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

Western United States Region

April 20, 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.

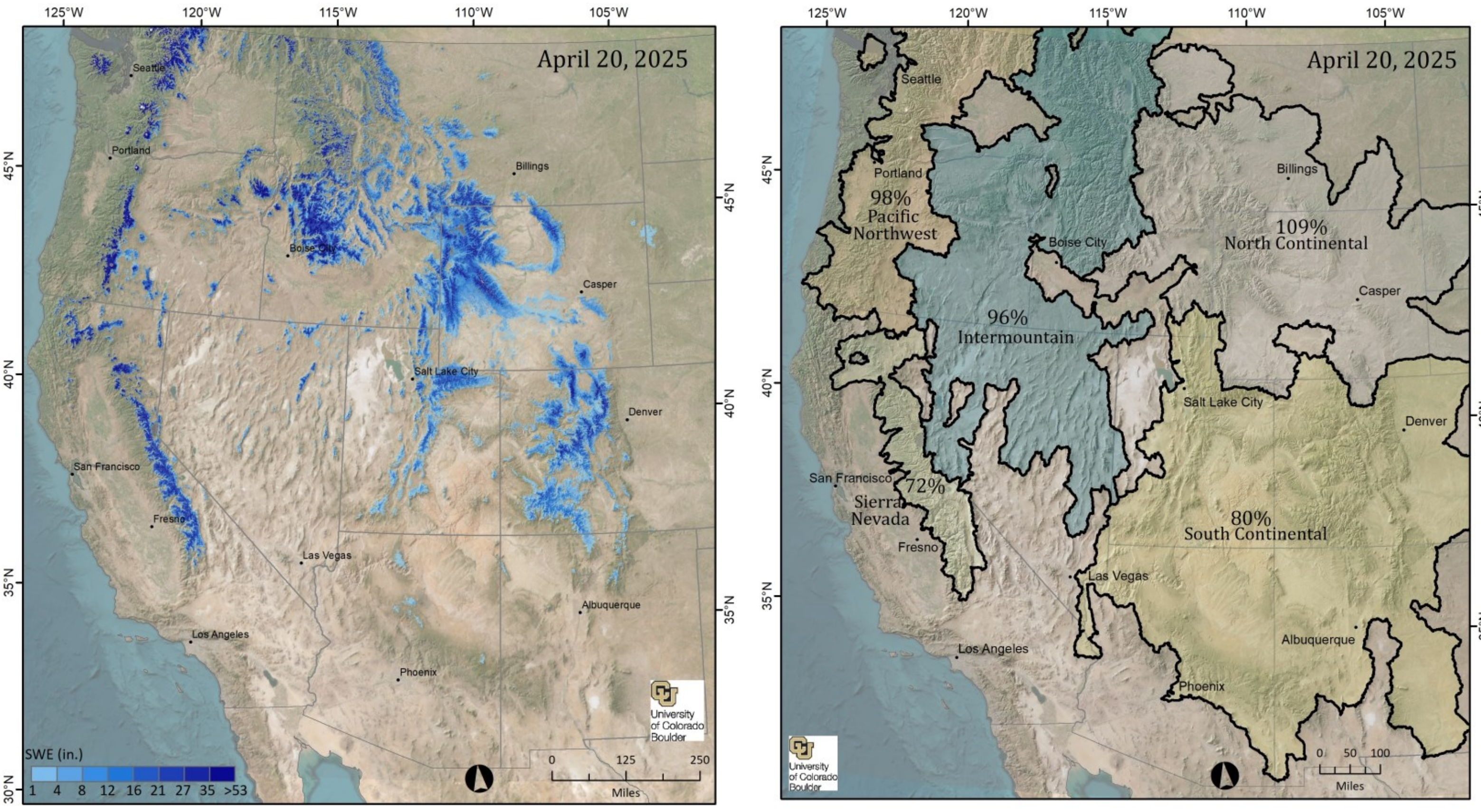

Figure 1. Estimated SWE and % of Average SWE across the Western U.S. SWE amounts across the entire Western region of the United States (left) and percent of long-term average (2001-2021) by five regions (right). Region boundaries are delineated based on Snowpack regimes of the Western United States (Trujillo 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/].

