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

Western United States Region

March 31, 2025

Team: Noah Molotch[1,2] , Karl Rittger[1], 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
Report generation funded by: U.S. Bureau of Reclamation
Contact: Leanne.Lestak@colorado.edu

Introduction

Figure 1 below displays estimated SWE amounts across the Western United States. 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 here. Please note that the basin-wide percent of long-term average from the spatial SWE estimates is not directly comparable with the SNOTEL basin-wide percent of average. A better comparison might be made with the percent of average in the elevation banded tables (linked below) that contain SNOTEL sites.

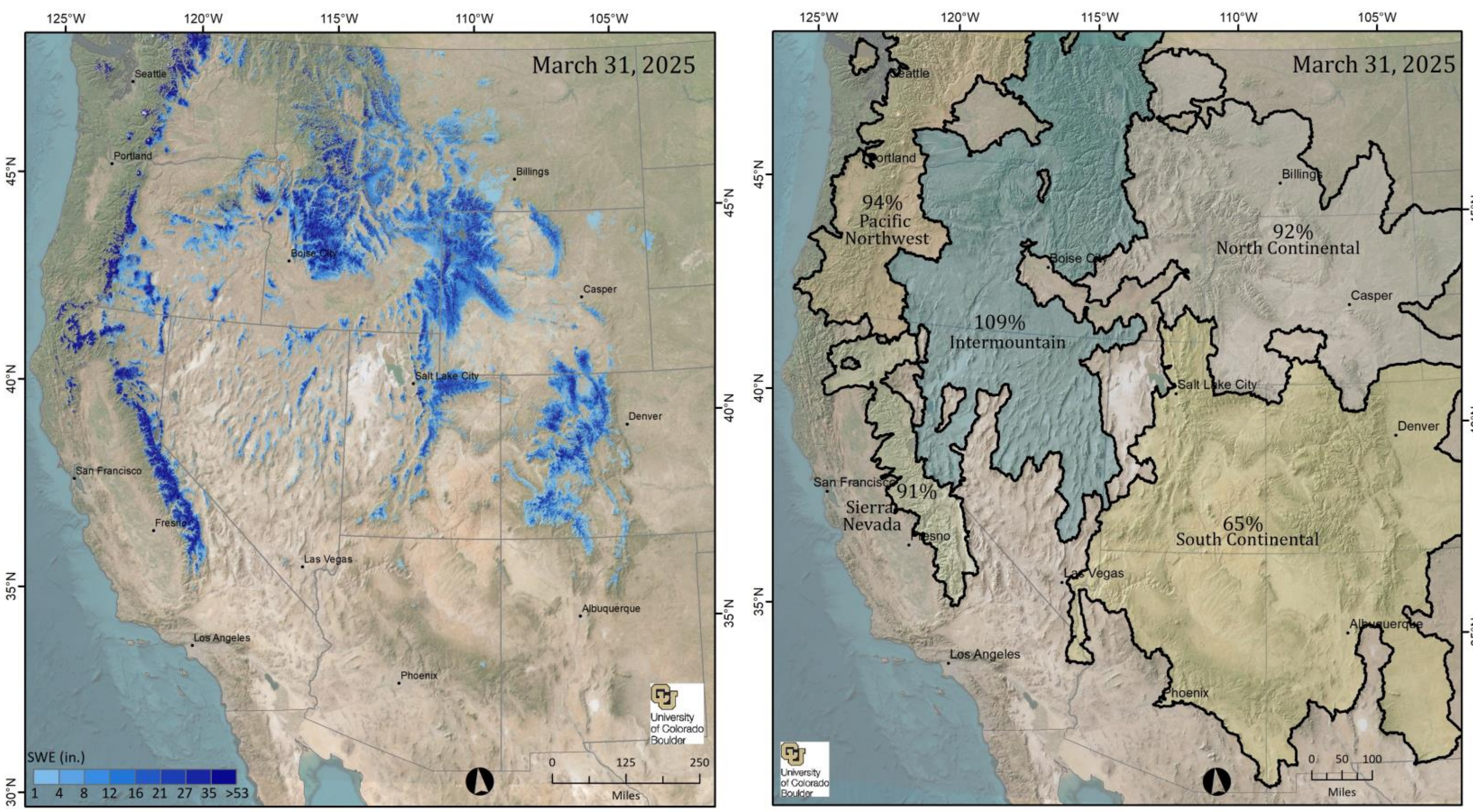

Figure 1. Estimated SWE and % of Average SWE across the Western U.S. SWE amounts across the entire Western region of the United States (left) and percent of long-term average (2001-2021) by five regions (right). Region boundaries are delineated based on Snowpack regimes of the Western United States (Trujillo and Molotch, 2014) and the Commission for Environmental Cooperation (CEC) Ecological Regions of North America, Level III [Commission for Environmental Cooperation, 2009, available at http://www.cec.org/north-american-environmental-atlas/terrestrial-ecoregions-level-iii/].

