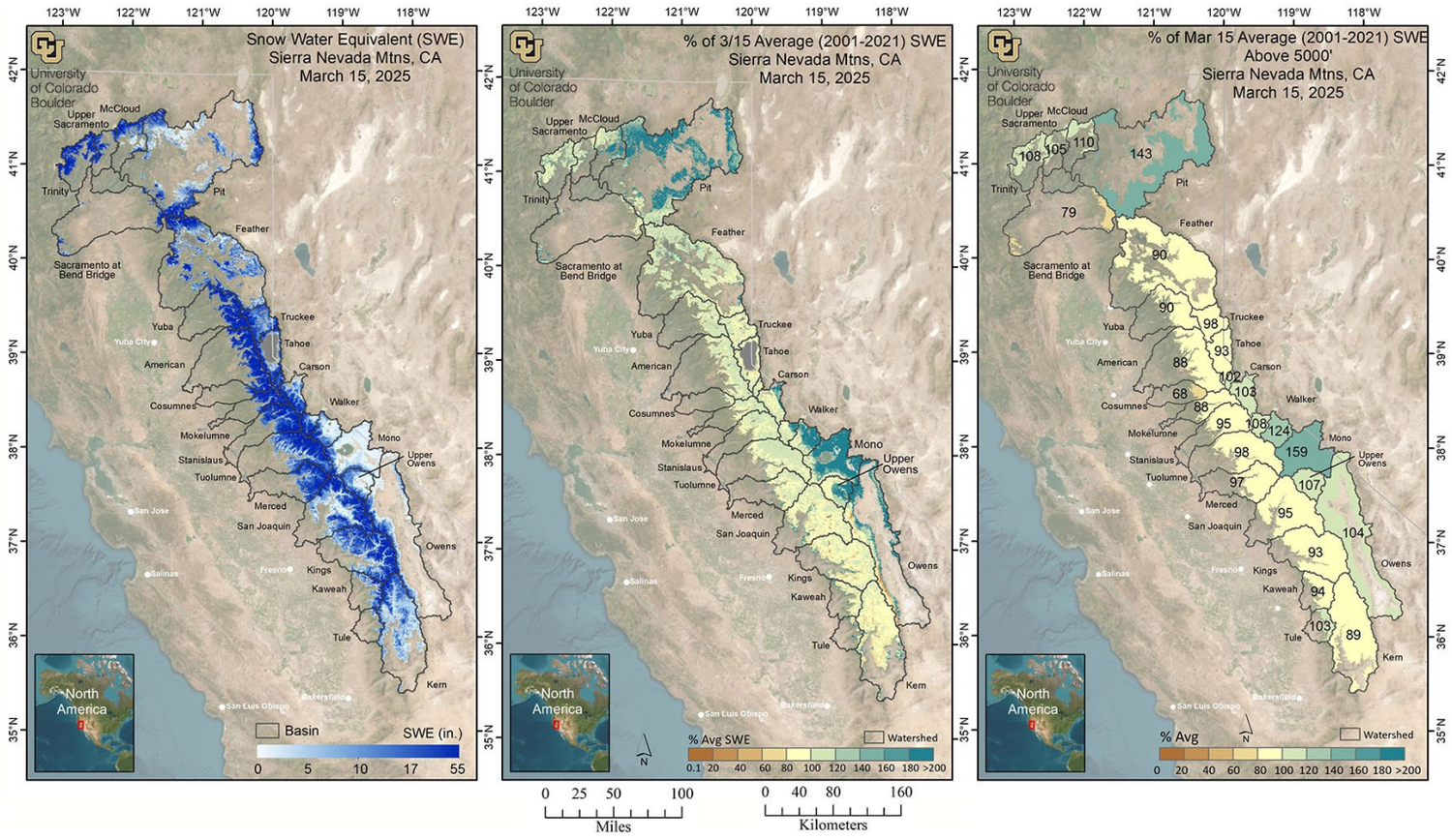


Figure 3. Estimated SWE and % of Average SWE across the Sierra Nevada, Past Report. SWE amounts (left), and percent of average (2001-2021) SWE for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000’ elevation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