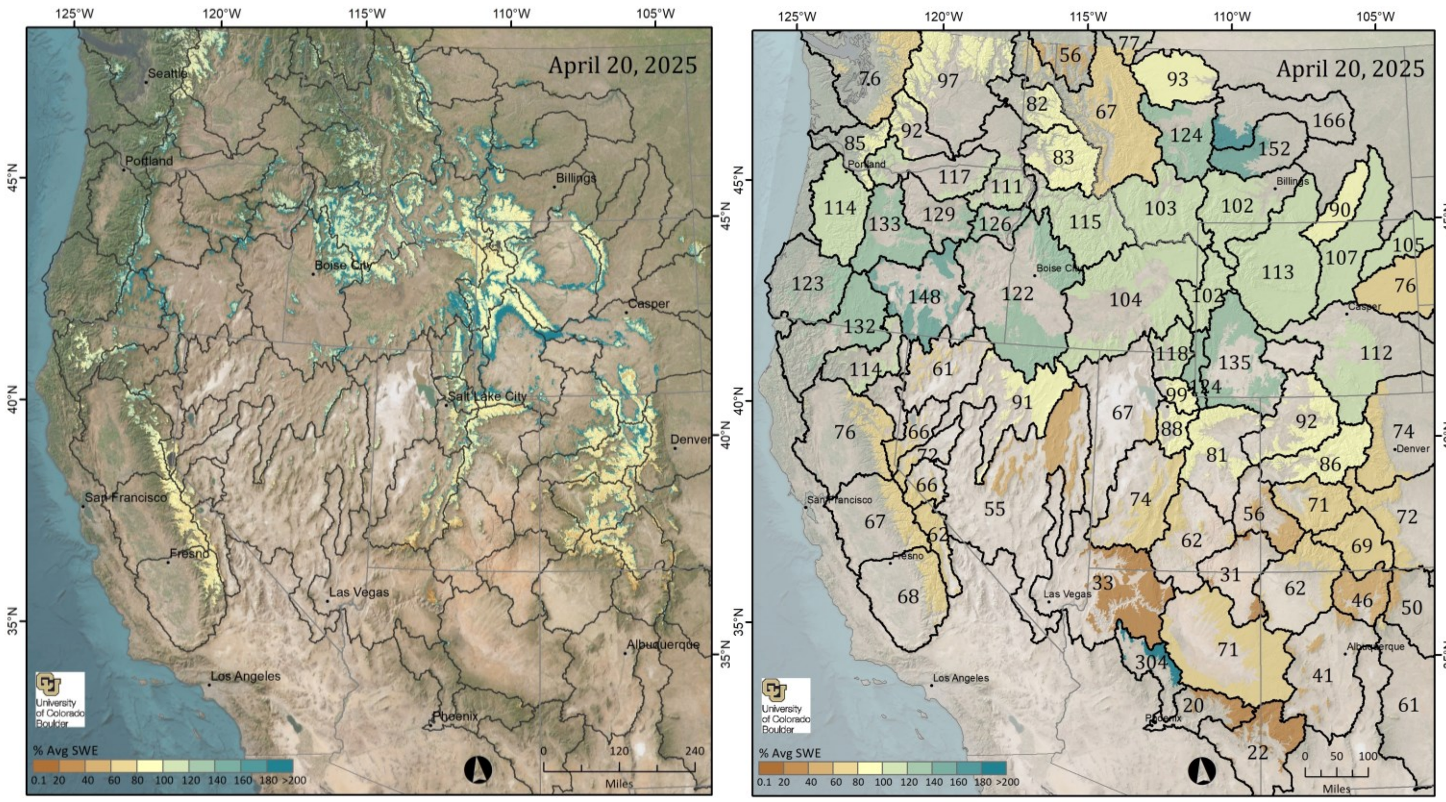

Figure 2. ***Estimated % of Average SWE across the Western U.S.*** Percent of long-term average (2001-2021) from the spatial SWE calculated for each pixel (left) and by HUC-6 basin (right); integer within each watershed represents the percent of average SWE for the report date. Shaded areas (right) correspond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