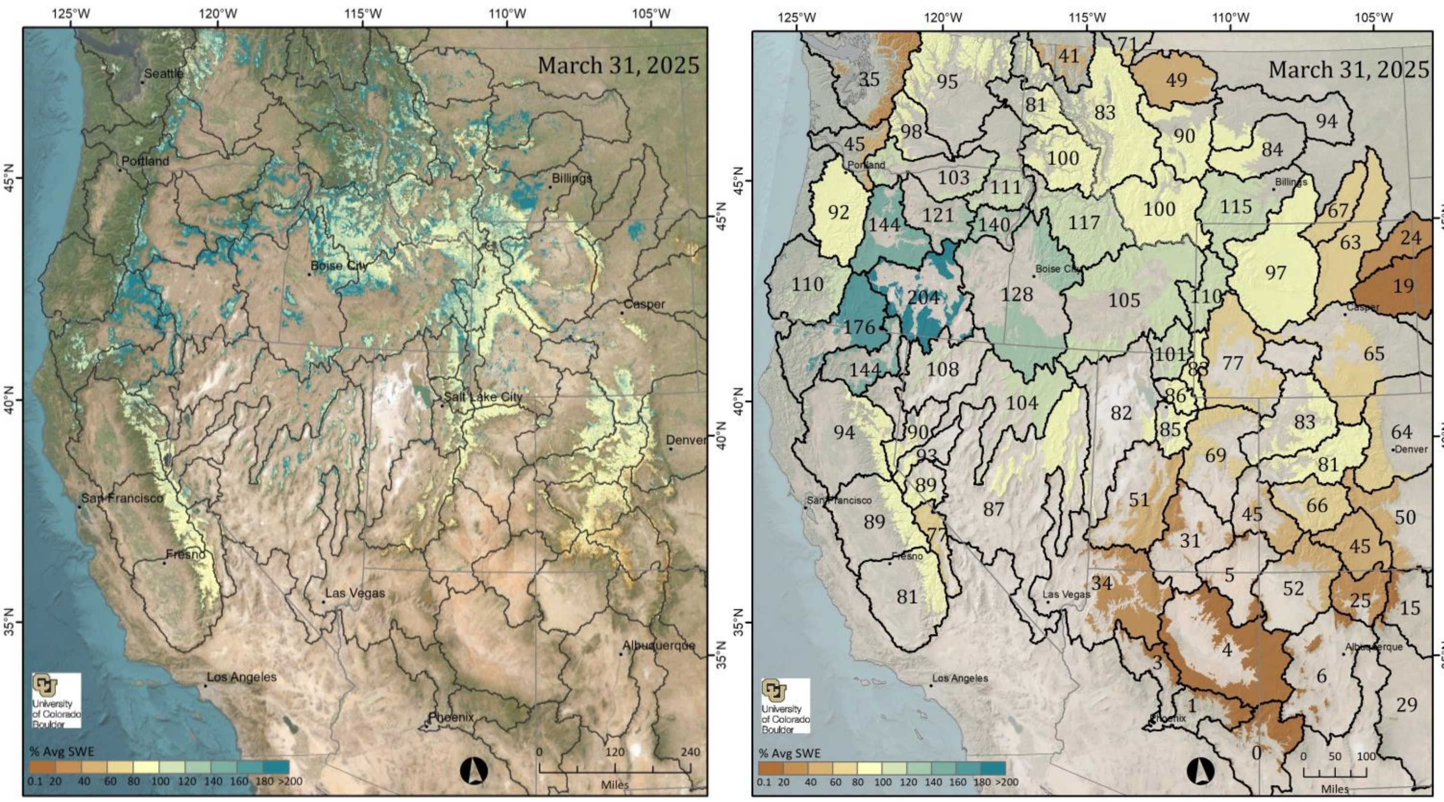

Figure 2. ***Estimated % of Average SWE across the Western U.S.*** Percent of long-term average (2001-2021) from the spatial SWE calculated for each pixel (left) and by HUC-6 basin (right); integer within each watershed represents the percent of average SWE for the report date. Shaded areas (right) correspond to the elevation bands used in the tables below.

For detailed maps and tabular summaries of SWE and snowpack water storage volumes for specific regions and watersheds, click on the links below:

Pacific Northwest
North Continental
South Continental
Intermountain
Sierra Nevada
Elevation Banded SWE Tables

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 meters for the Western region of the United States 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 Sierra Nevada has been distributed to water managers in California since 2012.

The spatial SWE data fusion (SWE-fusion) analysis method for the Western U.S. uses the following data as inputs:

- In-situ SWE from all operational NRCS and CDEC snow pillow sites, and the CoCoRaHS network when appropriate
- Fractional snow-covered area (fSCA) data from recent cloud-free satellite images
- 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 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-fusion product.

Data availability for reporting

Snow pillows located throughout the Western U.S. region are input as the dependent variable in the SWE-fusion system. 799 Natural Resources Conservation Service (NRCS) Snow Telemetry (SNOTEL) sites and 131 California Department of Water Resources (CA-DWR) California Data Exchange Center (CDEC) are potentially available for each model run. In addition, the Community Collaborative Rain, Hail and Snow (CoCoRaHS, https://www.cocorahs.org/) network provides over 500 snow measurements across the modeling domain.

Maps and Tables by Region

Maps and tables for each of the five western regions (Figure 1b) are shown below. Note that the basin-wide averages may reflect variable conditions across the elevation bands; see banded-elevation tables (linked below). Basin-wide percent of average is calculated across all model pixels inside a given basin and base elevation. Basin base elevations vary anywhere between 2,000’ to 7,000’. Base elevations are dependent on long-term snow coverage. For example, a base elevation in the north could be lower as compared to a base elevation in the south.

Pacific Northwest

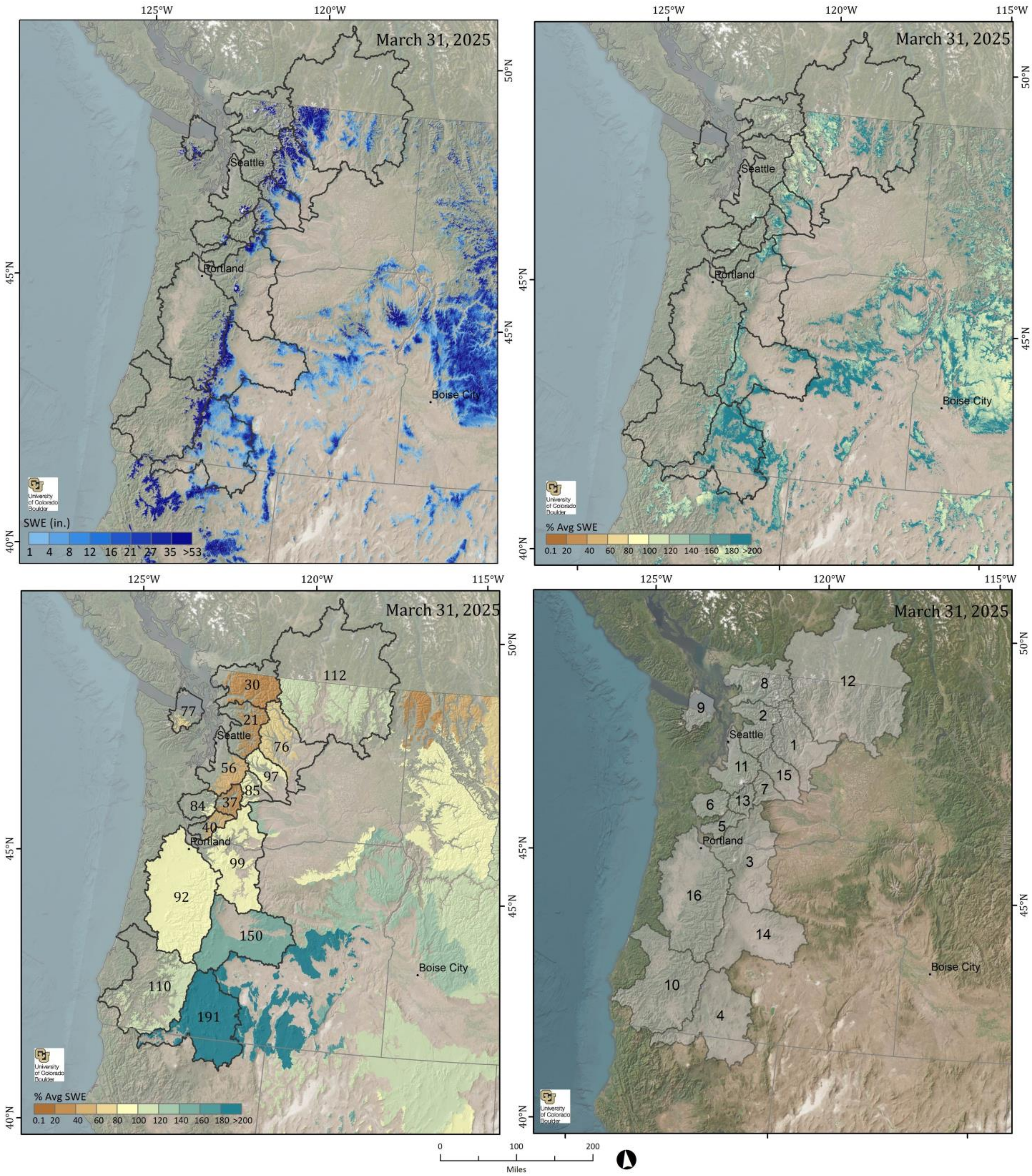

Figure 3. Estimated SWE and % of Average SWE across the Pacific Northwest Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used in the banded-elevation tables*, and basin identification numbers that correspond to Table 1 below (lower right). The North Puget Sound and Upper Columbia basin portions that are inside Canada do not contain SWE-fusion model data due to lack of data availability needed to run the model in Canada.*