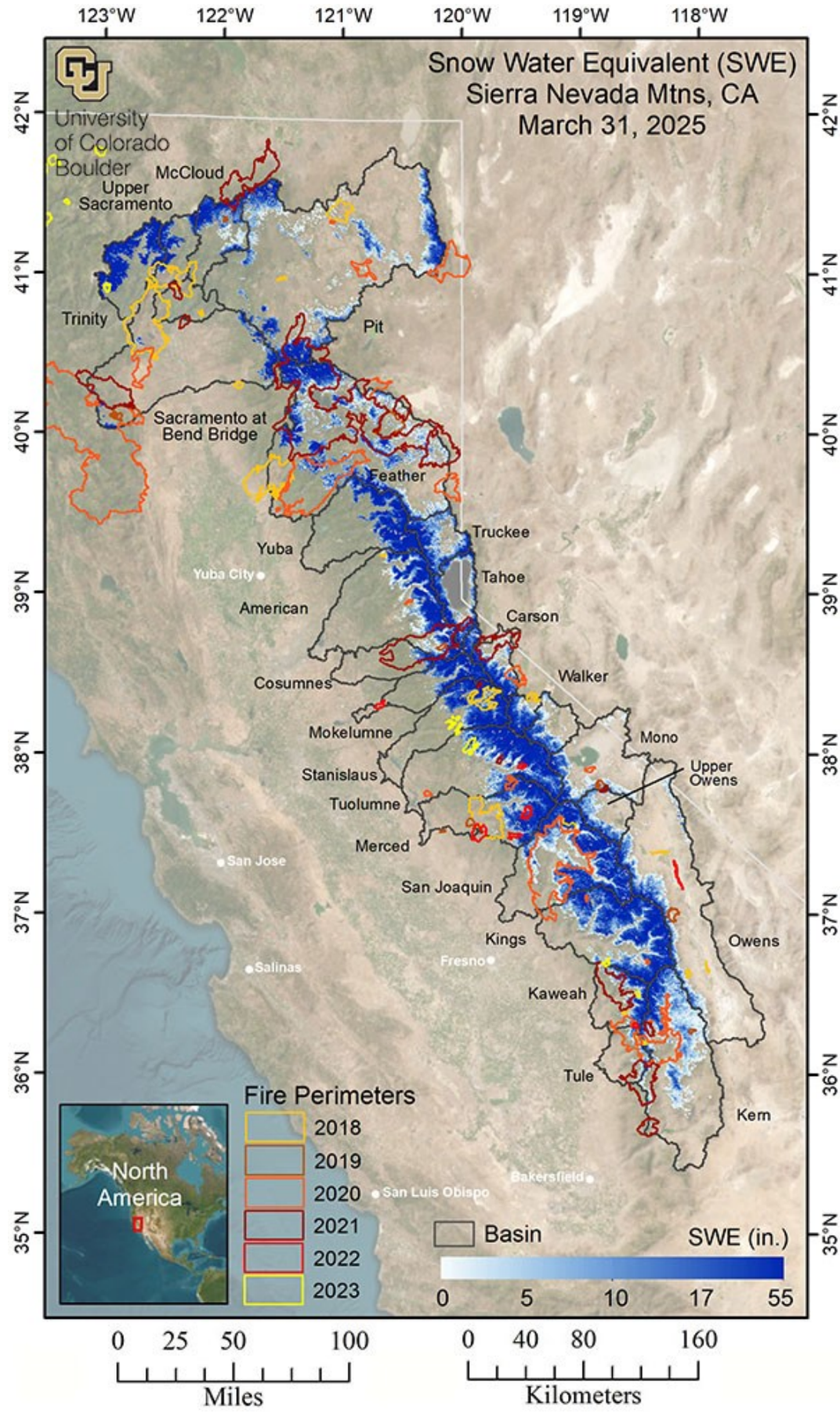


Figure 4. Estimated SWE with Fire Perimeters, Sierra Nevada. SWE amounts are shown with fire perimeters from 2018-2024 (colored from yellow to red).

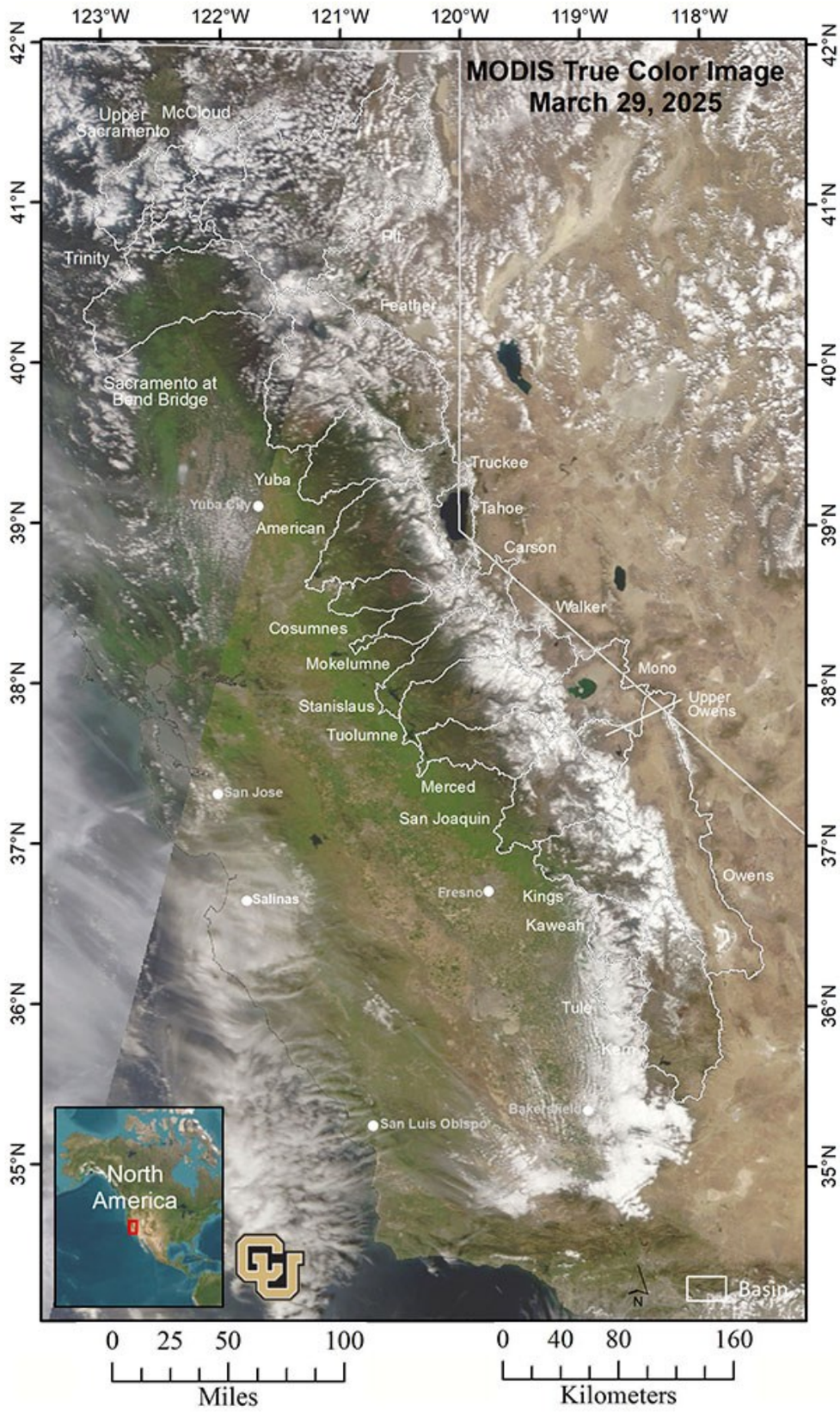


Figure 5. MODIS image, Sierra Nevada. The most recent cloud-free true color MODIS image, showing the Sierra Nevada as close to the model run as possible. Model input fractional snow-covered area (fSCA) was derived from the MODIS Snow Today product (Rittger, et al. 2019) which was calculated using the SPIRES algorithm (Bair, et al. 2021) and from the MODIS cloud-gap-filled product (Hall, et al. 2019).

