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

Western United States Region

May 26, 2025

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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. SWE values for the California domain are not available for 5/26/25. Our model is based on snow sensor data, currently there are fewer than 25 non-zero reporting snow sensor values, the May 17, 2025 was the final report for the 2025 water year.

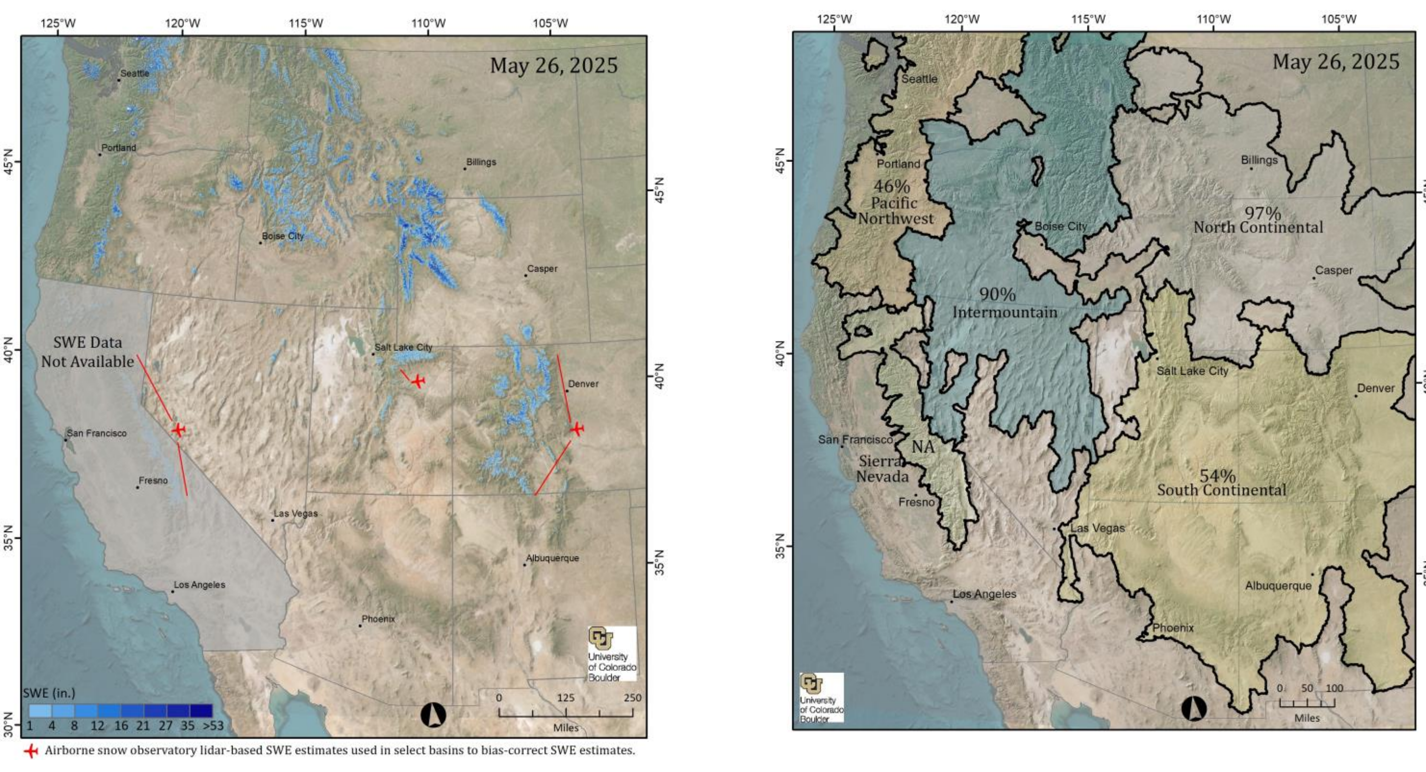

Figure 1. Estimated SWE and % of Average SWE across the Western U.S. SWE amounts across the entire Western region of the United States with red airplane markers indicating areas where the model was bias-corrected by Airborne Snow Observatory data (left) and percent of long-term average (2001-2021) by 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/]. SWE values for the California domain are not available for 5/26/25. Our model is based on snow sensor data, currently there are fewer than 25 non-zero reporting snow sensor values, the May 17, 2025 was the final report for the 2025 water year.