Table 1. SWE by watershed. Shown are percent of average SWE to date for the current date (2001-21 as derived from the regression model), mean SWE for the current report, current percent of snow-covered area, current SWE 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), first of the month snow surveys, and current snow pillow sensors (the number of stations are in parentheses), for those areas collected, summarized for each basin. [*SWE tables by banded elevation are here.*]

Pacific Northwest SWE Report for 3/31/2025

	% of Average		SWE (in)					Pillows		Surveys
Basin	3/15	3/31	3/15	3/31	SCA	Vol. (AF)	Area (mi. sq)	3/15	3/31	3/31
1. Central Columbia	105	76	17.4	14.9	45.1	1,695,265	2,136	19.7 (6)	20.4 (7)	NA
2. Central Puget Sound	90	21	8.2	2.6	6.3	169,013	1,238	31.5 (5)	35.3 (5)	26.5 (1)
3. Hood-Sandy-Lower Deschutes	85	99	2.1	2.7	10.8	735,511	5,080	19.1 (11)	22.4 (11)	6.8 (2)
4. Klamath	197	191	5.9	5.8	37.6	2,217,234	7,199	20.5 (16)	21.7 (16)	32.7 (3)
5. Lewis	44	40	2.2	2.5	6.3	76,617	581	31.8 (7)	36.4 (7)	NA
6. Lower Cowlitz	95	84	8.2	7.3	26.2	71,860	185	21.2 (2)	23.1 (2)	NA
7. Naches	104	85	8.8	8.6	37.7	281,144	610	35.7 (4)	40.4 (4)	NA
8. North Puget Sound	84	30	8.1	3.4	9.3	415,528	2,313	33.0 (9)	37.4 (9)	7.2 (6)
9. Olympic	120	77	24.3	18.1	42.4	229,195	238	28.0 (3)	31.7 (3)	14.6 (3)
10. Rogue-Umpqua	106	110	4.2	6.0	16.7	1,080,696	3,371	14.3 (6)	15.7 (6)	13.5 (3)
11. South Puget Sound	64	56	3.6	3.9	8.7	240,309	1,148	19.2 (14)	20.3 (14)	4.5 (4)
12. Upper Columbia	126	112	10.7	8.2	37.5	2,412,176	5,502	14.9 (7)	13.8 (7)	8.4 (7)
13. Upper Cowlitz	68	37	4.8	3.7	7.9	141,527	714	33.2 (3)	37.1 (3)	NA
14. Upper Deschutes-Crooked	150	150	5.0	5.5	25.3	1,646,043	5,608	26.4 (7)	30.0 (7)	14.3 (5)
15. Upper Yakima	111	97	11.0	10.6	43.2	582,075	1,033	20.4 (3)	20.4 (3)	NA
16. Willamette	86	92	1.1	1.7	4.9	1,054,249	11,356	12.6 (18)	15.5 (18)	0.0 (1)

*Basin boundaries were derived from a combination of NRCS basins and HUC8 boundaries.

North Continental

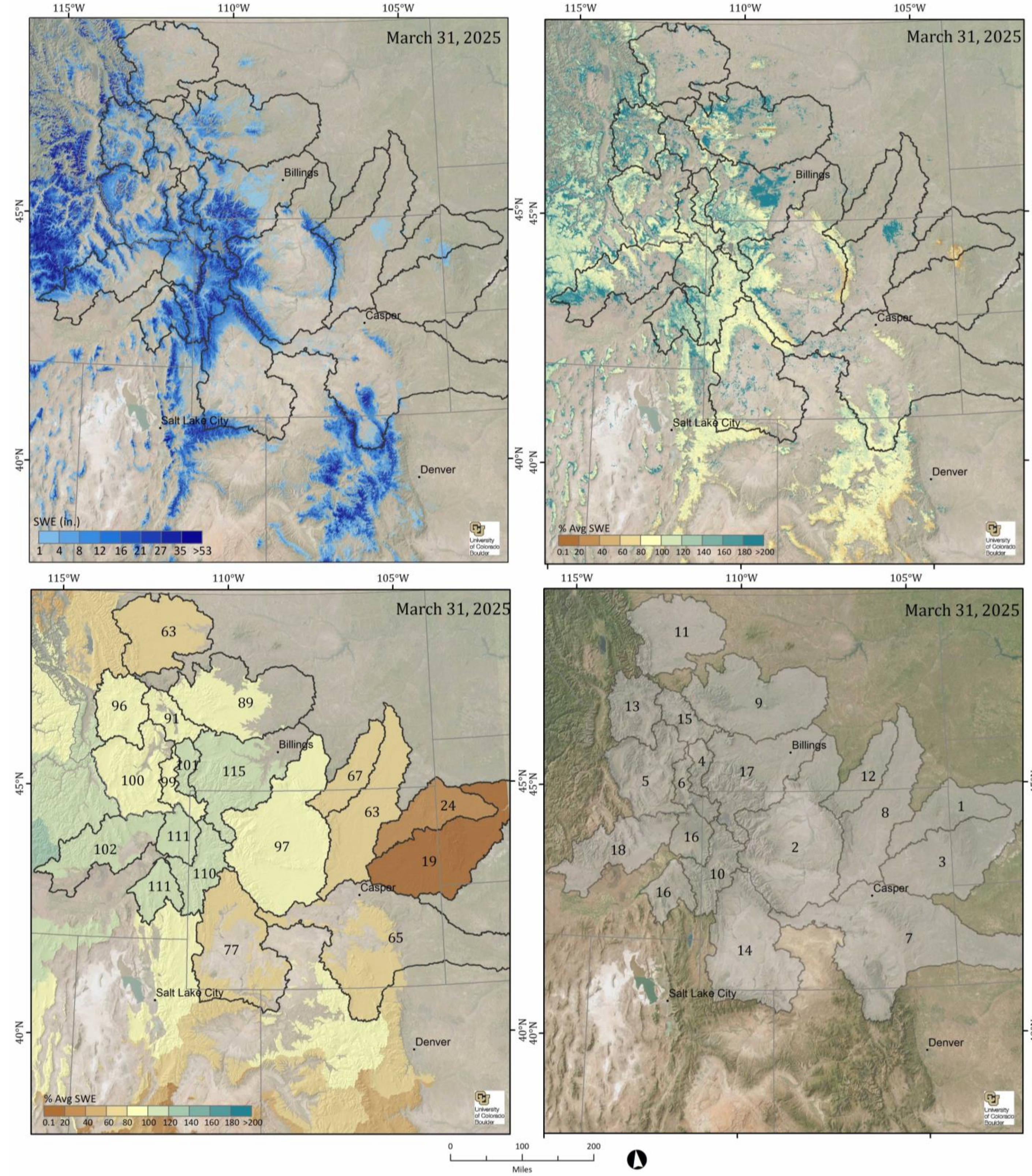

Figure 4. Estimated SWE and % of Average SWE across the North Continental Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used in the banded-elevation tables*, and basin identification numbers that correspond to Table 2 below (lower right).*