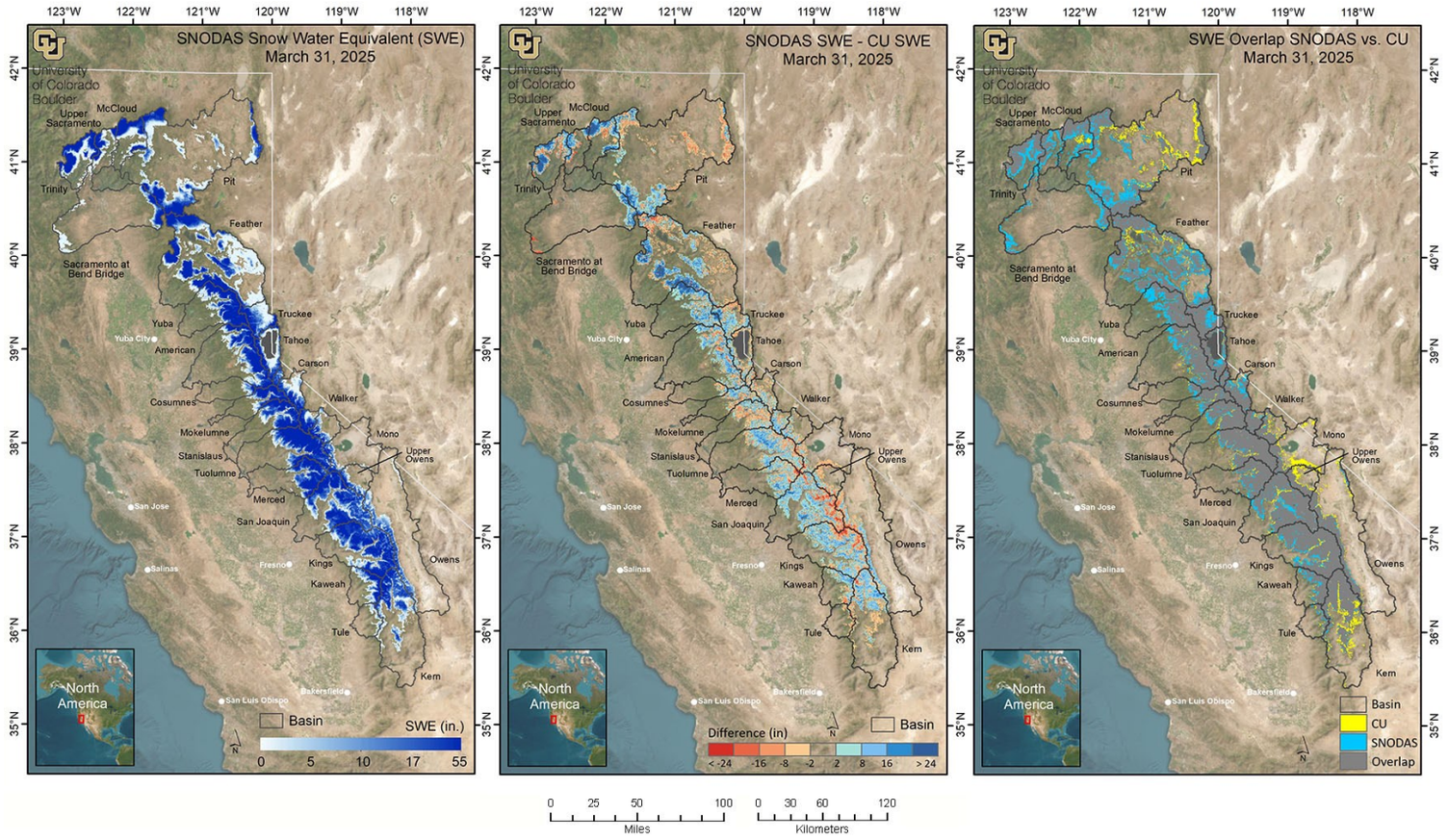


Figure 6. Comparison of CU regression SWE product and SNODAS SWE for the Sierra Nevada. The map on the left shows estimated SWE from the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) SNOw Data Assimilation System (SNODAS). The middle map shows the difference between the SNODAS SWE estimate and CU SWE-fusion estimate. Red pixels denote areas where SNODAS SWE is less than CU SWE and blue pixels show areas where SNODAS SWE is higher than CU SWE. The map on the right shows the snow-cover extent of SNODAS and CU SWE estimates. Yellow pixels show where the location of CU snow extends beyond the location of the SNODAS snow extent. Blue pixels show where the SNODAS snow extends beyond the CU snow extent. Gray areas indicate regions where both products agree on the snow-cover extent.