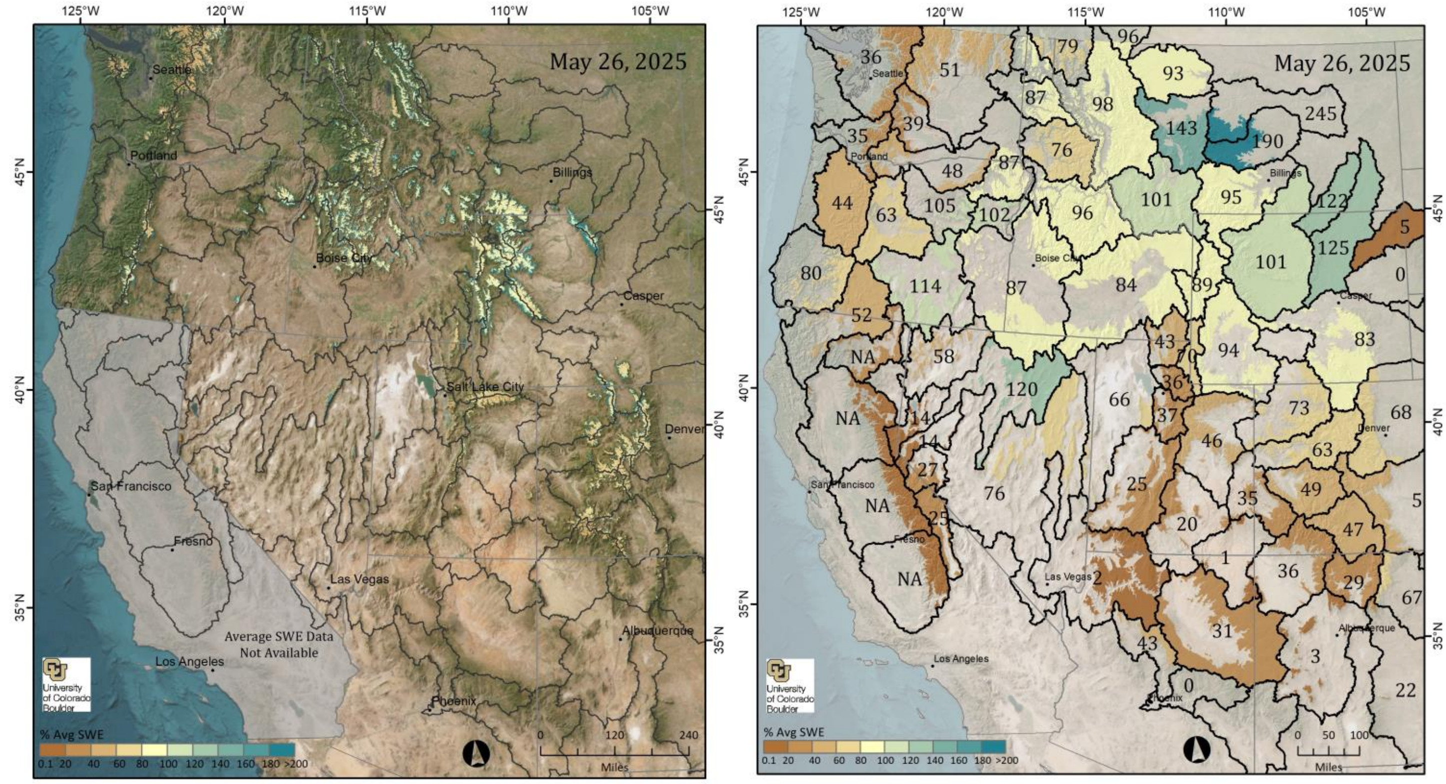

Figure 2. ***Estimated % of Average SWE across the Western U.S.*** Percent of long-term average (2001-2021) from the spatial SWE calculated for each pixel (left) and by HUC-6 basin (right); integer within each watershed represents the percent of average SWE for the report date. Shaded areas (right) correspond to the elevation bands used in the tables below. SWE values for the California domain are not available for 5/26/25. Our model is based on snow sensor data, currently there are fewer than 25 non-zero reporting snow sensor values, the May 17, 2025 was the final report for the 2025 water year.

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.

SWE input data available 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. When available and when appropriate SWE spatial data at 50-meter resolution from the Airborne Snow Observatory (Painter, et.al. 2016) is used to bias-correct model output.