Table 2. SWE by watershed. Shown are percent of average SWE to date for the current date (2001-21 as derived from the regression model), mean SWE for the current report, current percent of snow-covered area, current SWE 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), first of the month snow surveys, and current snow pillow sensors (the number of stations are in parentheses), for those areas collected, summarized for each basin. [*SWE tables by banded elevation are here.*]

North Continental SWE Report for 3/31/2025

	% of Average		SWE (in)					Pillows		Surveys
Basin	3/15	3/31	3/15	3/31	SCA	Vol. (AF)	Area (mi. sq)	3/15	3/31	3/31
1. Belle Fourche	37	24	0.3	0.2	4.3	63,366	7,200	5.6 (1)	4.4 (1)	NA
2. Bighorn	135	97	2.9	2.6	21.1	3,095,705	22,740	10.3 (21)	12.0 (21)	20.1 (1)
3. Cheyenne	25	19	0.1	0.0	2.2	27,074	15,348	4.6 (2)	3.3 (2)	NA
4. Gallatin	112	101	6.8	6.4	48.1	630,349	1,846	17.8 (4)	19.9 (4)	13.4 (4)
5. Jefferson	105	100	6.0	5.9	46.7	2,784,910	8,788	10.9 (14)	12.8 (14)	10.6 (8)
6. Madison Headwaters in WY	110	99	7.5	7.1	53.4	958,129	2,524	15.0 (7)	17.3 (7)	9.0 (5)
7. North Platte	78	65	4.0	3.3	27.7	1,816,041	10,281	16.6 (22)	17.9 (22)	15.4 (11)
8. Powder	72	63	0.5	0.4	7.9	273,010	13,385	5.7 (5)	6.3 (5)	NA
9. Smith-Judith-Musselshell	100	89	2.6	2.5	29.8	1,089,304	8,335	12.5 (9)	14.6 (9)	15.8 (3)
10. Snake	89	110	9.7	12.9	85.9	3,871,352	5,626	19.2 (10)	21.8 (11)	12.3 (5)
11. Sun-Teton-Marias	89	63	1.2	1.0	7.5	538,993	10,463	7.1 (5)	7.4 (5)	7.6 (1)
12. Tongue	70	67	0.7	0.7	6.0	215,956	5,400	7.5 (6)	9.3 (6)	NA
13. Upper Clark Fork	110	96	5.5	4.5	38.2	1,445,704	5,981	10.2 (12)	11.3 (12)	6.0 (17)
14. Upper Green	102	77	6.9	4.9	38.5	2,508,253	9,539	12.9 (20)	14.1 (21)	16.8 (2)
15. Upper Missouri	113	91	2.9	2.4	25.5	374,659	2,951	6.7 (2)	6.7 (2)	1.4 (1)
16. Upper Snake Basins	102	111	6.5	6.5	54.1	2,380,640	6,875	19.3 (11)	20.8 (11)	18.8 (13)
17. Upper Yellowstone	108	115	5.9	6.5	53.9	3,826,500	11,070	13.4 (20)	15.2 (20)	8.8 (5)
18. Wood and Lost Basins	105	102	7.3	5.5	39.1	2,167,161	7,420	12.5 (16)	12.9 (16)	6.6 (6)

*Basin boundaries were derived from a combination of NRCS basins and HUC8 boundaries.

South Continental

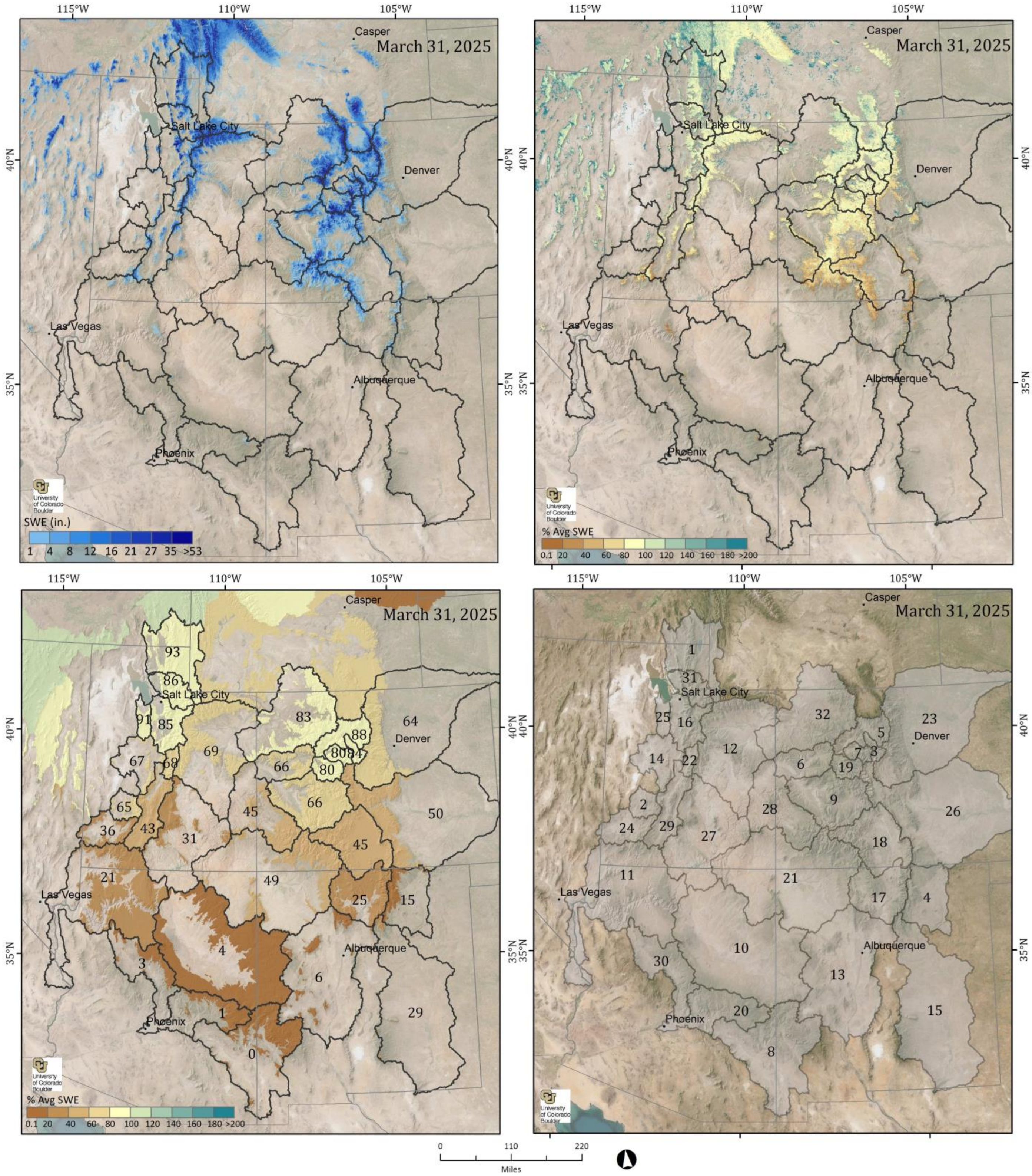

Figure 5. Estimated SWE and % of Average SWE across the South Continental Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in the banded-elevation tables, and basin identification numbers that correspond to Table 3 below (lower right).