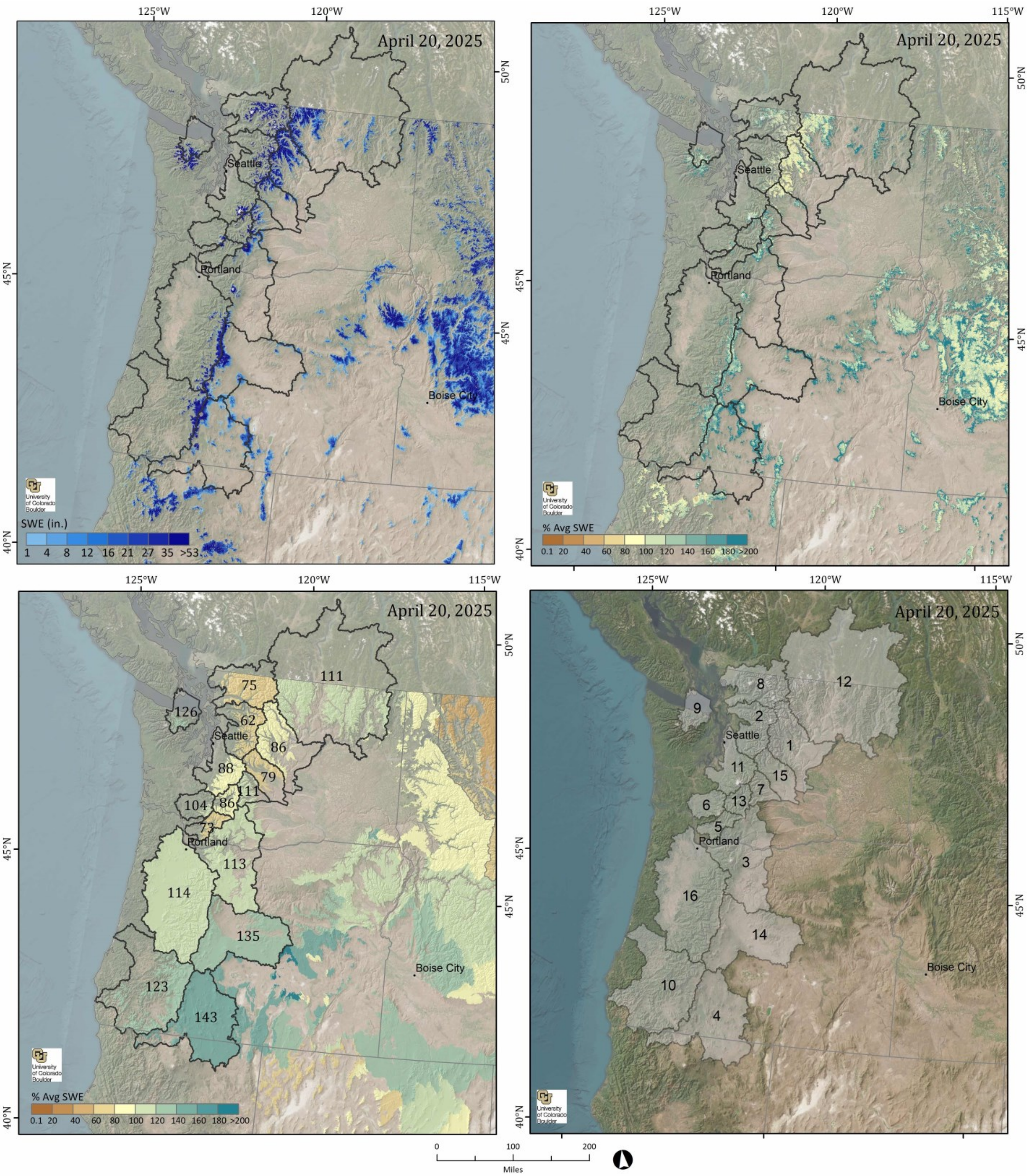

Figure 3. Estimated SWE and % of Average SWE across the Pacific Northwest Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 4/20/2025