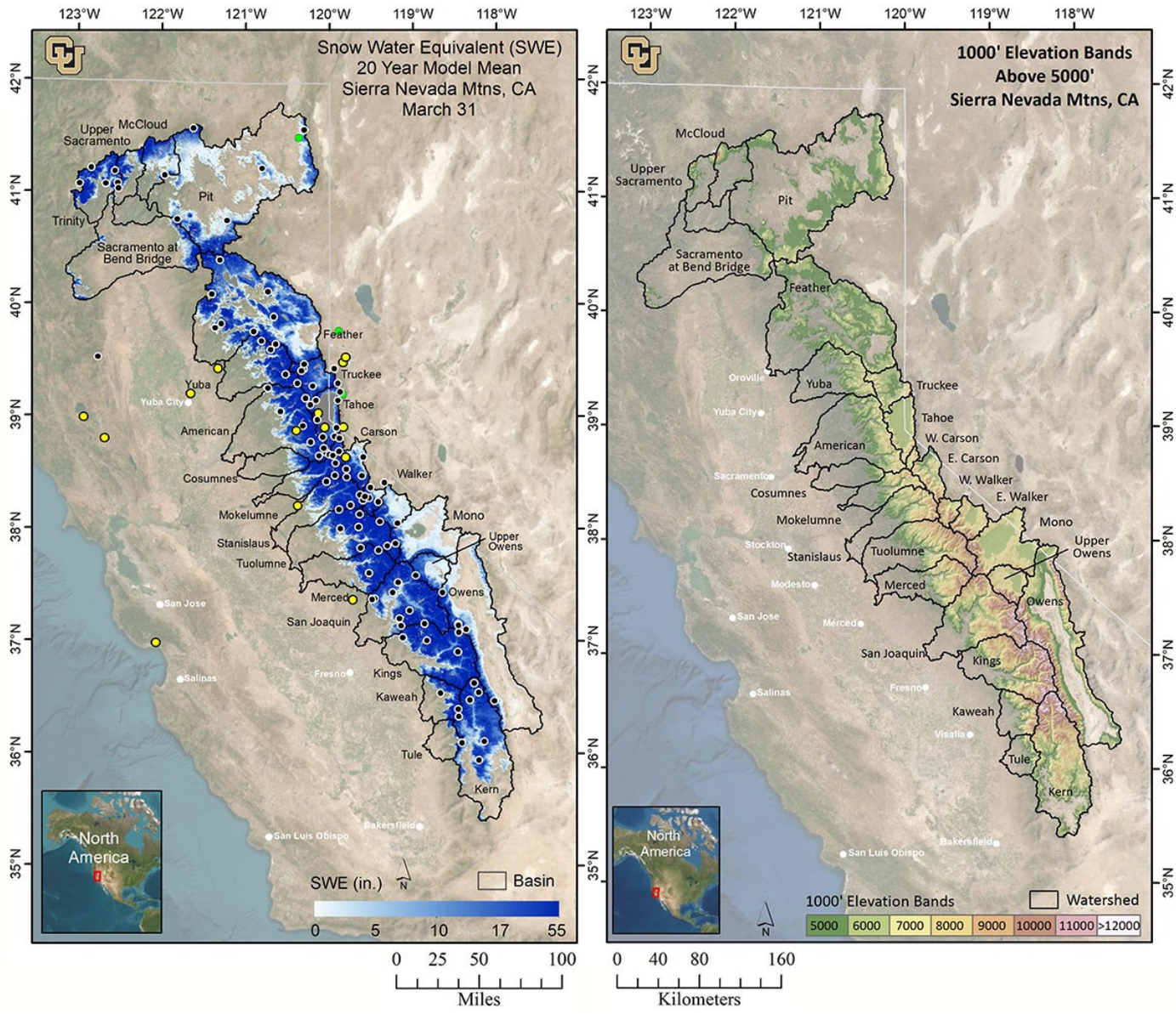


Figure 7. Historical average CU SWE and Elevation Bands for the Sierra Nevada. Long-term (2001-2021) average CU SWE (left), and the Banded Elevation map (right) identifies basins used in this report (black boundaries) and 1000' elevation bands (colored shading) that match those used in Table 1 and Table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

Methods

The spatial SWE-fusion 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 gap-filled and cloud-free MODIS satellite image which has been processed using the Snow Today algorithm (Rittger, et al. 2019, https://nsidc.org/snow-today), the SPIReS algorithm (Bair, et al. 2021), and the MODIS cloud-gap-filled algorithm (Hall, et al. 2019).

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 (1985-2021) 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 Fang, et al. (2022) for details. (For computational efficiency, only one image during the 1985-2021 period that best matches the real-time snow pillow-observed pattern is selected as an independent variable.)

The real-time regression SWE-fusion 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 12 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.

List of All Known Data Issues/Caveats – any of these could apply to this model run

- SATELLITE FSCA - Recent snowpack accumulation may be under-estimated due to issues with satellite-observed fSCA.
- 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 percent of current average SWE (between 2001-2021 as derived from the regression model), mean SWE, percent of snow-covered area, 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), survey data, and snow pillow data, for those areas collected, summarized for each basin. The last column shows mean SWE by basin from SNODAS*.*

Basin	3/15/25 % 3/15 Avg.	3/31/25 % 3/31 Avg.	3/15/25 SWE (in)	3/31/25 SWE (in)	3/31/25 % SCA	3/31/25‡ Vol (af)	Area (mi2) > 5000'	3/31/25 Surveys	3/15/25 Pillows	3/31/25 Pillows	3/31/25 SNODAS* (in)
Trinity	108	119	22.6	28.5	89.3	488,161	321.3	44.0 (1)	31.0 (4)	40.0 (4)	39.5
Upper Sacramento	105	115	19.4	23.9	79.7	146,628	115.2	40.0 (2)	30.3 (1)	30.0 (1)	35.8
McCloud	110	119	18.2	21.9	85.8	192,790	164.9	32.2 (3)	33.3 (1)	39.4 (1)	42.3
Pit	143	138	7.1	6.6	34.7	729,741	2,064.7	15.5 (2)	24.5 (7)	25.7 (7)	7.9
Sac at Bend Bridge	79	88	8.9	11.6	48.2	148,891	239.8	1.0 (1)	NA	NA	17.0
Feather§	90	95	10.3	10.3	52.0	1,151,447	2,086.7	20.2 (20)	27.7 (6)	30.9 (6)	12.9
Yuba	90	95	17.8	19.9	75.6	548,633	515.6	34.5 (12)	43.9 (5)	48.4 (5)	28.8
American§	88	92	17.0	15.4	71.4	651,989	795.5	19.3 (13)	20.8 (11)	21.2 (11)	18.8
Cosumnes	68	76	7.6	8.5	46.5	41,879	91.9	NA	NA	NA	7.8
Mokelumne	88	87	17.0	17.0	63.4	284,711	314.8	23.1 (6)	25.8 (3)	34.0 (2)	18.6
Stanislaus	95	89	17.6	17.2	65.7	510,617	557.0	22.3 (14)	27.3 (5)	29.2 (5)	16.9
Tuolumne§	98	92	16.3	16.4	65.6	795,176	909.8	24.1 (16)	25.9 (7)	25.8 (7)	18.9
Merced	97	90	15.2	15.8	65.9	453,639	538.8	25.6 (6)	28.1 (2)	27.2 (2)	17.9
San Joaquin§	95	87	13.8	14.3	70.8	923,228	1,207.1	22.0 (25)	17.9 (7)	18.0 (7)	15.3
Kings	93	85	16.5	15.3	69.9	986,158	1,207.0	22.1 (22)	23.4 (6)	18.9 (5)	16.9
Kaweah	94	86	9.8	10.9	62.6	182,478	314.1	24.0 (3)	20.8 (2)	20.3 (2)	13.0
Tule	103	104	5.4	4.5	49.8	33,385	137.6	NA	11.3 (1)	6.9 (1)	3.0
Kern§	89	74	6.3	4.7	34.6	422,926	1,682.2	14.1 (11)	16.0 (6)	17.0 (6)	5.4
Truckee	98	91	16.3	13.1	59.3	288,269	411.5	33.5 (1)	19.5 (6)	20.9 (6)	15.7
Tahoe	93	90	16.1	15.0	67.5	244,752	304.9	25.7 (2)	21.4 (7)	20.8 (7)	14.1
W Carson	102	99	20.9	18.9	77.2	65,629	65.0	NA	20.6 (3)	20.9 (3)	17.5
E Carson	103	92	13.6	10.7	47.7	202,852	354.3	NA	14.3 (4)	14.2 (4)	10.4
W Walker	108	99	19.6	16.9	66.4	161,776	179.6	21.0 (1)	21.7 (4)	22.3 (4)	19.4
E Walker	124	93	9.0	6.2	33.9	115,556	350.7	NA	14.7 (1)	15.4 (1)	6.5
Mono	159	80	4.4	3.0	18.3	159,401	1,002.9	NA	NA	NA	1.9
Upper Owens	107	81	8.5	6.1	36.3	120,796	373.7	25.5 (3)	36.4 (1)	38.0 (1)	4.4
Owens	104	74	4.0	2.9	19.9	271,265	1,772.0	10.9 (8)	14.9 (5)	14.5 (5)	2.5

§ Data in all ASO-collected basins have been bias-corrected using ASO data and therefore the SWE changes might not represent snowmelt/accumulation 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.

* This is a comparison to the SNODAS (SNOw Data Assimilation System) nationwide product from the National Weather Service.

