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

Western United States Region

April 27, 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.

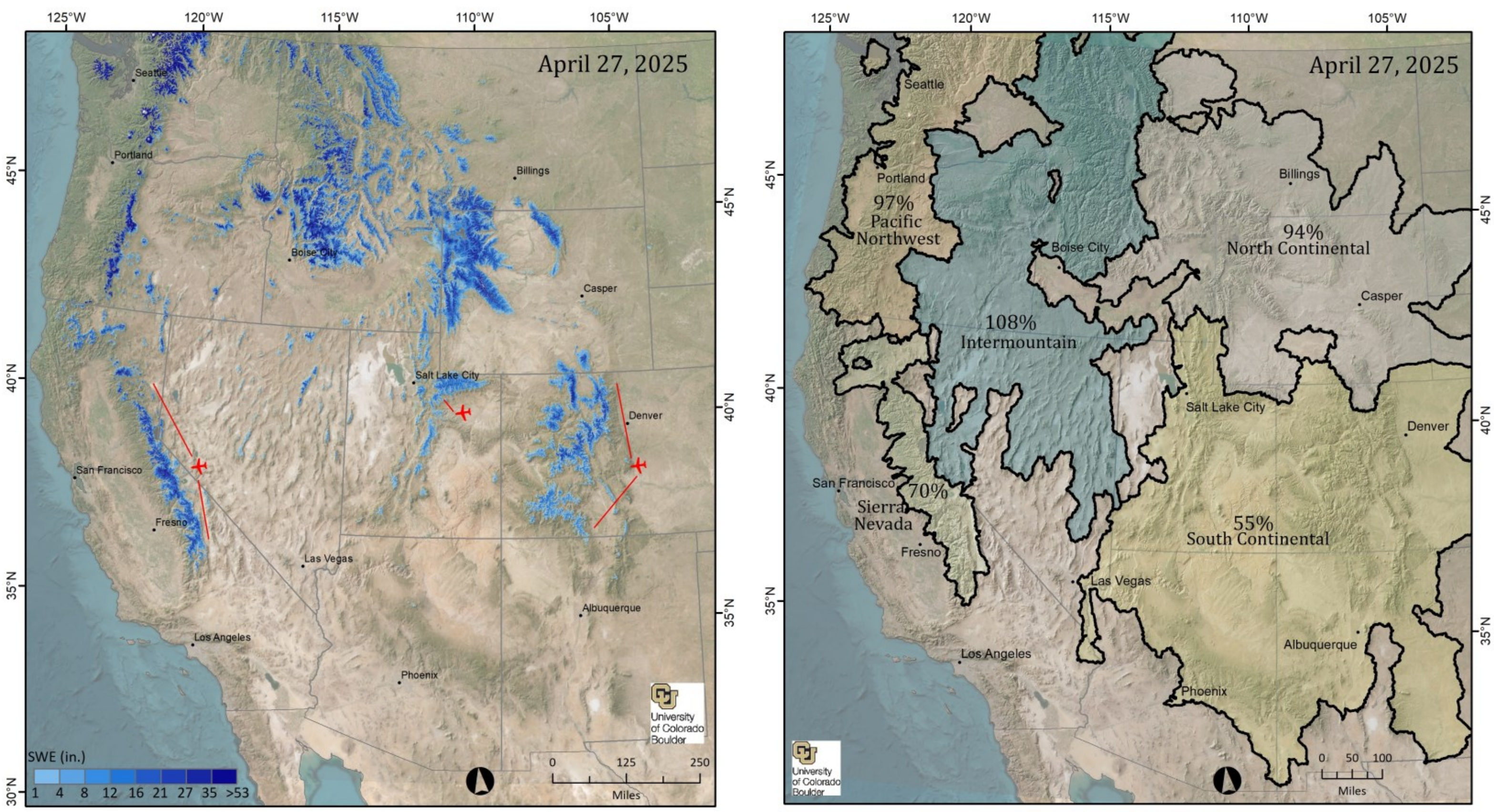

Figure 1. Estimated SWE and % of Average SWE across the Western U.S. SWE amounts across the entire Western region of the United States with red airplane markers indicating areas where the model was bias-corrected by Airborne Snow Observatory data (left) and percent of long-term average (2001-2021) by 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/].