Table 3. SWE by watershed. Shown are percent of average SWE to date for the current date (2001-21 as derived from the regression model), mean SWE for the current report, current percent of snow-covered area, current SWE 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), first of the month snow surveys, and current snow pillow sensors (the number of stations are in parentheses), for those areas collected, summarized for each basin. [SWE tables by banded elevation are here.]()

South Continental SWE Report for 3/31/2025

	% of Average		SWE (in)					Pillows		Surveys
Basin	3/15	3/31	3/15	3/31	SCA	Vol. (AF)	Area (mi. sq)	3/15	3/31	3/31
1. Bear	109	93	7.9	5.3	39.6	1,735,147	6,181	16.2 (18)	16.3 (18)	10.9 (7)
2. Beaver	94	65	2.3	1.3	11.1	56,724	836	11.5 (2)	12.3 (2)	NA
3. Blue	98	84	10.2	9.2	68.1	330,043	670	15.5 (5)	16.6 (5)	7.7 (1)
4. Canadian	38	15	0.7	0.3	6.9	17,143	1,265	3.1 (2)	0.1 (1)	0.1 (2)
5. Colorado Headwaters	95	88	8.2	7.7	61.5	1,185,484	2,874	14.4 (13)	15.3 (13)	13.3 (10)
6. Colorado Headwaters-Plateau	84	66	5.8	4.2	34.4	401,437	1,801	11.5 (1)	12.5 (1)	13.7 (1)
7. Eagle	92	80	8.3	7.7	54.0	379,937	921	12.9 (3)	12.3 (3)	16.3 (2)
8. Gila	1	0	0.0	0.0	0.0	137	4,924	0.4 (6)	0.0 (6)	NA
9. Gunnison	79	66	6.0	4.8	43.3	1,640,434	6,433	11.6 (11)	11.1 (11)	11.4 (5)
10. Little Colorado	16	4	0.0	0.0	0.1	2,873	16,379	5.2 (5)	3.2 (5)	1.6 (9)
11. Lower Colorado Mainstream	56	21	0.2	0.1	2.1	45,618	10,695	6.1 (5)	4.0 (5)	1.3 (1)
12. Lower Green	81	69	6.6	5.1	38.5	1,523,006	5,647	10.3 (24)	9.4 (24)	19.8 (1)
13. Lower Rio Grande	10	6	0.1	0.0	0.7	2,916	1,795	2.0 (6)	0.7 (6)	NA
14. Lower Sevier	123	67	3.8	1.5	15.3	71,273	897	11.4 (4)	11.7 (4)	NA
15. Pecos	54	29	1.8	0.9	16.1	15,232	331	1.2 (2)	0.1 (2)	NA
16. Provo-Utah Lake-Jordan	106	85	6.8	4.6	33.2	658,724	2,681	19.9 (17)	20.0 (18)	15.6 (8)
17. Rio Chama-Upper Rio Grande	32	25	0.7	0.5	9.5	149,666	5,207	4.2 (13)	2.9 (13)	2.5 (4)
18. Rio Grande Headwaters	55	45	2.2	1.6	19.3	647,925	7,595	7.7 (14)	6.6 (13)	4.9 (9)
19. Roaring Fork	91	80	9.8	9.1	57.6	659,243	1,359	14.0 (7)	14.0 (7)	16.4 (2)
20. Salt	6	1	0.1	0.0	1.3	1,816	2,361	1.1 (8)	0.0 (8)	NA
21. San Juan	49	49	2.0	1.7	18.1	591,316	6,406	10.1 (14)	8.3 (15)	NA
22. San Pitch	88	68	4.5	3.1	20.1	140,295	857	12.8 (6)	13.0 (6)	14.5 (2)
23. South Platte	59	64	2.5	2.6	24.6	775,114	5,620	11.6 (21)	12.6 (21)	7.4 (23)
24. Southwestern Utah	40	36	0.5	0.4	5.2	32,233	1,440	4.3 (5)	3.3 (5)	1.1 (2)
25. Toole Valley-Vernon Creek	124	91	2.3	1.4	13.5	67,608	906	14.0 (4)	12.7 (4)	NA
26. Upper Arkansas	55	50	1.9	1.5	14.8	469,912	5,875	6.7 (7)	6.2 (7)	7.9 (5)
27. Upper Colorado-Dirty Devil	48	31	2.2	1.1	9.8	150,259	2,597	5.1 (7)	4.3 (7)	10.1 (2)
28. Upper Colorado-Dolores	60	45	2.8	1.9	21.3	348,541	3,434	10.9 (8)	9.4 (9)	5.0 (3)
29. Upper Sevier	56	43	2.4	1.4	14.2	285,145	3,758	7.3 (16)	6.2 (16)	3.5 (2)
30. Verde	38	3	0.3	0.0	0.2	331	1,816	3.2 (7)	0.7 (7)	0.9 (2)
31. Weber-Ogden	101	86	7.7	5.2	36.7	560,645	2,041	18.4 (16)	17.6 (17)	NA
32. White-Yampa	94	83	7.2	5.9	44.0	1,861,337	5,948	17.2 (15)	17.9 (15)	14.4 (4)

*Basin boundaries were derived from a combination of NRCS basins and HUC8 boundaries.