† Deep and recent snow in areas that typically are snow-free can report high percent of average for this date because the mean 2001-2021 regression-derived SWE for that area is low or 0.

- Data omitted due to inconsistencies with independent SWE estimates.

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

Basin	Elevation Band	3/15/25 % 3/15 Avg.	3/31/25 % 3/31 Avg.	3/15/25 SWE (in)	3/31/25 SWE (in)	3/31/25 % SCA	3/31/25‡ Vol (af)	Area (mi2) > 5000'	3/31/25 Surveys	3/15/25 Pillows	3/31/25 Pillows	3/31/25 SNODAS* (in)
Trinity	5000-6000'	112	128	19.0	24.5	85.1	198,660	152.3	NA	28.2 (2)	33.8 (2)	29.2
	6000-7000'	107	115	25.0	31.4	93.0	222,477	132.9	44.0 (1)	33.9 (2)	46.2 (2)	47.1
	7000-8000'	101	105	28.6	34.7	93.7	65,078	35.1	NA	NA	NA	55.7
	> 8000'	95	97	31.3	37.8	88.0	1,947	1.0	NA	NA	NA	58.5
Upper Sacramento	5000-6000'	106	121	16.4	19.9	73.7	67,937	64.1	36.0 (1)	30.3 (1)	30.0 (1)	25.7
	6000-7000'	106	114	21.8	27.1	86.6	52,358	36.2	44.0 (1)	NA	NA	44.0
	7000-8000'	102	105	24.3	30.2	91.6	14,131	8.8	NA	NA	NA	54.3
	8000-9000'	100	102	22.9	26.4	72.2	3,258	2.3	NA	NA	NA	64.6
	9000-10,000'	89	87	30.0	37.7	95.1	3,492	1.7	NA	NA	NA	74.9
	10,000-11,000'	85	82	32.0	43.7	88.1	2,025	0.9	NA	NA	NA	67.3
	> 11,000'	96	91	44.5	55.5	91.8	3,426	1.2	NA	NA	NA	59.7
McCloud	5000-6000'	118	132	14.3	17.3	82.8	89,074	96.8	28.5 (2)	33.3 (1)	39.4 (1)	32.5
	6000-7000'	108	116	21.5	25.9	89.3	57,672	41.7	39.5 (1)	NA	NA	46.2
	7000-8000'	100	105	24.5	29.4	92.0	22,237	14.2	NA	NA	NA	64.9
	8000-9000'	100	105	25.1	30.1	85.5	10,398	6.5	NA	NA	NA	80.1
	9000-10,000'	98	99	31.9	37.1	89.0	6,112	3.1	NA	NA	NA	75.8
	10,000-11,000'	89	89	37.1	44.2	96.8	3,411	1.5	NA	NA	NA	79.8
	> 11,000'	87	80	51.6	62.9	98.9	3,886	1.2	NA	NA	NA	68.0
Pit	5000-6000'	161	140	3.7	2.5	17.5	184,581	1,410.4	NA	44.4 (1)	49.9 (1)	4.0
	6000-7000'	133	139	12.3	12.8	66.3	343,028	503.5	8.0 (1)	22.8 (3)	23.2 (3)	13.1
	7000-8000'	125	132	20.6	24.0	90.0	165,378	129.4	23.0 (1)	19.6 (3)	20.2 (3)	28.3
	8000-9000'	128	137	27.5	31.9	93.1	33,025	19.4	NA	NA	NA	30.6
	> 9,000'	111	119	27.6	36.2	98.0	3,730	1.9	NA	NA	NA	41.0
Sac at Bend Bridge	5000-6000'	64	77	4.2	6.0	31.8	49,796	156.1	1.0 (1)	NA	NA	10.2
	6000-7000'	92	97	14.2	18.9	75.0	63,620	63.1	NA	NA	NA	24.9
	7000-8000'	100	100	27.2	31.4	91.3	26,205	15.6	NA	NA	NA	40.9
	8000-9000'	96	94	31.2	35.2	88.4	8,159	4.3	NA	NA	NA	55.3
	> 9,000'	92	90	29.9	35.9	90.8	1,110	0.6	NA	NA	NA	67.5
Feather§	5000-6000'	77	89	5.9	5.8	39.9	380,358	1,228.9	14.7 (11)	30.5 (1)	33.2 (1)	8.8
	6000-7000'	101	99	15.0	14.7	65.9	571,374	730.6	27.4 (7)	29.8 (4)	33.2 (4)	17.5
	7000-8000'	105	105	26.1	29.2	88.5	190,824	122.4	25.2 (2)	16.5 (1)	19.3 (1)	26.7
	> 8,000'	102	99	34.4	34.5	86.5	8,891	4.8	NA	NA	NA	34.9
Yuba	5000-6000'	54	69	6.2	7.5	43.8	76,581	190.9	15.5 (3)	NA	NA	16.6
	6000-7000'	102	104	22.2	24.5	93.2	270,366	207.2	33.6 (4)	42.3 (4)	46.7 (4)	33.0
	7000-8000'	108	106	28.7	32.0	95.9	191,395	112.3	46.7 (5)	50.5 (1)	55.1 (1)	40.7
	> 8,000'	106	103	31.9	37.0	96.1	10,292	5.2	NA	NA	NA	54.8
American§	5000-6000'	47	67	4.8	2.3	40.5	34,879	289.8	8.3 (3)	9.1 (4)	7.5 (4)	5.7
	6000-7000'	100	99	20.0	16.0	85.8	226,240	264.6	19.6 (7)	30.7 (1)	32.4 (1)	19.6
	7000-8000'	107	104	27.4	28.7	93.7	253,576	165.8	29.5 (3)	25.3 (4)	26.3 (4)	32.4
	8000-9000'	106	102	29.8	34.0	90.6	122,878	67.9	NA	30.1 (2)	33.0 (2)	36.5
	> 9,000'	100	97	31.9	36.4	87.6	14,416	7.4	NA	NA	NA	35.5
Cosumnes	5000-6000'	42	54	2.1	3.1	24.6	10,011	60.5	NA	NA	NA	2.6
	6000-7000'	91	94	15.6	16.5	86.6	20,889	23.8	NA	NA	NA	13.0
	> 7,000'	104	102	26.2	27.0	95.4	10,980	7.6	NA	NA	NA	32.6
Mokelumne	5000-6000'	24	22	1.3	1.1	9.0	4,574	81.1	NA	NA	NA	0.8
	6000-7000'	83	80	12.5	11.5	66.7	38,822	63.1	13.5 (1)	11.1 (1)	NA	10.3
	7000-8000'	104	101	23.9	24.3	88.2	111,573	86.2	16.0 (2)	NA	NA	27.6
	8000-9000'	106	102	28.0	28.8	88.5	117,897	76.8	31.0 (3)	33.2 (2)	34.0 (2)	32.8
	> 9,000'	103	99	29.1	29.5	83.6	11,845	7.5	NA	NA	NA	32.5
Stanislaus	5000-6000'	36	15	1.9	0.4	4.0	2,340	105.1	NA	NA	NA	0.1
	6000-7000'	90	77	13.1	10.6	60.4	73,316	129.4	11.2 (3)	NA	NA	7.9
	7000-8000'	102	98	20.8	21.1	86.5	160,653	142.9	20.5 (7)	24.0 (2)	26.0 (2)	21.0
	8000-9000'	107	102	25.8	26.9	88.7	165,640	115.4	36.5 (2)	29.9 (2)	31.6 (2)	29.9
	9000-10,000'	106	100	29.4	31.3	89.7	86,300	51.6	31.2 (2)	29.0 (1)	30.6 (1)	31.0
	10,000-11,000'	101	95	33.1	33.6	89.8	21,814	12.2	NA	NA	NA	27.1
	> 11,000'	95	89	28.4	26.9	85.5	554	0.4	NA	NA	NA	16.0