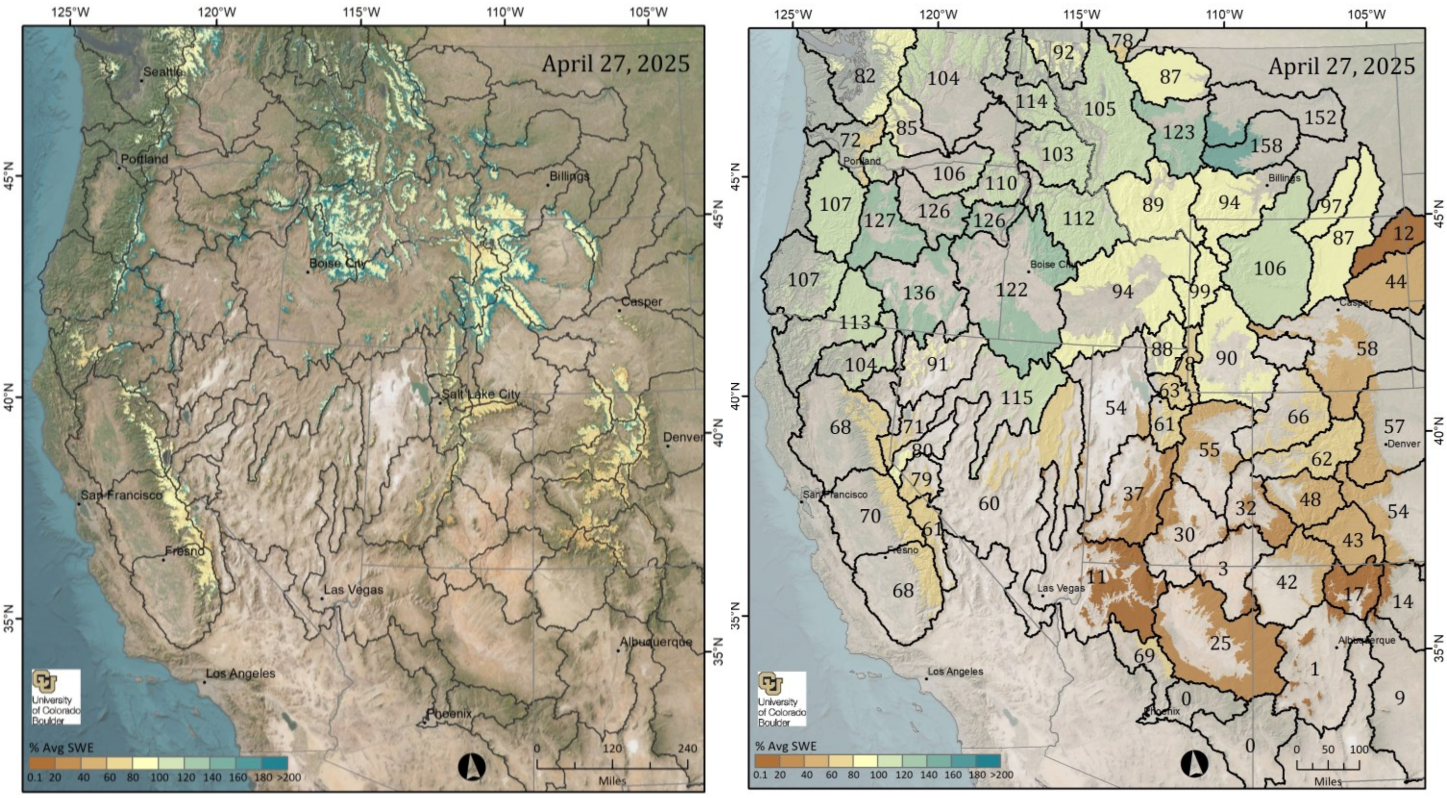

Figure 2. ***Estimated % of Average SWE across the Western U.S.*** Percent of long-term average (2001-2021) from the spatial SWE calculated for each pixel (left) and by HUC-6 basin (right); integer within each watershed represents the percent of average SWE for the report date. Shaded areas (right) correspond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

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

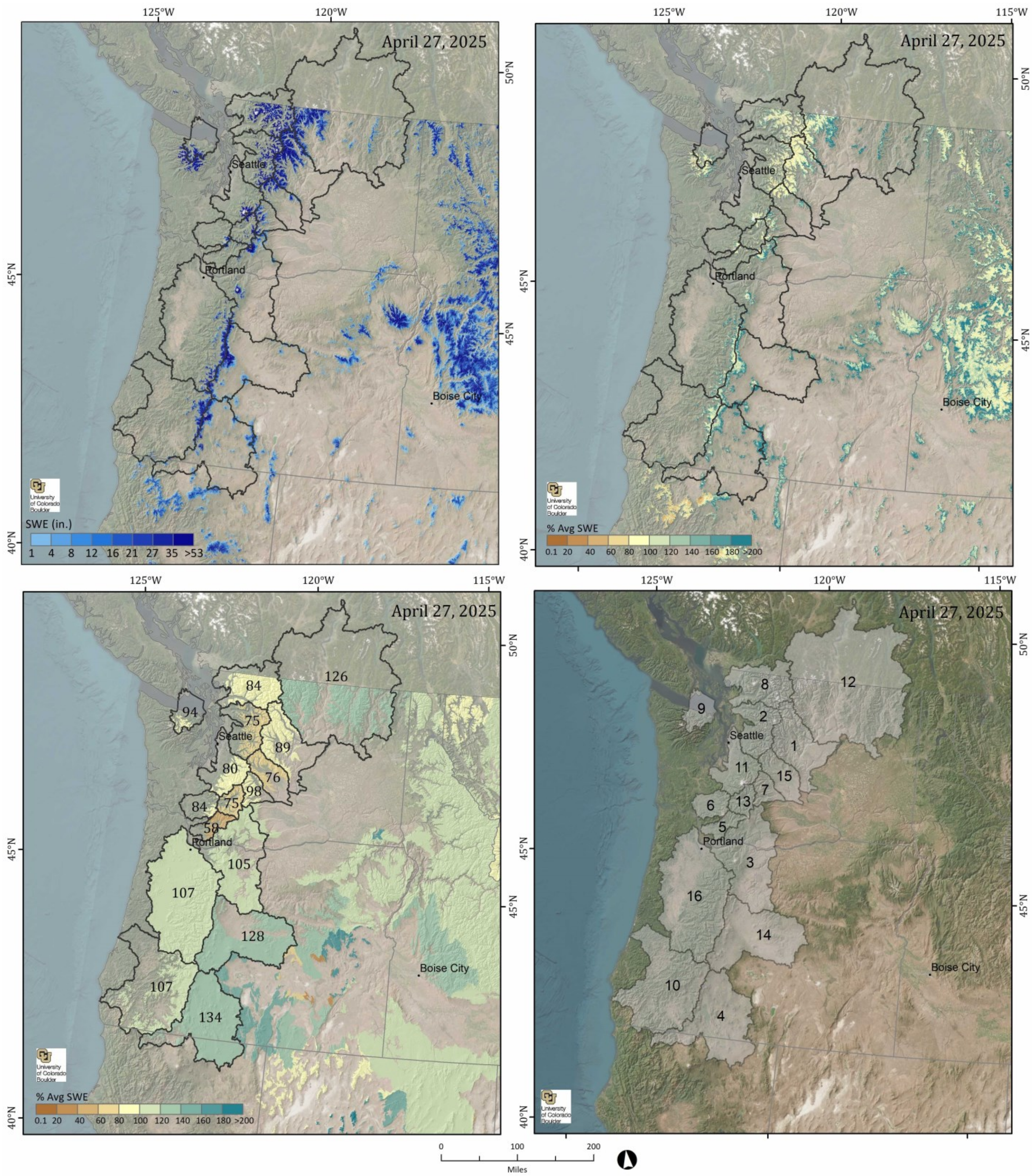

Figure 3. Estimated SWE and % of Average SWE across the Pacific Northwest Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 4/27/2025