Intermountain

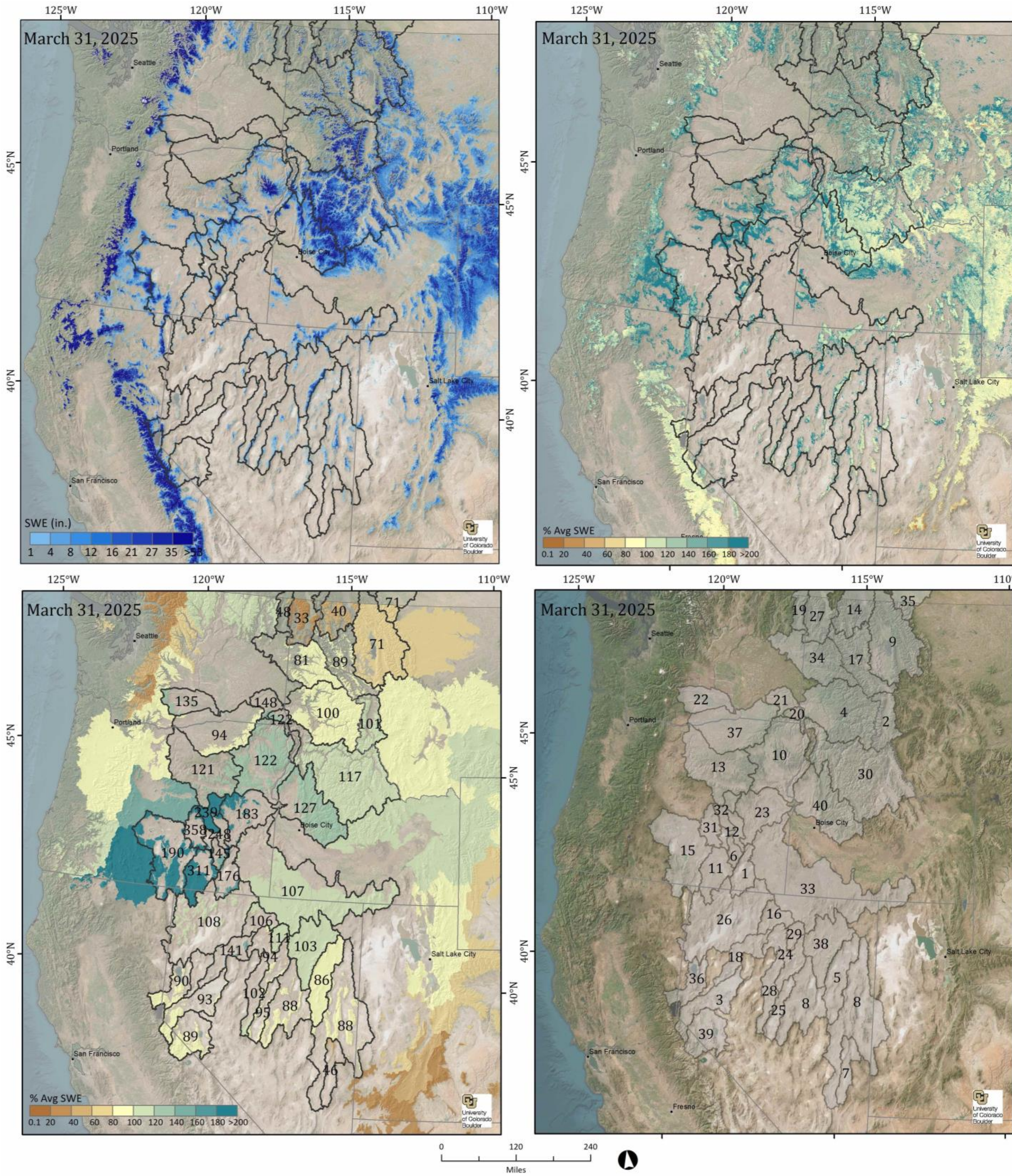

Figure 6. Estimated SWE and % of Average SWE across the Intermountain Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in the banded-elevation tables, and basin identification numbers that correspond to Table 4 below (lower right).

Table 4. SWE by watershed. Shown are percent of average SWE to date for the current date (2001-21 as derived from the regression model), mean SWE for the current report, current percent of snow-covered area, current SWE 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), first of the month snow surveys, and current snow pillow sensors (the number of stations are in parentheses), for those areas collected, summarized for each basin. [SWE tables by banded elevation are here.]

Intermountain SWE Report for 3/31/2025

	% of Average		SWE (in)					Pillows		Surveys
Basin	3/15	3/31	3/15	3/31	SCA	Vol. (AF)	Area (mi. sq)	3/15	3/31	3/31
1. Alvord Lake	149	176	6.2	5.4	40.8	94,144	324	NA	NA	17.6 (2)
2. Bitterroot	104	101	8.4	9.4	51.0	979,767	1,952	17.8 (4)	20.4 (4)	3.5 (1)
3. Carson	106	93	5.4	4.2	20.1	314,038	1,405	17.0 (7)	17.1 (7)	NA
4. Clearwater Basin	97	100	5.1	6.1	29.6	2,451,981	7,488	21.3 (7)	29.5 (11)	NA
5. Clover Valley and Franklin	188	86	2.2	0.7	8.0	160,611	4,048	17.9 (2)	19.9 (2)	NA
6. Donner und Blitzen	133	145	14.1	12.5	74.2	148,365	222	35.2 (2)	38.1 (2)	NA
7. Dry Lake Valley	133	46	3.0	0.6	7.3	9,603	289	NA	NA	NA
8. Eastern Nevada	124	88	4.0	2.0	21.1	468,286	4,372	8.2 (8)	7.6 (8)	4.6 (5)
9. Flathead	90	71	4.0	3.6	21.4	1,432,518	7,526	19.0 (13)	21.1 (13)	12.1 (17)
10. Grande Ronde-Burnt-Powder_Imnaha	123	122	7.1	5.7	35.0	1,627,170	5,312	17.7 (11)	19.8 (11)	20.2 (7)
11. Guano	164	311	1.1	0.8	8.5	82,861	2,036	0.0 (1)	0.0 (1)	6.8 (2)
12. Harney-Malheur Lakes	166	248	4.5	3.1	33.5	45,150	276	NA	NA	0.8 (1)
13. John Day	106	121	6.3	5.9	37.9	469,929	1,502	19.8 (2)	20.0 (2)	NA
14. Kootenai	80	40	3.5	2.1	12.2	188,097	1,673	18.4 (5)	20.8 (5)	21.4 (2)
15. Lake County-Goose Lake	180	190	6.3	5.6	39.7	1,073,258	3,602	22.9 (2)	22.0 (2)	16.6 (5)
16. Little Humboldt	158	106	6.6	2.2	18.0	49,714	419	16.3 (3)	14.0 (3)	NA
17. Lower Clark Fork	118	89	7.9	6.8	36.3	527,589	1,465	32.3 (4)	38.9 (4)	30.9 (5)
18. Lower Humboldt	183	141	4.1	1.4	13.3	20,618	274	10.6 (1)	2.9 (1)	NA
19. Lower Pend Oreille	102	48	7.4	4.4	19.2	30,212	129	23.6 (1)	26.5 (1)	NA
20. Lower Snake-Asotin	135	122	2.5	1.6	14.1	28,189	328	6.7 (2)	6.5 (2)	NA

*Basin boundaries were derived from a combination of NRCS basins and HUC8 boundaries.