	% of Average		SWE (in)					Pillows	
Basin	4/13	4/20	4/13	4/20	SCA	Vol. (AF)	Area (mi. sq)	4/13	4/20
1. Central Columbia	94	86	17.1	15.6	46.9	1,776,226	2,136	18.4 (7)	15.6 (7)
2. Central Puget Sound	42	62	5.2	10.8	27.3	710,036	1,238	35.9 (5)	32.9 (5)
3. Hood-Sandy-Lower Deschutes	125	113	2.6	2.2	7.7	584,049	5,080	20.5 (11)	17.4 (11)
4. Klamath	167	143	3.6	2.9	14.3	1,127,378	7,199	17.8 (15)	14.4 (15)
5. Lewis	67	73	3.1	3.6	8.2	111,259	581	42.6 (6)	40.2 (6)
6. Lower Cowlitz	103	104	6.9	7.2	19.3	70,675	185	21.3 (2)	19.8 (2)
7. Naches	118	111	10.3	9.1	30.5	295,830	610	40.5 (4)	38.3 (4)
8. North Puget Sound	48	75	5.1	11.0	25.6	1,353,828	2,313	37.9 (9)	35.9 (9)
9. Olympic	124	126	26.8	30.5	61.0	386,947	238	32.2 (3)	28.2 (3)
10. Rogue-Umpqua	129	123	5.2	5.3	15.4	944,501	3,371	13.4 (6)	10.0 (6)
11. South Puget Sound	84	88	4.9	5.5	12.7	338,997	1,148	20.3 (14)	19.1 (13)
12. Upper Columbia	120	111	6.8	5.4	21.9	1,575,839	5,502	11.9 (7)	8.8 (7)
13. Upper Cowlitz	73	86	6.0	8.7	18.7	330,930	714	36.1 (3)	32.8 (3)
14. Upper Deschutes-Crooked	154	135	4.3	3.9	14.7	1,162,045	5,608	26.8 (7)	22.5 (7)
15. Upper Yakima	95	79	8.8	7.2	24.3	394,096	1,033	17.7 (3)	14.2 (3)
16. Willamette	125	114	1.7	1.6	4.8	983,090	11,356	13.1 (18)	11.5 (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.