	% of Average		SWE (in)					Pillows	
Basin	4/20	4/27	4/20	4/27	SCA	Vol. (AF)	Area (mi. sq)	4/20	4/27
1. Central Columbia	86	89	15.6	14.5	50.0	1,655,623	2,136	15.6 (7)	12.9 (7)
2. Central Puget Sound	62	75	10.8	12.2	41.3	805,834	1,238	32.9 (5)	30.1 (5)
3. Hood-Sandy-Lower Deschutes	113	105	2.2	1.7	7.6	460,442	5,080	17.4 (11)	14.4 (11)
4. Klamath	143	134	2.9	1.7	9.7	661,062	7,199	14.4 (15)	13.0 (14)
5. Lewis	73	58	3.6	2.5	10.1	77,774	581	40.2 (6)	37.8 (6)
6. Lower Cowlitz	104	84	7.2	4.8	20.0	47,451	185	19.8 (2)	18.4 (2)
7. Naches	111	98	9.1	7.2	31.1	234,590	610	38.3 (4)	35.8 (4)
8. North Puget Sound	75	84	11.0	10.7	34.2	1,325,544	2,313	35.9 (9)	34.5 (9)
9. Olympic	126	94	30.5	21.3	66.7	270,152	238	28.2 (3)	25.4 (3)
10. Rogue-Umpqua	123	107	5.3	3.2	13.0	578,659	3,371	10.0 (6)	6.8 (6)
11. South Puget Sound	88	80	5.5	4.4	14.9	267,701	1,148	19.1 (13)	17.6 (13)
12. Upper Columbia	111	126	5.4	4.6	18.9	1,346,655	5,502	8.8 (7)	7.1 (7)
13. Upper Cowlitz	86	75	8.7	7.1	24.6	269,182	714	32.8 (3)	29.4 (3)
14. Upper Deschutes-Crooked	135	128	3.9	2.7	12.6	813,052	5,608	22.5 (7)	12.4 (6)
15. Upper Yakima	79	76	7.2	6.4	24.8	350,674	1,033	14.2 (3)	10.5 (3)
16. Willamette	114	107	1.6	1.2	4.8	711,890	11,356	11.5 (17)	9.0 (16)