Intemountain SWE Report for 3/31/2025											
	% of Average		SWE (in)					Pillows		Surveys
Basin	3/15	3/31	3/15	3/31	SCA	Vol. (AF)	Area (mi. sq)	3/15	3/31	3/31
21. Lower Snake-Tucannon	144	148	7.9	6.1	47.1	35,516	109	NA	NA	NA
22. Lower Yakima	148	135	6.5	5.6	36.7	147,363	489	20.9 (2)	21.1 (2)	NA
23. Malheur	156	183	8.6	6.6	50.9	349,761	992	15.5 (3)	13.4 (3)	NA
24. Middle Humboldt	171	94	3.9	0.8	7.8	27,000	633	NA	NA	NA
25. Northern Big Smoky Valley	132	95	6.0	2.8	23.4	84,465	570	NA	NA	NA
26. Northern Great Basin	127	108	2.4	1.1	8.8	131,496	2,226	6.9 (2)	5.3 (2)	0.4 (1)
27. Panhandle Basins	96	33	3.9	1.6	8.5	139,869	1,644	26.2 (3)	28.2 (3)	20.3 (1)
28. Reese	143	102	6.9	3.4	27.2	88,966	491	15.4 (2)	15.2 (2)	1.9 (2)
29. Rock	166	111	2.2	0.4	4.2	18,717	835	17.8 (1)	17.5 (1)	NA
30. Salmon Basin	109	117	10.8	11.7	61.7	7,443,545	11,932	18.7 (11)	22.0 (11)	9.2 (2)
31. Silver	182	358	4.4	3.7	40.5	84,142	431	NA	NA	NA
32. Silvies	188	239	5.4	3.0	30.7	211,199	1,316	14.5 (2)	13.9 (2)	NA
33. Southern Snake Basins	137	107	3.3	1.5	11.7	978,619	12,500	14.2 (12)	12.2 (13)	8.2 (9)
34. Spokane	123	81	3.4	2.2	12.0	372,928	3,146	16.8 (8)	17.7 (8)	13.2 (6)
35. St. Mary	96	71	8.6	7.6	49.8	260,904	648	7.6 (1)	8.2 (1)	NA
36. Truckee	107	90	6.4	4.9	23.3	368,954	1,420	19.0 (9)	19.9 (9)	34.4 (1)
37. Umatilla-Walla Walla-Willow	96	94	1.8	1.2	9.6	92,949	1,434	17.4 (7)	18.1 (7)	NA
38. Upper Humboldt	127	103	3.3	1.5	11.5	407,719	5,032	15.7 (8)	14.8 (8)	7.4 (7)
39. Walker	135	89	5.2	3.3	17.4	338,806	1,939	18.4 (7)	18.7 (7)	NA
40. West Central Basins	112	127	12.9	12.3	65.0	3,681,449	5,620	24.4 (14)	28.4 (14)	16.3 (8)

*Basin boundaries were derived from a combination of NRCS basins and HUC8 boundaries.

Sierra Nevada

There is a separate SWE report which also includes maps and tables that has a stronger focus on the Sierra Nevada, it is available **here**. The Sierra report incorporates additional vetting and can include bias-corrections with Airborne Snow Observatory data. Below is one of the maps from the current report.

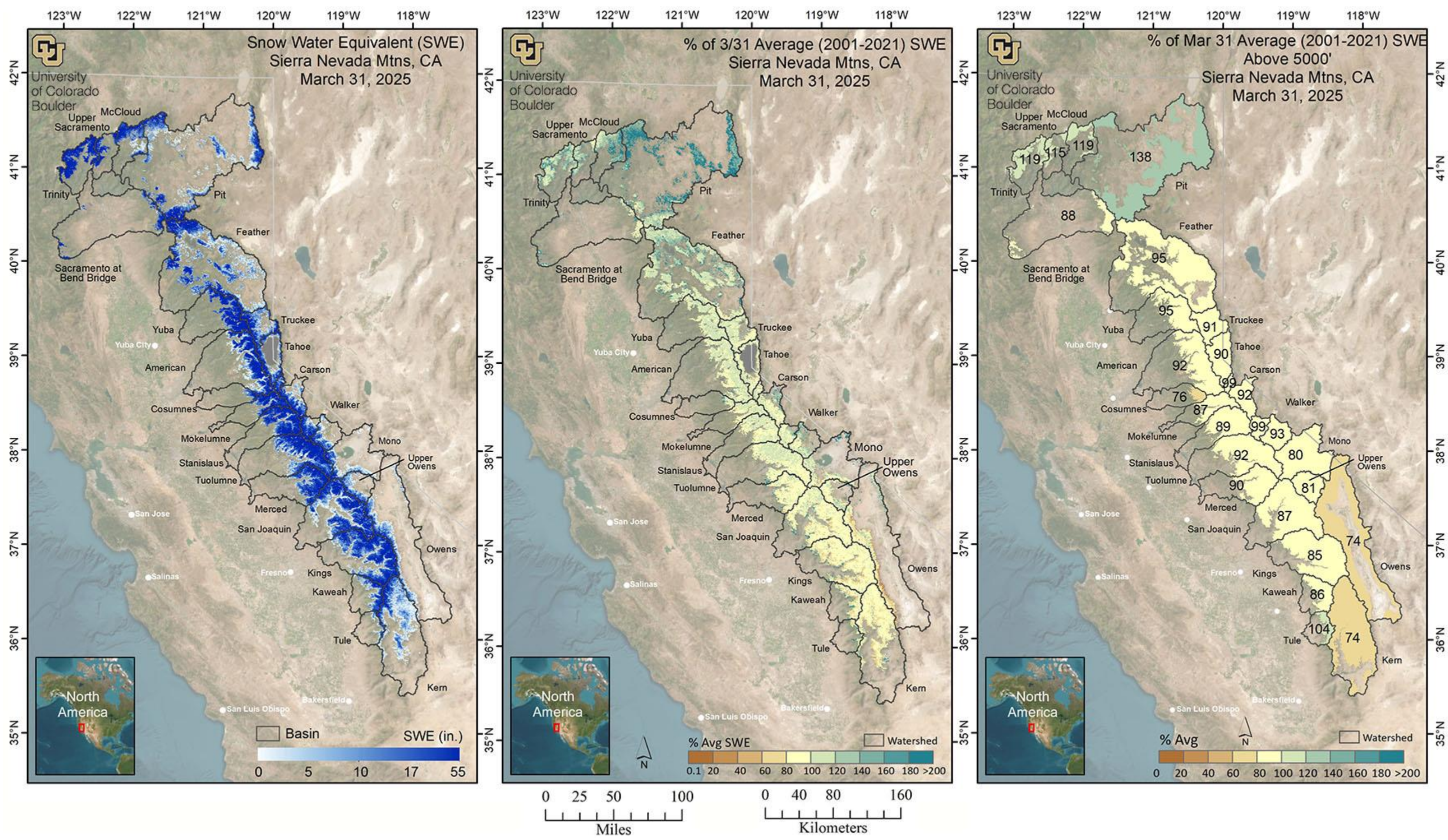

Figure 7. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts (left), and percent of average (2001-2021) SWE for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000’ elevation.