North Continental

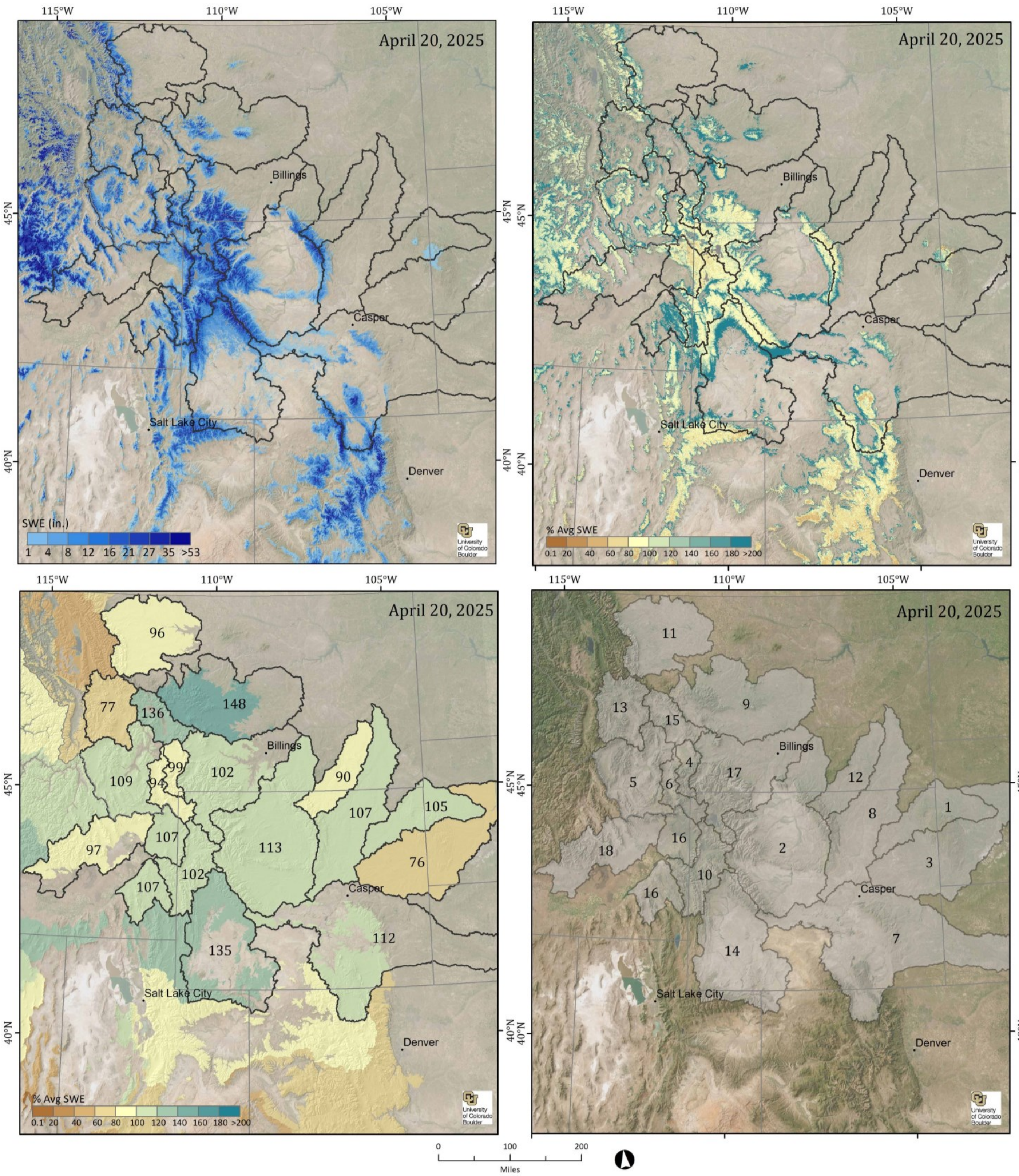

Figure 4. Estimated SWE and % of Average SWE across the North Continental Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 4/20/2025

	% of Average		SWE (in)					Pillows	
Basin	4/13	4/20	4/13	4/20	SCA	Vol. (AF)	Area (mi. sq)	4/13	4/20
1. Belle Fourche	25	105	0.0	0.1	1.9	23,868	7,200	2.7 (1)	1.5 (1)
2. Bighorn	95	113	2.2	2.9	27.3	3,482,422	22,740	11.1 (21)	10.8 (21)
3. Cheyenne	11	76	0.0	0.0	0.2	6,476	15,348	0.3 (2)	0.1 (2)
4. Gallatin	94	99	5.2	5.6	42.7	547,851	1,846	24.8 (3)	21.9 (4)
5. Jefferson	94	109	3.6	4.0	29.7	1,862,958	8,788	12.9 (14)	12.3 (14)
6. Madison Headwaters in WY	93	94	5.9	6.2	47.1	838,975	2,524	18.2 (7)	17.2 (7)
7. North Platte	66	112	2.4	3.6	36.8	1,974,796	10,281	17.0 (22)	16.8 (22)
8. Powder	72	107	0.2	0.4	5.9	313,101	13,385	5.4 (5)	4.6 (5)
9. Smith-Judith-Musselshell	111	148	1.6	1.7	16.6	771,976	8,335	15.1 (9)	15.0 (9)
10. Snake	102	102	11.4	11.2	77.3	3,363,759	5,626	20.8 (11)	19.9 (11)
11. Sun-Teton-Marias	73	96	1.0	1.2	8.5	650,576	10,463	6.7 (5)	6.4 (5)
12. Tongue	88	90	0.8	0.8	7.2	244,501	5,400	9.1 (6)	9.2 (6)
13. Upper Clark Fork	96	77	3.2	2.1	15.9	672,728	5,981	11.6 (12)	11.3 (12)
14. Upper Green	81	135	4.0	5.9	52.1	3,006,869	9,539	13.0 (21)	12.3 (21)
15. Upper Missouri	103	136	1.4	1.5	15.4	242,630	2,951	6.5 (2)	5.3 (2)
16. Upper Snake Basins	103	107	4.6	4.0	33.0	1,470,777	6,875	18.9 (11)	16.9 (11)
17. Upper Yellowstone	102	102	5.8	6.1	44.5	3,581,586	11,070	16.3 (18)	15.7 (19)
18. Wood and Lost Basins	98	97	3.6	3.0	19.5	1,184,633	7,420	10.3 (16)	8.1 (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.