§ 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

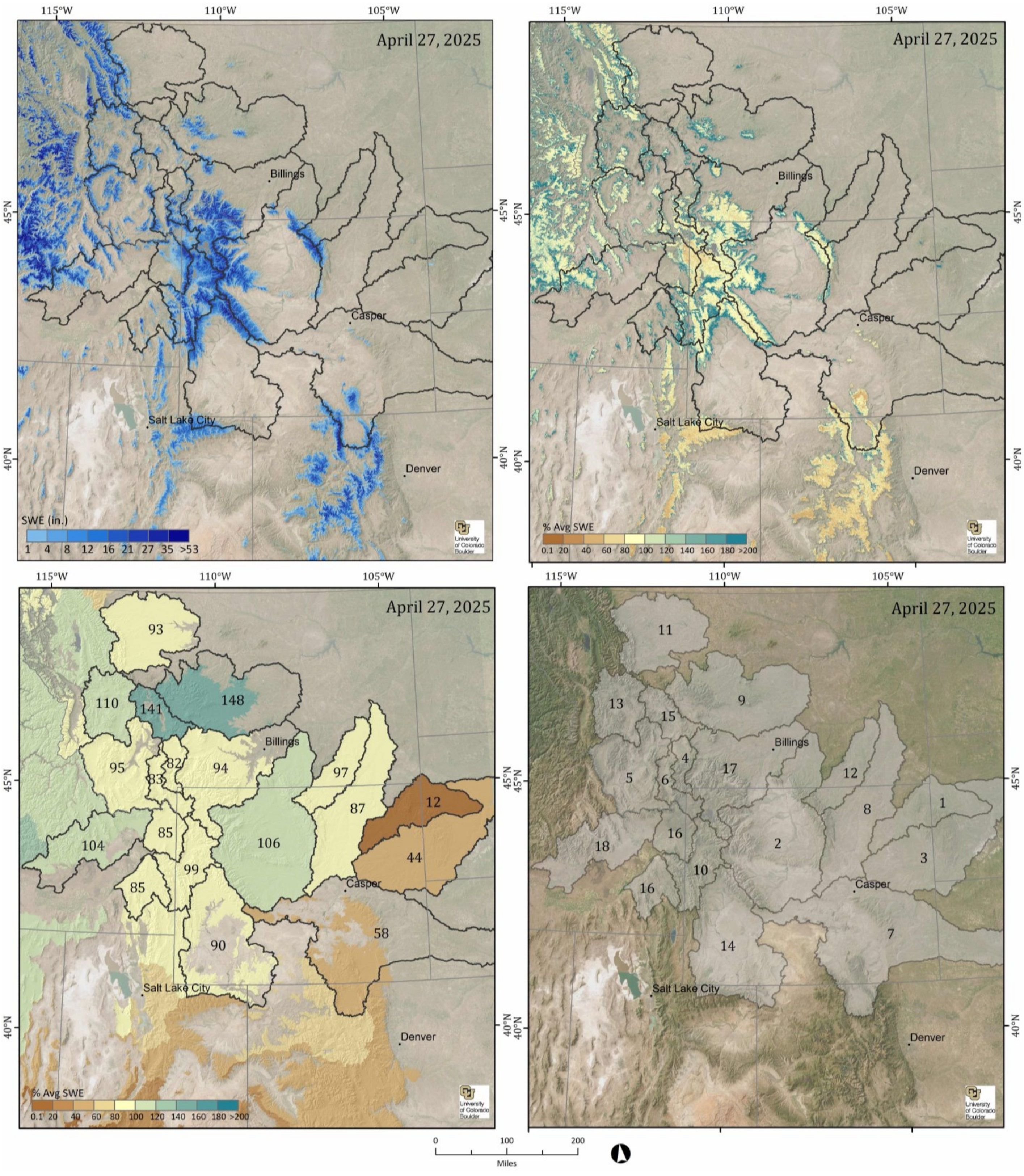

Figure 4. Estimated SWE and % of Average SWE across the North Continental Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 4/27/2025

	% of Average		SWE (in)					Pillows	
Basin	4/20	4/27	4/20	4/27	SCA	Vol. (AF)	Area (mi. sq)	4/20	4/27
1. Belle Fourche	105	12	0.1	0.0	0.1	1,043	7,200	1.5 (1)	0.0 (1)
2. Bighorn	113	106	2.9	2.3	17.5	2,838,203	22,740	10.8 (21)	11.0 (21)
3. Cheyenne	76	44	0.0	0.0	0.0	1,384	15,348	0.1 (2)	0.1 (2)
4. Gallatin	99	82	5.6	3.8	29.1	374,279	1,846	21.9 (4)	21.8 (4)
5. Jefferson	109	95	4.0	2.6	19.2	1,225,688	8,788	12.3 (14)	11.8 (14)
6. Madison Headwaters in WY	94	83	6.2	4.6	35.4	624,568	2,524	17.2 (7)	15.9 (7)
7. North Platte	112	58	3.6	1.4	13.5	774,269	10,281	16.8 (22)	15.0 (22)
8. Powder	107	87	0.4	0.2	2.2	170,564	13,385	4.6 (5)	4.3 (5)
9. Smith-Judith-Musselshell	148	148	1.7	1.0	9.1	462,858	8,335	15.0 (9)	14.0 (9)
10. Snake	102	99	11.2	9.1	63.7	2,716,050	5,626	19.9 (11)	18.8 (11)
11. Sun-Teton-Marias	96	93	1.2	0.7	5.2	403,837	10,463	6.4 (5)	5.3 (5)
12. Tongue	90	97	0.8	0.8	6.8	235,257	5,400	9.2 (6)	9.5 (6)
13. Upper Clark Fork	77	110	2.1	2.5	19.0	795,859	5,981	11.3 (12)	11.0 (12)
14. Upper Green	135	90	5.9	3.2	23.0	1,632,662	9,539	12.3 (21)	11.0 (21)
15. Upper Missouri	136	141	1.5	0.8	7.7	130,165	2,951	5.3 (2)	2.8 (2)
16. Upper Snake Basins	107	85	4.0	2.4	20.0	878,463	6,875	16.9 (11)	13.2 (11)
17. Upper Yellowstone	102	94	6.1	5.1	36.5	3,038,587	11,070	15.7 (19)	15.4 (19)
18. Wood and Lost Basins	97	104	3.0	2.3	16.3	913,125	7,420	8.1 (16)	6.1 (16)

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† 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.