Basin	Elevation Band	3/15/25 % 3/15 Avg.	3/31/25 % 3/31 Avg.	3/15/25 SWE (in)	3/31/25 SWE (in)	3/31/25 % SCA	3/31/25‡ Vol (af)	Area (mi2) > 5000'	3/31/25 Surveys	3/15/25 Pillows	3/31/25 Pillows	3/31/25 SNODAS* (in)
Tuolumne§	5000-6000'	50	24	1.9	0.5	5.8	4,331	167.5	NA	NA	NA	0.1
	6000-7000'	93	80	8.2	5.5	52.7	41,146	140.5	12.4 (6)	8.8 (1)	6.9 (1)	6.3
	7000-8000'	101	97	13.3	12.6	78.1	99,734	148.4	26.5 (4)	34.3 (1)	32.6 (1)	21.3
	8000-9000'	106	101	21.7	23.4	86.3	206,928	166.1	33.7 (3)	27.7 (3)	27.6 (3)	31.0
	9000-10,000'	106	100	28.2	30.3	88.6	282,425	174.7	31.1 (4)	27.7 (2)	29.0 (2)	31.5
	10,000-11,000'	104	97	27.0	29.0	88.6	133,269	86.3	NA	NA	NA	25.5
	11,000-12,000'	97	89	19.4	20.4	86.4	26,007	23.9	NA	NA	NA	10.9
	> 12,000'	88	79	9.2	10.4	91.3	1,335	2.4	NA	NA	NA	3.2
Merced	5000-6000'	61	39	0.6	0.3	4.9	1,078	69.7	NA	NA	NA	0.3
	6000-7000'	87	71	6.7	4.7	42.6	19,693	78.3	NA	NA	NA	5.5
	7000-8000'	95	90	14.5	14.1	74.2	99,441	131.9	15.5 (1)	NA	NA	17.3
	8000-9000'	101	96	18.5	20.1	81.4	131,665	122.8	30.0 (3)	28.1 (2)	27.2 (2)	27.5
	9000-10,000'	103	96	22.8	25.7	87.9	115,434	84.1	NA	NA	NA	28.6
	10,000-11,000'	100	92	27.4	29.9	89.7	63,328	39.7	27.7 (1)	NA	NA	23.8
	11,000-12,000'	96	88	33.1	34.5	89.5	20,415	11.1	NA	NA	NA	13.0
	> 12,000'	89	80	33.6	35.9	92.4	2,586	1.4	NA	NA	NA	6.4
San Joaquin§	5000-6000'	82	43	1.6	0.1	14.4	813	133.7	NA	NA	NA	0.6
	6000-7000'	89	71	3.4	1.9	48.9	17,357	175.8	13.8 (3)	14.2 (3)	14.2 (3)	6.5
	7000-8000'	93	88	6.9	7.8	76.5	86,157	207.2	18.3 (7)	18.7 (3)	18.2 (3)	14.6
	8000-9000'	96	91	13.3	16.6	82.9	172,448	195.2	23.8 (4)	NA	NA	23.1
	9000-10,000'	98	92	20.7	23.0	84.8	246,109	200.3	24.8 (3)	26.7 (1)	29.1 (1)	25.7
	10,000-11,000'	100	93	26.6	26.6	87.2	221,174	155.9	27.9 (5)	NA	NA	20.2
	11,000-12,000'	95	87	25.9	25.0	88.8	148,577	111.5	23.7 (3)	NA	NA	12.2
	12,000-13,000	91	81	22.9	21.3	87.4	29,561	26.1	NA	NA	NA	5.8
	> 13,000	86	76	19.0	13.4	89.9	1,033	1.5	NA	NA	NA	3.2
Kings	5000-6000'	79	60	1.1	0.2	12.0	1,030	95.3	NA	NA	NA	0.5
	6000-7000'	84	59	4.9	2.1	33.1	14,474	126.9	12.5 (1)	9.0 (1)	5.5 (1)	3.6
	7000-8000'	84	75	8.9	7.4	59.0	66,441	168.2	9.3 (3)	NA	NA	10.3
	8000-9000'	91	85	16.2	13.6	75.1	151,911	209.9	22.5 (8)	26.2 (1)	22.2 (1)	20.7
	9000-10,000'	97	90	21.5	19.0	82.4	219,464	216.7	26.2 (4)	25.2 (1)	26.7 (1)	25.8
	10,000-11,000'	99	91	23.4	24.2	89.3	252,382	195.8	26.5 (5)	30.8 (2)	21.8 (1)	25.0
	11,000-12,000'	96	88	25.2	27.0	92.2	212,162	147.4	27.5 (1)	18.6 (1)	18.2 (1)	18.8
	12,000-13,000	92	82	28.1	27.5	92.7	64,546	44.0	NA	NA	NA	11.9
	>13,000'	86	75	31.5	25.1	91.6	3,749	2.8	NA	NA	NA	6.7
Kaweah	5000-6000'	178	>200†	0.3	0.1	9.1	190	55.5	NA	NA	NA	0.3
	6000-7000'	106	89	3.5	1.5	40.0	4,830	59.5	NA	5.5 (1)	3.5 (1)	2.8
	7000-8000'	84	78	8.0	7.0	73.5	22,577	60.1	NA	NA	NA	8.3
	8000-9000'	89	82	11.5	14.8	86.0	44,755	56.8	20.5 (2)	NA	NA	15.6
	9000-10,000'	97	90	17.1	22.2	90.1	51,426	43.4	31.0 (1)	36.2 (1)	37.1 (1)	28.9
	10,000-11,000'	99	91	25.2	28.1	91.7	44,212	29.5	NA	NA	NA	33.3
	>11,000'	95	86	26.1	29.3	91.8	14,487	9.3	NA	NA	NA	28.9
Tule	5000-6000'	>200†	>200†	0.1	0.1	7.3	186	51.6	NA	NA	NA	0.1
	6000-7000'	151	181	3.2	1.8	55.5	3,907	40.0	NA	NA	NA	1.1
	7000-8000'	91	91	10.7	8.9	92.4	12,707	26.8	NA	11.3 (1)	6.9 (1)	4.7
	8000-9000'	86	80	15.9	14.8	92.8	11,954	15.2	NA	NA	NA	10.2
	> 9,000'	94	86	21.8	21.4	92.4	4,631	4.1	NA	NA	NA	20.4
Kern§	5000-6000'	55	11	0.2	0.0	0.5	62	246.2	NA	NA	NA	0.0
	6000-7000'	78	39	2.0	0.3	7.8	5,111	341.5	NA	NA	NA	0.1
	7000-8000'	86	53	4.9	1.5	22.8	26,903	326.6	NA	3.7 (1)	0.7 (1)	0.6
	8000-9000'	88	77	6.8	4.9	49.3	81,736	314.7	10.0 (4)	NA	NA	3.5
	9000-10,000'	91	84	9.3	8.1	63.0	81,615	189.2	14.8 (2)	17.7 (2)	20.6 (2)	14.8
	10,000-11,000'	96	88	14.6	14.1	74.6	97,402	129.2	16.2 (3)	15.7 (2)	16.1 (2)	21.3
	11,000-12,000'	99	89	19.1	17.7	81.8	86,291	91.2	18.5 (2)	25.4 (1)	27.6 (1)	18.8
	12,000-13,000	93	82	17.3	19.2	80.3	38,465	37.6	NA	NA	NA	12.0
	>13,000'	87	76	14.4	17.0	73.7	5,340	5.9	NA	NA	NA	5.8