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

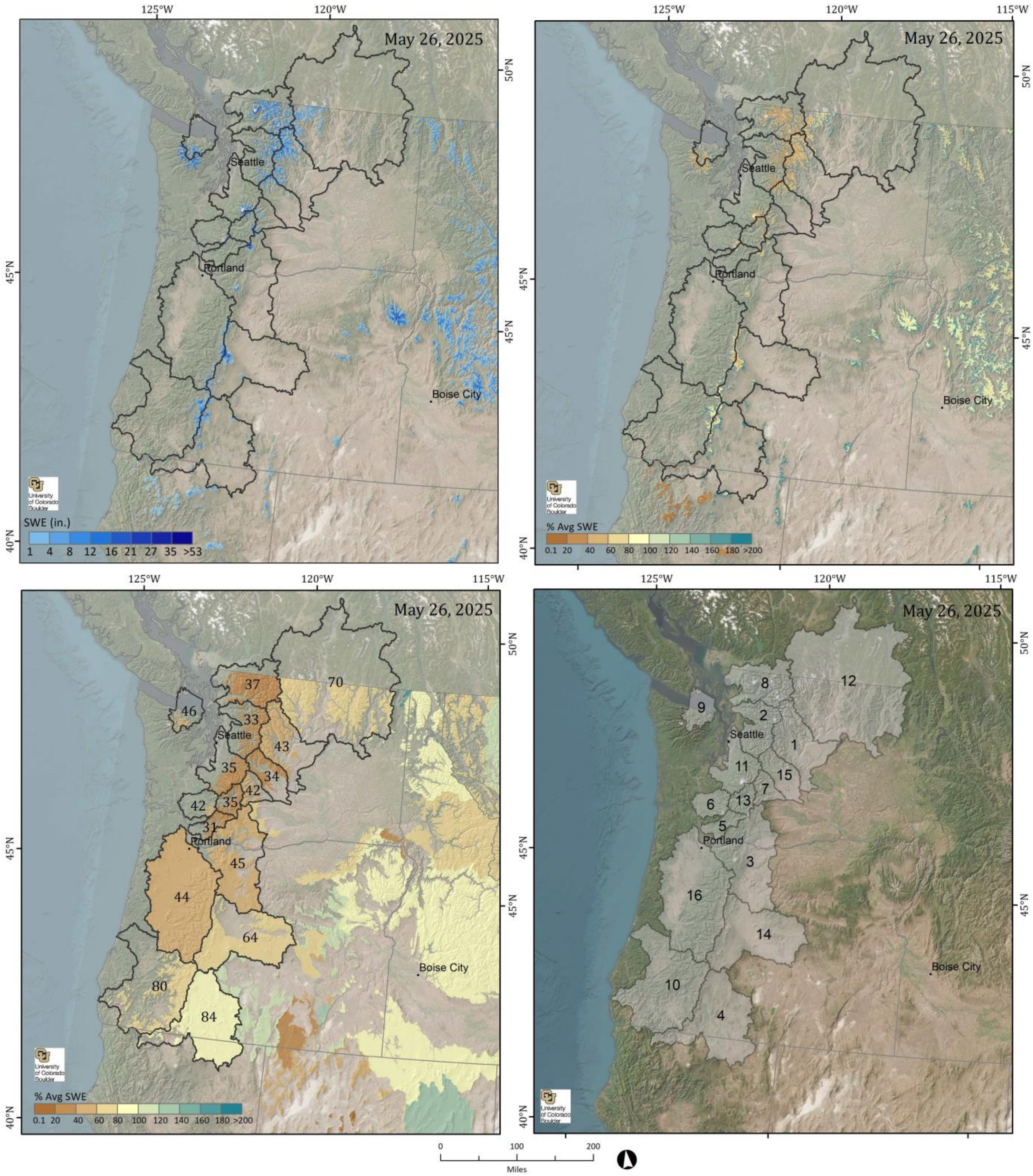

Figure 3. Estimated SWE and % of Average SWE across the Pacific Northwest Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 5/26/2025

	% of Average		SWE (in)					Pillows	
Basin	5/17	5/26	5/17	5/26	SCA	Vol. (AF)	Area (mi. sq)	5/17	5/26
1. Central Columbia	66	43	6.8	2.7	26.8	312,460	2,136	6.1 (7)	4.4 (7)
2. Central Puget Sound	51	33	6.1	3.1	30.1	201,715	1,238	14.7 (5)	9.8 (5)
3. Hood-Sandy-Lower Deschutes	68	45	0.6	0.2	2.3	59,162	5,080	9.3 (10)	6.7 (11)
4. Klamath	105	84	0.7	0.3	3.5	104,277	7,199	6.1 (14)	3.8 (14)
5. Lewis	47	31	1.3	0.5	4.7	15,418	581	26.8 (6)	19.3 (7)
6. Lower Cowlitz	53	42	1.8	0.8	7.2	7,550	185	12.5 (2)	9.7 (2)
7. Naches	71	42	3.4	1.1	11.3	34,762	610	20.9 (4)	15.3 (4)
8. North Puget Sound	65	37	6.6	2.8	26.8	347,451	2,313	23.9 (9)	21.4 (9)
9. Olympic	79	46	12.8	5.8	48.9	73,014	238	17.4 (3)	13.4 (3)
10. Rogue-Umpqua	99	80	1.9	0.8	8.5	138,103	3,371	3.4 (6)	1.9 (6)
11. South Puget Sound	61	35	2.7	1.0	10.2	61,968	1,148	9.7 (14)	7.9 (14)
12. Upper Columbia	88	70	1.5	0.6	6.3	169,226	5,502	3.6 (7)	2.8 (7)
13. Upper Cowlitz	54	35	3.9	1.7	16.3	64,828	714	13.3 (3)	6.0 (3)
14. Upper Deschutes-Crooked	90	64	1.2	0.4	4.6	132,661	5,608	4.1 (6)	0.6 (6)
15. Upper Yakima	52	34	2.4	0.9	9.0	47,034	1,033	0.0 (3)	0.0 (3)
16. Willamette	77	44	0.6	0.2	1.7	109,100	11,356	3.0 (17)	1.9 (17)

§ 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.