South Continental

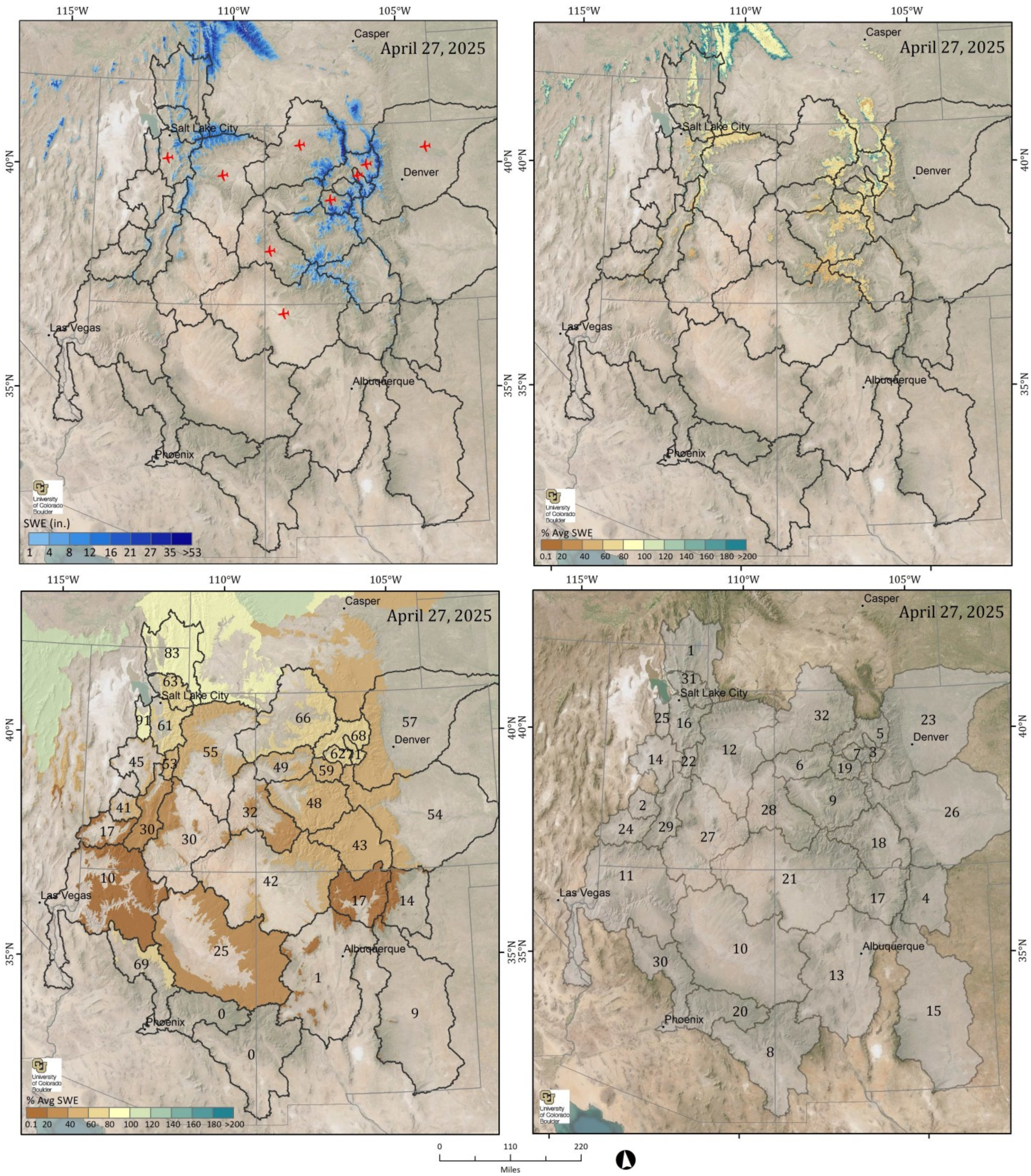

Figure 5. Estimated SWE and % of Average SWE across the South Continental Region. SWE amounts with red airplane markers indicating upper basin areas where the model was bias-corrected by Airborne Snow Observatory data (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (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 4/27/2025

	% of Average		SWE (in)					Pillows	
Basin	4/20	4/27	4/20	4/27	SCA	Vol. (AF)	Area (mi. sq)	4/20	4/27
1. Bear	121	83	3.9	1.9	16.8	623,051	6,181	12.2 (18)	9.7 (18)
2. Beaver	60	41	0.7	0.3	5.9	14,710	836	10.8 (2)	7.5 (2)
3. Blue§	90	71	10.7	7.1	44.5	252,417	670	15.4 (5)	13.9 (5)
4. Canadian	50	14	0.2	0.0	0.5	1,771	1,265	0.4 (2)	0.1 (2)
5. Colorado Headwaters§	96	68	6.7	4.0	31.6	618,323	2,874	13.3 (13)	11.9 (13)
6. Colorado Headwaters-Plateau	78	49	3.1	1.5	15.5	146,713	1,801	10.3 (1)	7.9 (1)
7. Eagle	82	62	6.6	4.1	30.0	198,973	921	9.5 (3)	6.5 (3)
8. Gila	22	0	0.0	0.0	0.0	0	4,924	0.0 (6)	0.0 (6)
9. Gunnison§	71	48	3.7	1.9	20.4	659,634	6,433	7.1 (11)	4.8 (11)
10. Little Colorado	71	25	0.0	0.0	0.0	1,545	16,379	2.2 (5)	0.6 (5)
11. Lower Colorado Mainstream	35	10	0.0	0.0	0.2	1,719	10,695	1.6 (5)	0.5 (5)
12. Lower Green§	81	55	3.7	2.0	21.9	605,334	5,647	6.9 (24)	4.4 (24)
13. Lower Rio Grande	41	1	0.1	0.0	0.0	39	1,795	0.3 (6)	0.0 (6)
14. Lower Sevier	107	45	1.0	0.2	4.4	11,477	897	8.3 (4)	5.3 (4)
15. Pecos	61	9	0.7	0.1	0.9	899	331	0.4 (2)	0.2 (2)
16. Provo-Utah Lake-Jordan§	88	61	3.2	1.7	18.5	238,005	2,681	16.3 (17)	12.5 (16)
17. Rio Chama-Upper Rio Grande	46	17	0.4	0.1	1.2	20,214	5,207	1.9 (13)	0.9 (13)
18. Rio Grande Headwaters	69	43	1.8	0.7	9.2	298,167	7,595	4.2 (14)	2.8 (14)
19. Roaring Fork§	75	59	8.4	5.6	38.6	408,689	1,359	11.4 (7)	9.0 (7)
20. Salt	20	0	0.0	0.0	0.0	0	2,361	0.1 (7)	0.0 (7)
21. San Juan	62	42	1.5	0.8	8.9	256,383	6,406	5.4 (15)	3.4 (15)
22. San Pitch	80	53	2.4	1.3	15.7	59,903	857	9.9 (6)	6.2 (6)
23. South Platte§	74	57	2.4	1.5	12.8	439,755	5,620	12.1 (21)	11.3 (20)
24. Southwestern Utah	57	17	0.3	0.0	0.9	3,175	1,440	2.1 (5)	1.1 (5)
25. Toole Valley-Vernon Creek	101	91	0.7	0.3	3.6	13,503	906	7.9 (4)	5.2 (4)
26. Upper Arkansas	72	54	1.7	0.9	8.5	292,530	5,875	4.3 (6)	2.4 (6)
27. Upper Colorado-Dirty Devil	62	30	1.0	0.3	5.5	47,498	2,597	2.2 (7)	0.2 (7)
28. Upper Colorado-Dolores§	56	32	1.4	0.6	6.8	102,271	3,434	5.7 (8)	3.8 (8)
29. Upper Sevier	70	30	1.1	0.3	5.3	66,193	3,758	4.4 (16)	2.6 (16)
30. Verde	304	69	0.1	0.0	0.2	335	1,816	0.4 (7)	0.1 (7)
31. Weber-Ogden	99	63	3.6	1.7	19.0	186,751	2,041	13.3 (17)	9.4 (16)
32. White-Yampa§	92	66	4.5	3.0	25.1	964,398	5,948	15.4 (15)	12.4 (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.