Basin	Elevation Band	3/15/25 % 3/15 Avg.	3/31/25 % 3/31 Avg.	3/15/25 SWE (in)	3/31/25 SWE (in)	3/31/25 % SCA	3/31/25‡ Vol (af)	Area (mi2) > 5000'	3/31/25 Surveys	3/15/25 Pillows	3/31/25 Pillows	3/31/25 SNODAS* (in)
Truckee	5000-6000'	92	36	8.8	1.1	10.0	3,402	58.2	NA	NA	NA	4.8
	6000-7000'	95	92	13.9	9.5	54.4	103,308	203.3	33.5 (1)	17.1 (4)	16.8 (4)	10.4
	7000-8000'	102	101	21.3	21.1	83.6	125,306	111.6	NA	24.5 (2)	29.0 (2)	24.9
	8000-9000'	105	101	25.6	27.5	89.5	44,714	30.5	NA	NA	NA	38.2
	9000-10,000'	106	99	26.5	27.5	88.4	10,895	7.4	NA	NA	NA	33.2
	10,000-11,000'	105	97	28.2	25.0	80.2	644	0.5	NA	NA	NA	27.8
Tahoe	6000-7000'	75	70	7.6	5.8	44.5	34,833	111.7	NA	17.5 (2)	16.7 (2)	4.1
	7000-8000'	97	95	18.0	17.1	78.9	96,140	105.4	25.7 (2)	23.7 (4)	23.1 (4)	18.6
	8000-9000'	103	100	24.2	23.9	83.8	89,648	70.3	NA	19.7 (1)	19.9 (1)	25.0
	9000-10,000'	103	99	26.2	26.0	83.0	22,890	16.5	NA	NA	NA	26.1
	> 10,000'	98	93	22.1	21.9	81.5	1,242	1.1	NA	NA	NA	17.3
W. Carson	5000-6000'	74	0	2.6	0.0	0.0	0	0.3	NA	NA	NA	0.6
	6000-7000'	82	43	7.1	1.7	21.0	173	1.9	NA	NA	NA	1.9
	7000-8000'	102	98	18.4	15.8	74.6	23,487	27.8	NA	NA	NA	16.1
	8000-9000'	105	101	23.6	21.9	82.3	32,335	27.7	NA	20.6 (3)	20.9 (3)	19.3
	9000-10,000'	101	99	24.9	25.2	86.3	9,328	7.0	NA	NA	NA	21.0
	> 10,000'	87	83	23.4	19.9	78.7	307	0.3	NA	NA	NA	18.0
E. Carson	5000-6000'	49	27	0.7	0.1	1.9	115	32.6	NA	NA	NA	0.0
	6000-7000'	99	56	5.5	1.0	11.7	4,435	79.3	NA	0.9 (1)	0.0 (1)	0.5
	7000-8000'	108	94	12.4	7.8	46.9	41,510	100.2	NA	16.5 (1)	16.4 (1)	7.2
	8000-9000'	106	102	20.4	18.6	77.5	96,621	97.3	NA	19.9 (2)	20.2 (2)	18.8
	9000-10,000'	103	97	24.9	24.8	83.3	45,908	34.7	NA	NA	NA	25.6
	>10,000'	101	94	26.1	26.1	78.6	14,265	10.2	NA	NA	NA	21.2
W. Walker	6000-7000'	124	56	4.8	0.3	5.9	126	7.3	NA	NA	NA	0.0
	7000-8000'	122	83	7.9	3.3	28.9	6,893	38.7	NA	6.0 (1)	4.7 (1)	2.3
	8000-9000'	109	105	16.7	14.3	74.2	35,076	46.1	21.0 (1)	16.8 (2)	17.1 (2)	18.8
	9000-10,000'	106	102	26.4	24.6	84.1	79,617	60.6	NA	47.1 (1)	50.2 (1)	29.9
	10,000-11,000'	102	97	30.1	28.5	84.5	37,864	24.9	NA	NA	NA	27.2
	> 11,000'	95	89	25.3	21.4	73.7	2,200	1.9	NA	NA	NA	17.7
E. Walker	6000-7000'	>200†	18	1.0	0.0	1.2	72	56.7	NA	NA	NA	0.0
	7000-8000'	163	53	3.8	0.8	9.8	4,560	110.4	NA	NA	NA	0.7
	8000-9000'	127	99	9.3	5.0	39.7	23,527	88.1	NA	NA	NA	6.0
	9000-10,000'	107	106	17.9	15.3	74.0	43,658	53.5	NA	14.7 (1)	15.4 (1)	17.6
	10,000-11,000'	102	100	21.6	20.1	79.0	37,240	34.7	NA	NA	NA	19.1
	>11,000'	101	97	19.4	16.6	74.7	6,500	7.3	NA	NA	NA	11.0
Mono	6000-7000'	>200†	23	0.5	0.0	0.8	80	297.2	NA	NA	NA	0.0
	7000-8000'	>200†	36	1.9	0.2	4.8	4,695	389.7	NA	NA	NA	0.0
	8000-9000'	135	78	6.0	2.5	28.8	24,197	178.8	NA	NA	NA	1.0
	9000-10,000'	105	97	13.0	11.5	72.6	38,720	62.9	NA	NA	NA	10.7
	10,000-11,000'	101	98	21.9	23.0	88.5	56,758	46.3	NA	NA	NA	17.6
	11,000-12,000'	97	91	23.4	23.7	85.8	29,962	23.8	NA	NA	NA	9.9
	> 12,000'	91	85	21.5	22.0	84.1	4,990	4.3	NA	NA	NA	3.3
Upper Owens	6000-7000'	165	4	1.2	0.0	0.3	12	60.9	NA	NA	NA	0.0
	7000-8000'	120	57	4.9	1.3	13.7	10,226	143.3	NA	NA	NA	0.2
	8000-9000'	98	88	11.1	7.4	59.7	29,877	75.3	20.5 (2)	NA	NA	6.1
	9000-10,000'	102	96	14.1	13.1	71.2	30,655	43.8	35.5 (1)	36.4 (1)	38.0 (1)	13.8
	10,000-11,000'	102	98	18.0	17.6	77.9	30,021	32.0	NA	NA	NA	13.3
	11,000-12,000'	103	96	21.5	20.8	80.9	17,243	15.5	NA	NA	NA	7.4
	> 12,000'	103	97	19.1	17.9	81.4	2,761	2.9	NA	NA	NA	2.8
Owens	5000-6000'	>200†	4	0.0	0.0	0.4	0	421.9	NA	NA	NA	0.0
	6000-7000'	>200†	12	0.1	0.0	1.4	51	342.5	NA	NA	NA	0.0
	7000-8000'	163	10	0.7	0.0	2.9	549	314.8	NA	NA	NA	0.1
	8000-9000'	116	36	2.0	0.5	14.9	4,761	178.7	6.0 (1)	NA	NA	2.0
	9000-10,000'	95	67	5.8	3.2	41.5	25,151	147.4	9.8 (4)	14.1 (3)	14.0 (3)	6.3
	10,000-11,000'	94	82	11.4	8.5	62.3	74,366	163.7	12.8 (2)	16.0 (2)	15.2 (2)	9.6
	11,000-12,000'	93	85	18.0	14.7	72.6	103,492	131.9	16.5 (1)	NA	NA	9.0
	12,000-13,000	93	83	20.7	16.9	72.0	55,933	62.1	NA	NA	NA	5.4
	>13,000'	95	83	18.7	14.2	66.7	6,960	9.2	NA	NA	NA	3.0