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

North Continental

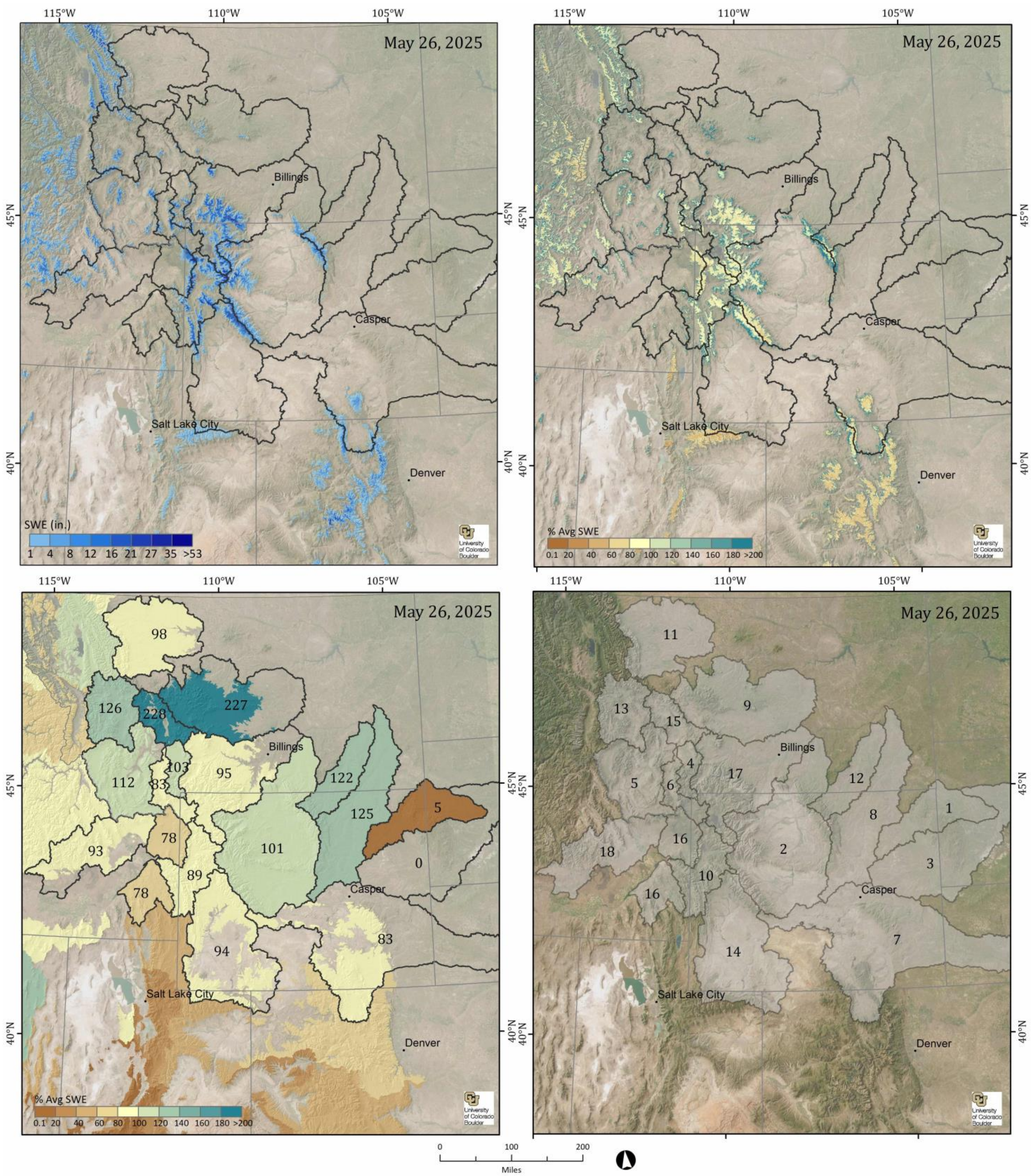

Figure 4. Estimated SWE and % of Average SWE across the North Continental Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 5/26/2025