Intermountain

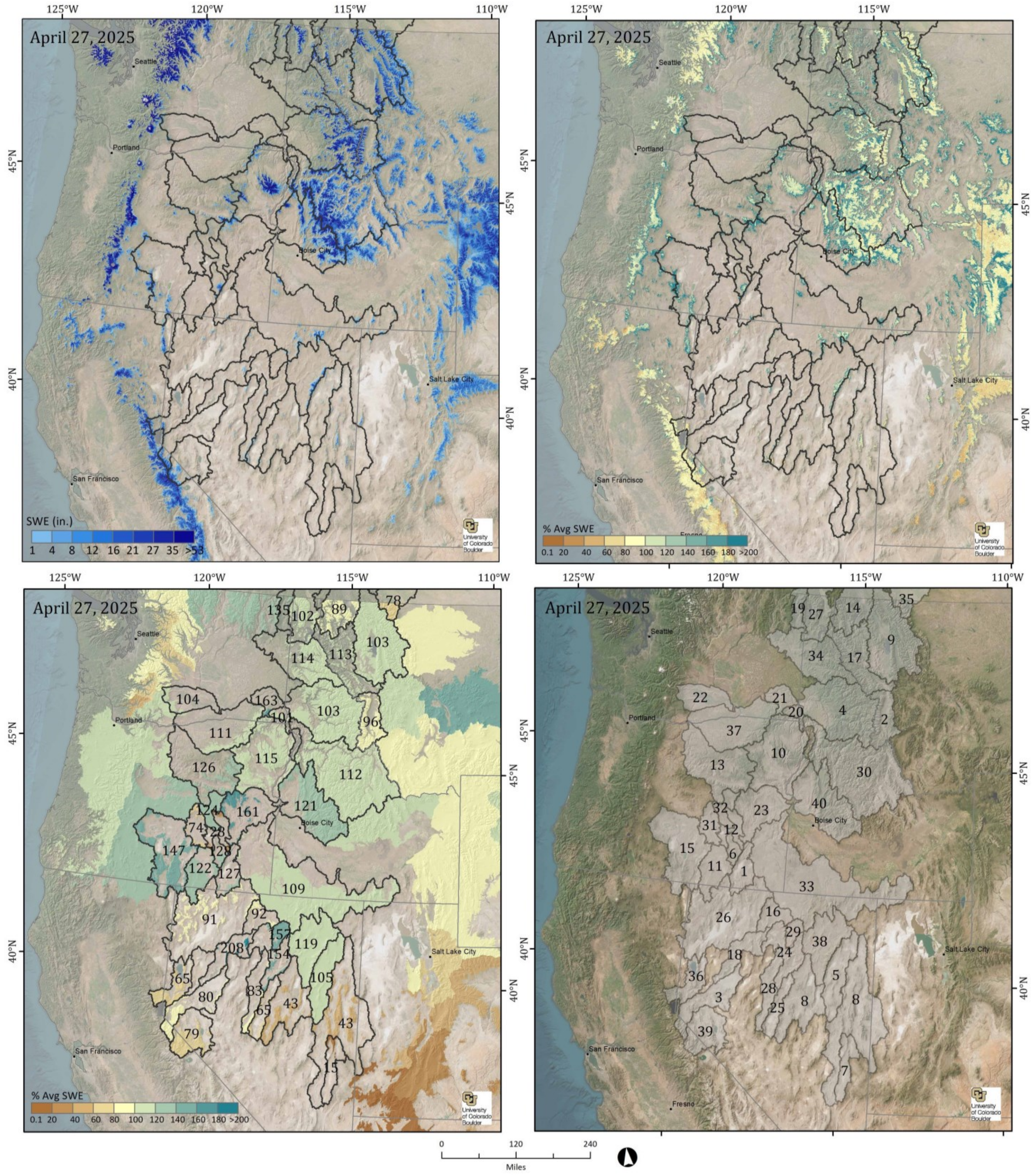

Figure 6. Estimated SWE and % of Average SWE across the Intermountain Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in the 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 4/27/2025