Table 5. SWE by watershed. Shown are percent of average SWE to date for the current date (2001-21 as derived from the regression model), mean SWE for the current report, current percent of snow-covered area, current SWE 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), first of the month snow surveys, and current snow pillow sensors (the number of stations are in parentheses), for those areas collected, summarized for each basin. [*SWE tables by banded elevation are here.*]()

Sierra Nevada SWE Report for 3/31/2025

	% of Average		SWE (in)					Pillows		Surveys	
	3/15	3/31	3/15	3/31	SCA	Vol. (AF)‡	Area (mi. sq)	3/15	3/31	3/31	SNODAS*
Trinity	108	119	22.6	28.5	89.3	488,161	321.3	31.0 (4)	40.0 (4)	44.0 (1)	39.5
Upper Sacramento	105	115	19.4	23.9	79.7	146,628	115.2	30.3 (1)	30.0 (1)	40.0 (2)	35.8
McCloud	110	119	18.2	21.9	85.8	192,790	164.9	33.3 (1)	39.4 (1)	32.2 (3)	42.3
Pit	143	138	7.1	6.6	34.7	729,741	2064.7	24.5 (7)	25.7 (7)	15.5 (2)	7.9
Sacramento at Bend Bridge	79	88	8.9	11.6	48.2	148,891	239.8	NA	NA	1.0 (1)	17.0
Feather§	90	95	10.3	10.3	52.0	1,151,447	2086.7	27.7 (6)	30.9 (6)	20.2 (20)	12.9
Yuba	90	95	17.8	19.9	75.6	548,633	515.6	43.9 (5)	48.4 (5)	34.5 (12)	28.8
American§	88	92	17.0	15.4	71.4	651,989	795.5	20.8 (11)	21.2 (11)	19.3 (13)	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	25.8 (3)	34.0 (2)	23.1 (6)	18.6
Stanislaus	95	89	17.6	17.2	65.7	510,617	557.0	27.3 (5)	29.2 (5)	22.3 (14)	16.9
Tuolumne§	98	92	16.3	16.4	65.6	795,176	909.8	25.9 (7)	25.8 (7)	24.1 (16)	18.9
Merced	97	90	15.2	15.8	65.9	453,639	538.8	28.1 (2)	27.2 (2)	25.6 (6)	17.9
San Joaquin§	95	87	13.8	14.3	70.8	923,228	1207.1	17.9 (7)	18.0 (7)	22.0 (25)	15.3
Kings	93	85	16.5	15.3	69.9	986,158	1207.0	23.4 (6)	18.9 (5)	22.1 (22)	16.9
Kaweah	94	86	9.8	10.9	62.6	182,478	314.1	20.8 (2)	20.3 (2)	24.0 (3)	13.0
Tule	103	104	5.4	4.5	49.8	33,385	137.6	11.3 (1)	6.9 (1)	NA	3.0
Kern§	89	74	6.3	4.7	34.6	422,926	1682.2	16.0 (6)	17.0 (6)	14.1 (11)	5.4
Truckee	98	91	16.3	13.1	59.3	288,269	411.5	19.5 (6)	20.9 (6)	33.5 (1)	15.7
Tahoe	93	90	16.1	15.0	67.5	244,752	304.9	21.4 (7)	20.8 (7)	25.7 (2)	14.1
W Carson	102	99	20.9	18.9	77.2	65,629	65.0	20.6 (3)	20.9 (3)	NA	17.5
E Carson	103	92	13.6	10.7	47.7	202,852	354.3	14.3 (4)	14.2 (4)	NA	10.4
W Walker	108	99	19.6	16.9	66.4	161,776	179.6	21.7 (4)	22.3 (4)	21.0 (1)	19.4
E Walker	124	93	9.0	6.2	33.9	115,556	350.7	14.7 (1)	15.4 (1)	NA	6.5
Mono	159	80	4.4	3.0	18.3	159,401	1002.9	NA	NA	NA	1.9
Upper Owens	107	81	8.5	6.1	36.3	120,796	373.7	36.4 (1)	38.0 (1)	25.5 (3)	4.4
Owens	104	74	4.0	2.9	19.9	271,265	1772.0	14.9 (5)	14.5 (5)	10.9 (8)	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.

† 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.

‡ 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.

Elevation Banded SWE Tables
Due to the length of the banded elevation tables (tables 6-10), that data is being hosted on our GitHub repository. Direct links to all of the tables are below. Access to the GitHub repository for the tables in both HTML and CSV formats is **here**.

- Pacific Northwest (Table 6)
- North Continental (Table 7)
- South Continental (Table 8)
- Intermountain, part 1 (Table 9a)
- Intermountain, part 2 (Table 9b)
- Sierra Nevada (Table 10)

The value of spatially explicit estimates of SWE
Snowmelt makes up the large majority (~60-85%) of the annual streamflow in the Western U.S. The spatial distribution of 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 hundreds of NRCS SNOTEL and California DWR CDEC snow pillow sites spread across the Western U.S., 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 pillow sites. The spatial SWE-fusion creates a detailed picture of the spatial pattern of SWE using snow pillows, satellite, and other data, extending beyond the snow pillow sites to unmonitored areas.

Interpreting the spatial SWE estimates in the context of snow pillow sites
The spatial SWE-fusion product estimates SWE for every pixel where the fractional snow-covered area (fSCA) satellite product identifies snow-cover. Comparatively, snow pillow samples on average 8-20 points per basin within a narrower elevation range. Thus, the basin-wide percent of long-term average from the spatial SWE-fusion estimates is not directly comparable with the snow pillow basin-wide percent of average. A better comparison might be made with the % average in the elevation bands (elevation-banded tables 6-10) that contain snow pillow sites.

Location of Reports, Excel Format Tables, and JPG Maps
https://github.com/CU-Mountain-Hydrology/WestWide

Methods
The spatial SWE-fusion estimation method is described in Yang, et. al. (2022) and Schneider and Molotch (2016). The method uses a General Linear Model in which the dependent variable is derived from the operationally measured in situ SWE from all online NRCS SNOTEL and CDEC snow pillow sites in the domain and when applicable the CoCoRaHS SWE values. The snow pillow SWE observations are scaled by the satellite-based fractional snow-covered area (fSCA) across the 500-meter pixel containing that snow pillow site before being used in the linear regression model. The fSCA is a near-real-time cloud-free daily satellite image from the Snow Today fSCA image (Rittger, et. al. 2019, https://nsidc.org/snow-today) which uses the SPIReS algorithm (Bair, et al. 2021).

The following independent variables (predictors) enter 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 Landsat 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.)
- 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 from Airborne Snow Observatory lidar data and from snow surveys at 10 locations in Colorado.

List of All Known Data Issues/Caveats

- SATELLITE FSCA - Recent snowpack accumulation particularly in the Arizona / NM region may be under-estimated due to issues with satellite-observed fSCA.
- GLACIER & NON-SEASONAL SNOW – SWE values on non-seasonal snow and glaciers need to be excluded before data analysis.
- 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 overestimate 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 SNOTEL 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.
- 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.
- EARLY SEASON FSCA ERRORS – The gap-filled fSCA requires some cloud-free images to determine fSCA amounts. Early in the season and if it has been particularly cloudy the algorithm hasn't had time to calculate fSCA amounts in some areas, typically in the Pacific Northwest and northern areas of the domain.

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