	% of Average		SWE (in)					Pillows	
Basin	5/17	5/26	5/17	5/26	SCA	Vol. (AF)	Area (mi. sq)	5/17	5/26
1. Belle Fourche	1	5	0.0	0.0	0.0	12	7,200	0.0 (1)	0.0 (1)
2. Bighorn	74	101	1.0	0.8	8.2	910,862	22,740	5.1 (20)	4.0 (20)
3. Cheyenne	0	0	0.0	0.0	0.0	0	15,348	0.2 (1)	0.0 (2)
4. Gallatin	89	103	2.8	1.5	14.4	147,990	1,846	17.8 (4)	14.5 (4)
5. Jefferson	86	112	1.5	0.6	6.2	289,848	8,788	7.6 (13)	7.5 (14)
6. Madison Headwaters in WY	66	83	2.4	1.3	11.6	172,133	2,524	9.8 (7)	6.8 (7)
7. North Platte	49	83	0.6	0.3	6.9	185,672	10,281	8.4 (22)	6.9 (22)
8. Powder	55	125	0.1	0.1	1.0	46,550	13,385	2.0 (5)	1.9 (5)
9. Smith-Judith-Musselshell	119	227	0.4	0.1	1.4	51,578	8,335	9.6 (8)	5.6 (9)
10. Snake	83	89	4.5	2.9	26.3	859,695	5,626	8.3 (11)	6.0 (11)
11. Sun-Teton-Marias	79	98	0.3	0.1	1.3	79,783	10,463	1.0 (5)	0.0 (4)
12. Tongue	82	122	0.4	0.3	3.5	73,027	5,400	4.9 (6)	3.8 (6)
13. Upper Clark Fork	96	126	1.2	0.5	5.3	175,152	5,981	6.1 (12)	4.1 (12)
14. Upper Green	68	94	1.3	1.0	10.0	499,979	9,539	4.8 (20)	3.7 (20)
15. Upper Missouri	137	228	0.4	0.2	1.6	24,298	2,951	0.1 (2)	0.0 (2)
16. Upper Snake Basins	68	78	1.1	0.7	6.4	256,456	6,875	5.2 (11)	4.2 (11)
17. Upper Yellowstone	83	95	2.9	2.1	19.1	1,232,536	11,070	10.0 (19)	8.3 (19)
18. Wood and Lost Basins	67	93	0.9	0.4	4.3	141,937	7,420	1.2 (16)	0.4 (15)

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ǂ 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.