	% of Average		SWE (in)					Pillows	
Basin	4/20	4/27	4/20	4/27	SCA	Vol. (AF)	Area (mi. sq)	4/20	4/27
1. Alvord Lake	118	127	1.7	1.2	8.8	20,889	324	NA	NA
2. Bitterroot	66	96	4.4	6.6	40.6	683,750	1,952	15.8 (4)	13.8 (4)
3. Carson	72	80	2.4	2.6	19.0	191,676	1,405	13.3 (7)	10.5 (7)
4. Clearwater Basin	83	103	4.8	5.4	30.4	2,171,448	7,488	27.1 (11)	24.9 (11)
5. Clover Valley and Franklin	82	105	0.3	0.2	2.2	42,661	4,048	12.8 (2)	7.9 (2)
6. Donner und Blitzen	141	128	7.5	5.3	35.2	62,493	222	36.2 (2)	32.0 (2)
7. Dry Lake Valley	19	15	0.1	0.1	0.7	851	289	NA	NA
8. Eastern Nevada	46	43	0.4	0.2	2.7	49,791	4,372	3.5 (8)	2.1 (8)
9. Flathead	58	103	2.7	4.9	31.6	1,953,067	7,526	22.7 (12)	20.7 (13)
10. Grande Ronde-Burnt-Powder_Imnaha	116	115	4.7	3.6	18.7	1,014,888	5,312	14.1 (10)	10.7 (10)
11. Guano	128	122	0.1	0.1	0.6	7,215	2,036	0.0 (1)	0.1 (1)
12. Harney-Malheur Lakes	90	28	0.2	0.0	0.4	672	276	NA	NA
13. John Day	129	126	4.4	2.8	19.4	224,874	1,502	11.2 (2)	5.2 (2)
14. Kootenai	45	89	2.3	3.5	20.8	314,871	1,673	20.9 (5)	19.5 (5)
15. Lake County-Goose Lake	156	147	2.4	1.3	9.9	243,246	3,602	19.9 (2)	18.0 (2)
16. Little Humboldt	80	92	0.7	0.4	3.6	8,702	419	8.2 (3)	6.7 (3)
17. Lower Clark Fork	72	113	5.0	6.8	40.3	534,502	1,465	40.8 (4)	40.3 (4)
18. Lower Humboldt	82	208	0.3	0.4	6.4	5,730	274	0.0 (1)	0.0 (1)
19. Lower Pend Oreille	118	135	11.6	9.7	49.7	66,770	129	26.3 (1)	24.6 (1)
20. Lower Snake-Asotin	91	101	0.8	0.5	4.4	9,617	328	2.8 (2)	0.8 (2)

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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.

Intermountain SWE Report for 4/27/2025									
	% of Average		SWE (in)					Pillows	
Basin	4/20	4/27	4/20	4/27	SCA	Vol. (AF)	Area (mi. sq)	4/20	4/27
21. Lower Snake-Tucannon	148	163	4.5	3.1	23.2	17,896	109	NA	NA
22. Lower Yakima	108	104	2.2	1.6	9.7	41,725	489	15.5 (2)	11.0 (2)
23. Malheur	152	161	2.8	1.9	13.9	98,507	992	5.1 (3)	3.7 (3)
24. Middle Humboldt	81	154	0.2	0.1	2.0	3,800	633	NA	NA
25. Northern Big Smoky Valley	57	65	0.8	0.5	8.8	14,748	570	NA	NA
26. Northern Great Basin	61	91	0.3	0.2	1.7	21,350	2,226	2.7 (2)	0.7 (2)
27. Panhandle Basins	82	102	4.5	4.4	23.6	387,510	1,644	30.0 (3)	28.6 (3)
28. Reese	62	83	0.9	0.6	9.2	15,373	491	10.2 (2)	5.5 (2)
29. Rock	79	157	0.1	0.1	0.6	2,249	835	12.2 (1)	7.0 (1)
30. Salmon Basin	115	112	9.8	7.7	45.0	4,869,485	11,932	20.6 (11)	18.6 (11)
31. Silver	262	74	0.2	0.1	0.6	1,270	431	NA	NA
32. Silvies	157	124	0.6	0.3	2.6	18,732	1,316	14.2 (1)	8.0 (1)
33. Southern Snake Basins	122	109	0.7	0.3	2.6	205,133	12,500	7.7 (13)	5.0 (13)
34. Spokane	82	114	1.9	1.9	11.5	313,761	3,146	14.1 (7)	11.4 (8)
35. St. Mary	77	78	7.9	7.1	45.7	246,978	648	3.7 (1)	0.2 (1)
36. Truckee	66	65	2.6	1.9	11.7	142,897	1,420	15.5 (8)	13.4 (9)
37. Umatilla-Walla Walla-Willow	114	111	1.0	0.5	4.0	38,051	1,434	14.1 (7)	13.0 (7)
38. Upper Humboldt	103	119	0.9	0.6	4.6	163,846	5,032	11.0 (8)	7.7 (8)
39. Walker	66	79	1.9	2.1	22.6	216,799	1,939	15.8 (7)	13.7 (7)
40. West Central Basins	122	121	9.7	7.1	38.4	2,123,736	5,620	22.8 (15)	19.4 (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. Below is one of the maps from the current report.