§ Data in all ASO-collected basins have been bias-corrected using ASO data and therefore the SWE changes might not represent snowmelt/accumulation 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.

* This is a comparison to the SNODAS (SNOw Data Assimilation System) nationwide product from the National Weather Service.

- Data omitted due to inconsistencies with independent SWE estimates.

† Deep and recent snow in areas that typically are snow-free can report high percent of average for this date because the mean 2001-2021 regression-derived SWE for that area is low or 0.

Location of Reports and Excel Format Tables

https://github.com/CU-Mountain-Hydrology/SierraNevada

References and Additional Sources

Bair, E.H., T. Stillinger and J. Dozier. (2021). Snow Property Inversion From Remote Sensing (SPIReS): A Generalized Multispectral Unmixing Approach With Examples From MODIS and Landsat 8 OLI. IEEE Transactions on Geoscience and Remote Sensing, 59(9): 7270-7284. DOI: 10.1109/TGRS.2020.3040328.

Fang, Y., Liu, Y. & Margulis, S.A. A western United States snow reanalysis dataset over the Landsat era from water years 1985 to 2021 (2022). Sci Data 9, 677. https://doi.org/10.1038/s41597-022-01768-7.

Hall, D. K., G. A. Riggs, N.E. DiGirolamo and M.O. Román (2019). MODIS Cloud-Gap Filled Snow-Cover Products: Advantages and Uncertainties. *Hydrology and Earth System Sciences*, 23:5227-5241. DOI: 10.5194/hess-23-5227-2019.

Molotch, N.P. (2009). Reconstructing snow water equivalent in the Rio Grande headwaters using remotely sensed snow cover data and a spatially distributed snowmelt model. *Hydrological Processes*, 23. DOI: 10.1002/hyp.7206, 2009.

Molotch, N.P., and S.A. Margulis. (2008). Estimating the distribution of snow water equivalent using remotely sensed snow cover data and a spatially distributed snowmelt model: a multi-resolution, multi-sensor comparison. *Advances in Water Resources*, 31.

Molotch, N.P., and R.C. Bales. (2006). Comparison of ground-based and airborne snow-surface albedo parameterizations in an alpine watershed: impact on snowpack mass balance. *Water Resources Research*, 42, DOI:10.1029/2005WR004522.

Molotch, N.P., and R.C. Bales. (2005). Scaling snow observations from the point to the grid-element: implications for observation network design. *Water Resources Research*, 41. DOI: 10.1029/2005WR004229.

Molotch, N.P., T.H. Painter, R.C. Bales, and J. Dozier. (2004). Incorporating remotely sensed snow albedo into a spatially distributed snowmelt model. *Geophysical Research Letters*, 31. DOI:10.1029/2003GL019063, 2004.

Rittger, K., M. S. Raleigh, J. Dozier, A. F. Hill, J. A. Lutz, and T. H. Painter. 2019. Canopy Adjustment and Improved Cloud Detection for Remotely Sensed Snow Cover Mapping. Water Resources Research 24 August 2019. DOI:10.1029/2019WR024914.

Schneider D. and N.P. Molotch. (2016). Real-time estimation of snow water equivalent in the Upper Colorado River Basin using MODIS-based SWE reconstructions and SNOTEL data. *Water Resources Research*, 52(10): 7892-7910. DOI: 10.1002/2016WR019067.

Yang, K., K. N. Musselman, K. Rittger, S. A. Margulis, T. H. Painter and N. P. Molotch. (2022). Combining ground-based and remotely sensed snow data in a linear regression model for real-time estimation of snow water equivalent. *Advances in Water Resources,* 160, 2022, 104075. DOI: 10.1016/j.advwatres.2021.104075.