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

South Continental

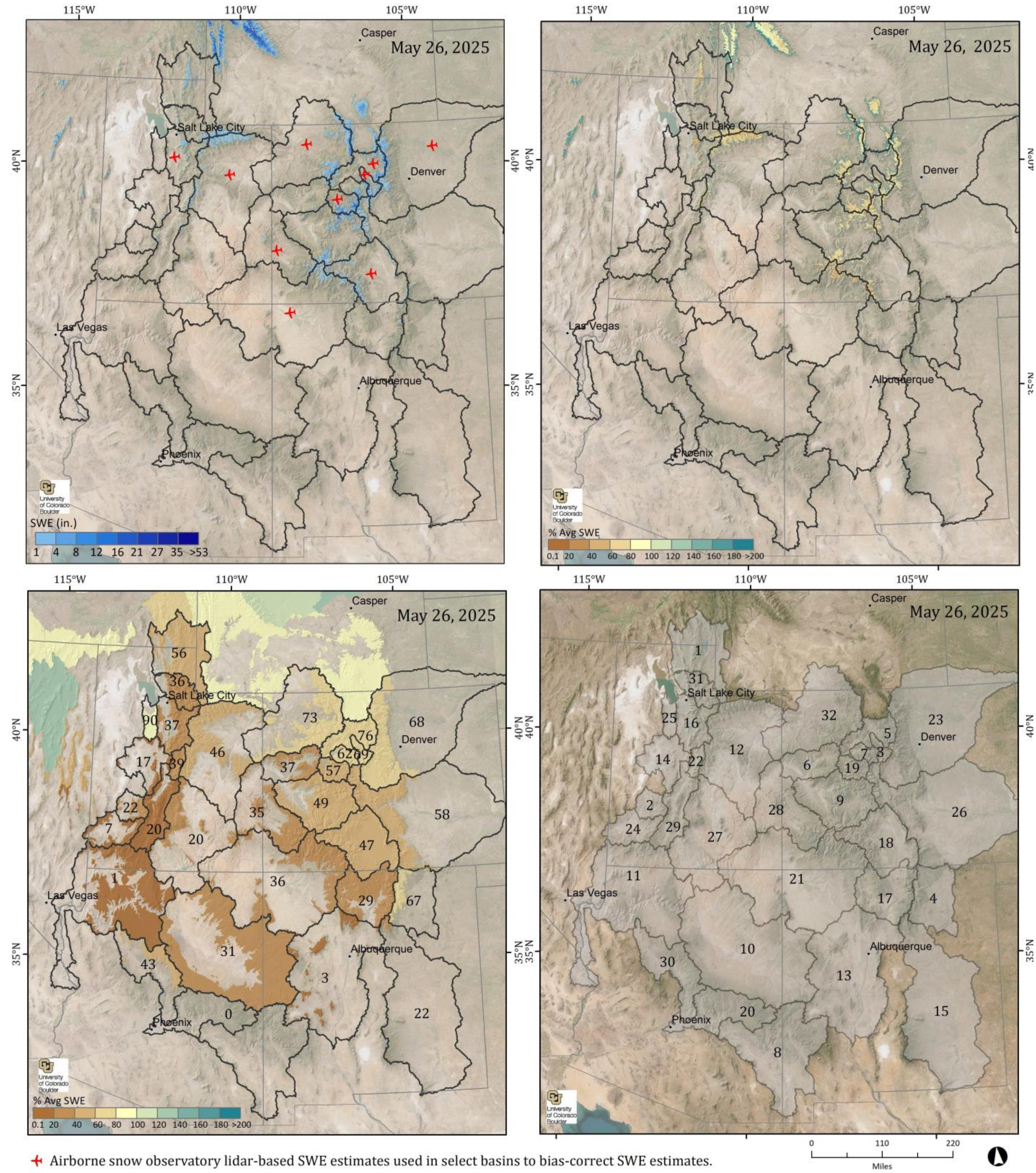

Figure 5. Estimated SWE and % of Average SWE across the South Continental Region. SWE amounts with red airplane markers indicating upper basin areas where the model was bias-corrected by Airborne Snow Observatory data (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (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 5/26/2025

	% of Average		SWE (in)					Pillows	
Basin	5/17	5/26	5/17	5/26	SCA	Vol. (AF)	Area (mi. sq)	5/17	5/26
1. Bear	55	56	0.6	0.2	4.4	68,675	6,181	3.5 (18)	1.6 (18)
2. Beaver	28	22	0.1	0.0	1.4	1,681	836	6.0 (2)	4.5 (2)
3. Blue§	61	69	4.2	2.2	32.8	77,907	670	10.4 (5)	7.2 (5)
4. Canadian	50	67	0.0	0.0	0.3	515	1,265	0.2 (2)	0.0 (2)
5. Colorado Headwaters§	62	76	2.2	1.1	15.6	176,126	2,874	8.0 (13)	5.7 (13)
6. Colorado Headwaters-Plateau	31	37	0.5	0.2	3.3	15,865	1,801	0.2 (1)	0.0 (1)
7. Eagle	50	62	2.0	1.2	20.7	57,131	921	0.0 (3)	0.0 (3)
8. Gila	0	NA	0.0	0.0	0.0	0	4,924	0.0 (6)	0.0 (6)
9. Gunnison§	38	49	0.8	0.6	8.1	193,929	6,433	1.2 (11)	0.1 (11)
10. Little Colorado	16	31	0.0	0.0	0.0	111	16,379	0.4 (5)	0.2 (5)
11. Lower Colorado Mainstream	3	1	0.0	0.0	0.0	5	10,695	0.0 (5)	0.0 (5)
12. Lower Green§	39	46	0.6	0.3	8.1	81,176	5,647	1.2 (23)	0.4 (24)
13. Lower Rio Grande	4	3	0.0	0.0	0.0	9	1,795	0.0 (6)	0.0 (6)
14. Lower Sevier	41	17	0.1	0.0	0.3	219	897	0.2 (4)	0.1 (4)
15. Pecos	33	22	0.1	0.0	0.5	225	331	0.1 (2)	0.1 (2)
16. Provo-Utah Lake-Jordan§	36	37	0.4	0.2	4.6	24,905	2,681	4.4 (16)	1.7 (18)
17. Rio Chama-Upper Rio Grande	18	29	0.1	0.0	0.7	5,192	5,207	0.6 (13)	0.1 (13)
18. Rio Grande Headwaters§	31	47	0.3	0.2	4.1	90,440	7,595	0.6 (14)	0.0 (13)
19. Roaring Fork§	47	57	3.0	2.3	25.7	168,981	1,359	3.0 (7)	1.0 (7)
20. Salt	0	0	0.0	0.0	0.0	0	2,361	0.0 (6)	0.1 (6)
21. San Juan	30	36	0.3	0.2	4.3	52,079	6,406	1.4 (15)	0.6 (15)
22. San Pitch	36	39	0.4	0.2	6.0	9,336	857	1.2 (6)	0.0 (6)
23. South Platte§	54	68	0.9	0.5	9.4	143,782	5,620	7.7 (21)	5.1 (21)
24. Southwestern Utah	15	7	0.0	0.0	0.1	98	1,440	0.0 (5)	0.0 (5)
25. Toole Valley-Vernon Creek	91	90	0.1	0.0	0.5	1,440	906	1.8 (4)	0.3 (4)
26. Upper Arkansas	50	58	0.6	0.2	5.7	76,980	5,875	0.1 (6)	0.0 (7)
27. Upper Colorado-Dirty Devil	17	20	0.1	0.0	1.2	4,813	2,597	0.0 (7)	0.0 (7)
28. Upper Colorado-Dolores§	25	35	0.3	0.1	2.6	27,331	3,434	2.0 (8)	2.0 (7)
29. Upper Sevier	22	20	0.1	0.0	1.0	5,170	3,758	0.8 (16)	0.5 (16)
30. Verde	19	43	0.0	0.0	0.0	25	1,816	0.1 (7)	0.0 (7)
31. Weber-Ogden	40	36	0.5	0.1	4.0	15,491	2,041	1.9 (16)	0.3 (17)
32. White-Yampa§	48	73	1.2	0.7	10.1	207,637	5,948	5.4 (15)	3.4 (15)