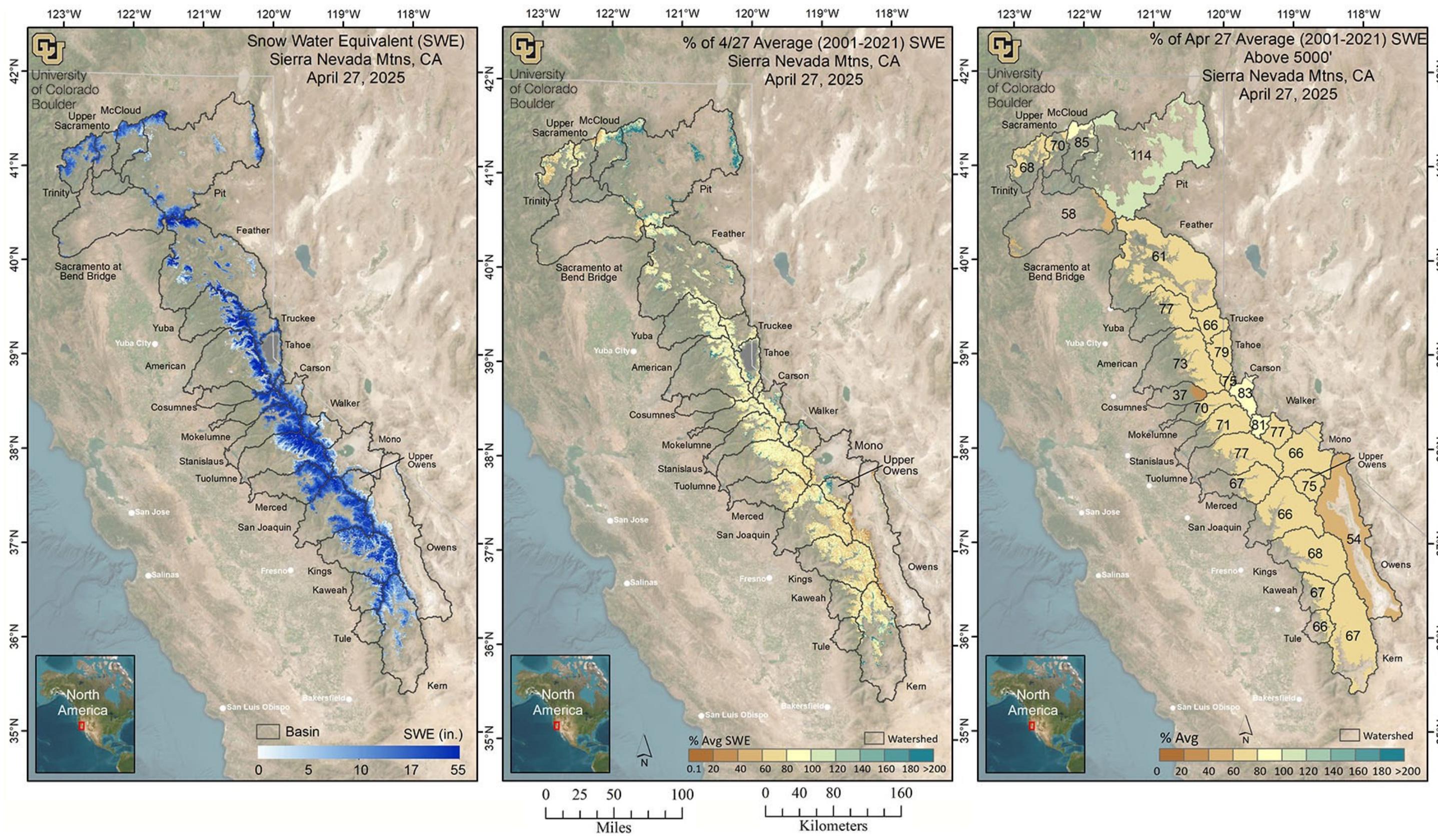

Figure 7. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts (left), and percent of average (2001-2021) SWE for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

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 4/27/2025

	% of Average		SWE (in)					Pillows		
	4/20	4/27	4/20	4/27	SCA	Vol. (AF)‡	Area (mi. sq)	4/20	4/27	SNODAS* (in)
Trinity	105	68	21.6	12.4	66.5	212,405	321.4	25.9 (4)	20.7 (4)	25.0
Upper Sacramento	108	70	20.1	11.3	59.5	69,481	115.2	21.1 (1)	12.5 (1)	23.4
McCloud	108	85	17.0	11.5	71.4	100,823	164.9	32.6 (1)	28.5 (1)	35.4
Pit	108	114	4.2	3.5	17.6	380,270	2065.9	17.9 (7)	13.5 (7)	4.0
Sacramento at Bend Bridge	74	58	8.4	5.4	25.7	69,683	239.8	NA	NA	8.4
Feather§	77	61	6.8	4.3	20.0	474,865	2087.7	21.9 (6)	16.0 (6)	7.1
Yuba§	87	77	14.3	11.4	50.6	312,688	516.4	44.6 (5)	40.7 (5)	20.5
American§	68	73	10.8	9.8	44.2	417,619	795.3	16.2 (11)	12.9 (11)	11.5
Cosumnes	32	37	3.1	2.7	10.9	13,370	91.9	NA	NA	3.4
Mokelumne	69	70	12.3	10.8	43.3	181,012	315.1	34.5 (2)	32.7 (2)	13.8
Stanislaus	69	71	12.3	11.0	49.2	327,127	557.4	26.5 (5)	23.7 (5)	12.6
Tuolumne§	68	77	12.9	12.4	61.3	601,748	910.3	18.7 (6)	18.9 (7)	17.4
Merced	65	67	11.6	10.4	40.0	299,311	538.8	27.2 (2)	21.2 (2)	13.9
San Joaquin	66	66	11.2	10.4	42.6	669,890	1208.5	9.6 (7)	5.7 (7)	10.0
Kings§	70	68	11.7	11.1	48.5	716,466	1207.3	14.4 (5)	12.7 (5)	11.1
Kaweah§	68	67	7.5	6.5	39.5	108,233	314.1	16.4 (2)	18.2 (2)	10.6
Tule	66	66	3.5	2.8	28.8	20,630	137.6	0.7 (1)	0.0 (1)	2.0
Kern§	63	67	3.8	3.4	22.7	307,519	1682.1	12.5 (6)	10.5 (6)	3.9
Truckee	67	66	9.5	7.5	31.7	164,394	412.0	15.3 (6)	13.5 (6)	9.5
Tahoe	68	79	10.9	10.6	45.2	172,651	306.0	16.6 (7)	13.3 (7)	9.1
W Carson	77	75	14.9	12.5	57.3	43,279	65.0	16.9 (3)	13.6 (3)	9.7
E Carson	73	83	8.7	8.5	54.4	159,900	354.3	10.6 (4)	8.1 (4)	8.0
W Walker	75	81	12.8	12.7	74.3	121,564	179.6	18.9 (4)	16.9 (4)	18.2
E Walker	68	77	4.7	4.7	40.4	87,863	351.0	15.5 (1)	14.8 (1)	6.6
Mono	58	66	1.9	1.9	17.8	100,180	1004.4	NA	NA	2.4
Upper Owens	61	75	4.8	4.8	31.9	96,423	374.5	37.0 (1)	34.9 (1)	2.9
Owens	63	54	2.7	2.0	16.2	190,973	1772.0	8.1 (5)	5.4 (5)	1.6

§ 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 (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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