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Intermountain

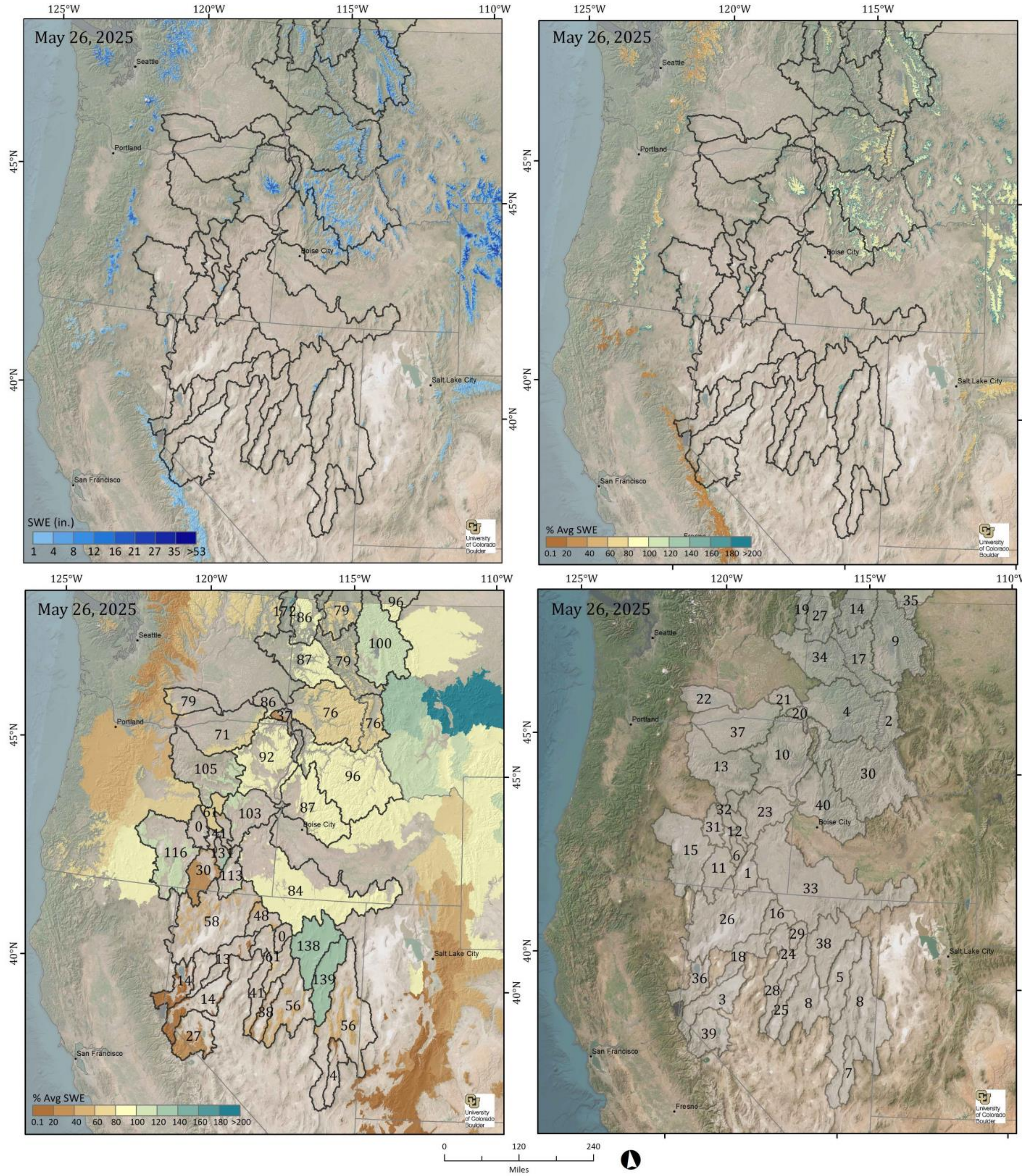

Figure 6. Estimated SWE and % of Average SWE across the Intermountain Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in the 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 5/26/2025

	% of Average		SWE (in)					Pillows	
Basin	5/17	5/26	5/17	5/26	SCA	Vol. (AF)	Area (mi. sq)	5/17	5/26
1. Alvord Lake	162	113	0.7	0.2	2.6	3,465	324	NA	NA
2. Bitterroot	62	76	2.3	1.4	16.7	144,929	1,952	6.0 (4)	4.4 (4)
3. Carson	48	14	0.6	0.1	3.4	8,503	1,405	1.7 (7)	0.1 (7)
4. Clearwater Basin	68	76	1.8	0.8	10.6	323,695	7,488	13.9 (11)	11.4 (10)
5. Clover Valley and Franklin	113	139	0.1	0.0	0.6	9,262	4,048	0.2 (2)	0.0 (2)
6. Donner und Blitzen	190	131	3.4	0.9	12.7	10,590	222	18.3 (2)	15.1 (2)
7. Dry Lake Valley	21	4	0.0	0.0	0.0	6	289	NA	NA
8. Eastern Nevada	53	56	0.1	0.0	0.5	6,797	4,372	1.0 (8)	0.3 (8)
9. Flathead	92	100	2.9	1.5	14.5	605,470	7,526	11.6 (12)	10.6 (12)
10. Grande Ronde-Burnt-Powder_Imnaha	82	92	1.6	0.8	7.8	230,019	5,312	4.3 (10)	2.7 (11)
11. Guano	359	30	0.0	0.0	0.0	98	2,036	0.0 (1)	0.0 (1)
12. Harney-Malheur Lakes	105	41	0.0	0.0	0.0	9	276	NA	NA
13. John Day	94	105	1.0	0.3	4.1	24,838	1,502	0.0 (2)	0.0 (2)
14. Kootenai	65	79	1.6	0.6	9.9	57,306	1,673	8.8 (5)	6.5 (5)
15. Lake County-Goose Lake	169	116	0.5	0.1	1.9	21,464	3,602	10.6 (2)	6.9 (2)
16. Little Humboldt	111	48	0.1	0.0	0.3	431	419	1.8 (3)	0.1 (3)
17. Lower Clark Fork	72	79	2.6	1.0	14.7	81,863	1,465	29.9 (4)	26.2 (4)
18. Lower Humboldt	192	13	0.1	0.0	0.0	15	274	0.0 (1)	0.0 (1)
19. Lower Pend Oreille	103	172	4.2	1.7	23.1	11,459	129	13.6 (1)	9.4 (1)
20. Lower Snake-Asotin	78	37	0.1	0.0	0.3	291	328	0.1 (2)	0.0 (2)

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Intermountain SWE Report for 5/26/2025									
	% of Average		SWE (in)					Pillows	
Basin	5/17	5/26	5/17	5/26	SCA	Vol. (AF)	Area (mi. sq)	5/17	5/26
21. Lower Snake-Tucannon	125	86	0.9	0.1	1.5	532	109	NA	NA
22. Lower Yakima	83	79	0.5	0.2	2.0	4,050	489	2.6 (2)	0.0 (2)
23. Malheur	172	103	0.6	0.2	1.9	8,118	992	0.0 (3)	0.0 (3)
24. Middle Humboldt	285	61	0.0	0.0	0.0	23	633	NA	NA
25. Northern Big Smoky Valley	53	38	0.2	0.0	0.6	1,000	570	NA	NA
26. Northern Great Basin	116	58	0.1	0.0	0.2	1,000	2,226	0.0 (2)	0.0 (2)
27. Panhandle Basins	71	86	2.1	0.9	13.4	78,414	1,644	19.6 (3)	15.5 (3)
28. Reese	84	41	0.2	0.0	0.6	680	491	0.2 (2)	0.1 (2)
29. Rock	180	0	0.0	0.0	0.0	0	835	0.1 (1)	0.0 (1)
30. Salmon Basin	70	96	2.8	1.4	15.7	859,604	11,932	8.8 (11)	5.1 (11)
31. Silver	15	0	0.0	0.0	0.0	0	431	NA	NA
32. Silvies	80	61	0.0	0.0	0.2	824	1,316	0.0 (1)	0.0 (2)
33. Southern Snake Basins	132	84	0.2	0.0	0.4	18,663	12,500	1.3 (13)	0.2 (13)
34. Spokane	74	87	0.5	0.1	2.4	24,521	3,146	1.8 (8)	0.8 (8)
35. St. Mary	79	96	4.3	2.8	22.4	96,203	648	0.0 (1)	0.0 (1)
36. Truckee	55	14	0.7	0.1	3.7	9,022	1,420	8.9 (9)	5.7 (9)
37. Umatilla-Walla Walla-Willow	116	71	0.3	0.0	0.7	2,342	1,434	5.6 (7)	3.0 (7)
38. Upper Humboldt	100	138	0.3	0.1	1.7	38,364	5,032	3.3 (8)	2.1 (8)
39. Walker	68	27	0.8	0.2	4.9	22,113	1,939	8.1 (7)	0.2 (6)
40. West Central Basins	79	87	2.5	1.1	10.9	314,751	5,620	6.9 (15)	4.2 (15)

§ 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.

*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. SWE values for the California domain are not available for 5/26/25. Our model is based on snow sensor data, currently there are fewer than 25 non-zero reporting snow sensor values, the May 17, 2025 was the final report for the 2025 water year.

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)

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 (Painter, et.al. 2016) and from snow surveys at 10 locations in Colorado. Additionally, as a final step, when appropriate and when available, ASO data can be used to bias-correct model output.

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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