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

South Continental

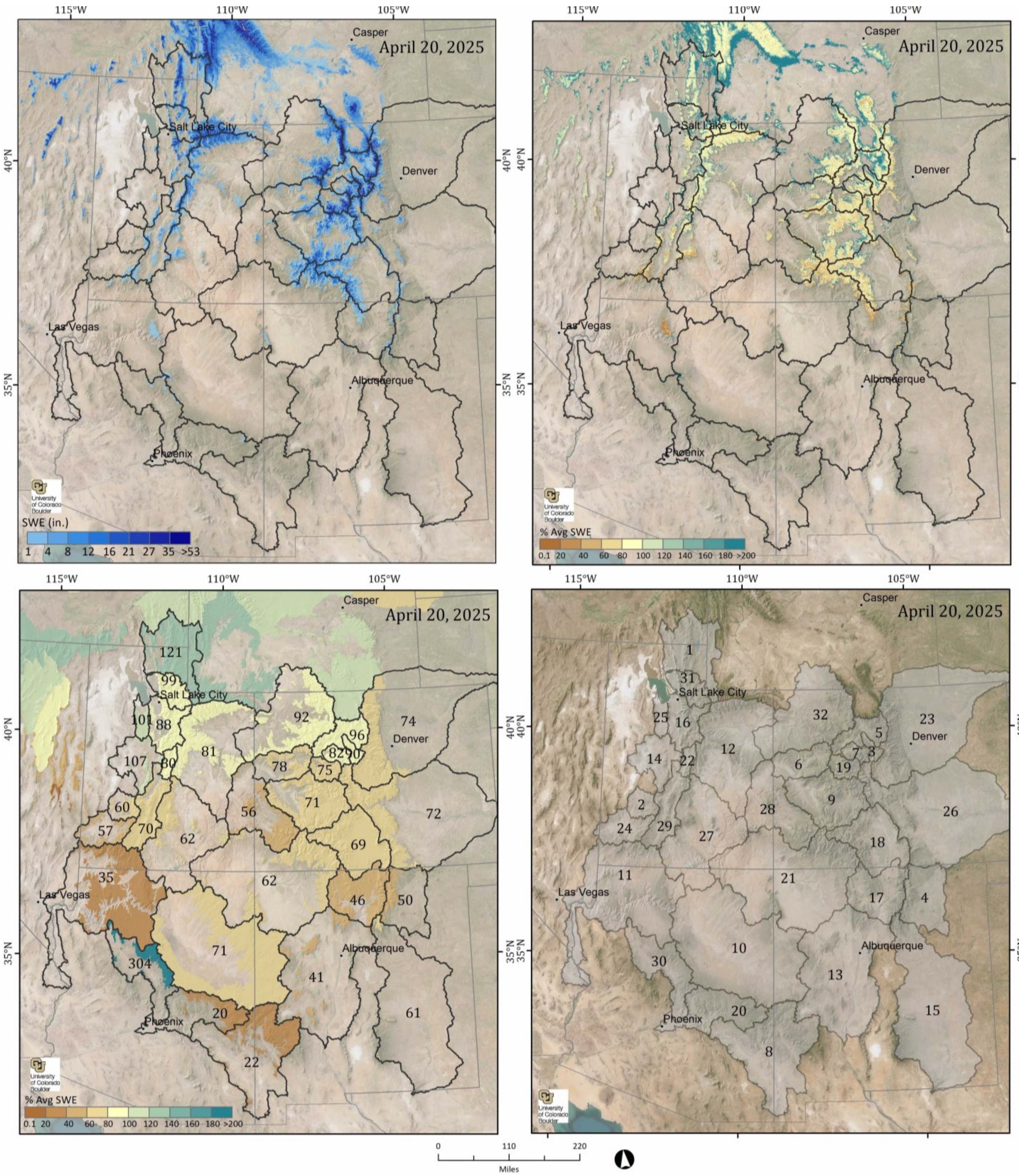

Figure 5. Estimated SWE and % of Average SWE across the South Continental Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in 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 4/20/2025

	% of Average		SWE (in)					Pillows	
Basin	4/13	4/20	4/13	4/20	SCA	Vol. (AF)	Area (mi. sq)	4/13	4/20
1. Bear	84	121	3.3	3.9	30.9	1,286,851	6,181	13.3 (18)	12.2 (18)
2. Beaver	59	60	0.9	0.7	10.8	29,608	836	11.2 (2)	10.8 (2)
3. Blue§	78	90	7.8	10.7	65.3	382,494	670	16.4 (5)	15.4 (5)
4. Canadian	19	50	0.1	0.2	6.9	15,636	1,265	0.3 (2)	0.4 (2)
5. Colorado Headwaters§	82	96	6.4	6.7	51.2	1,021,389	2,874	14.4 (13)	13.3 (13)
6. Colorado Headwaters-Plateau	65	78	3.2	3.1	32.0	297,620	1,801	11.8 (1)	10.3 (1)
7. Eagle	75	82	6.1	6.6	49.1	324,282	921	11.2 (3)	9.5 (3)
8. Gila	0	22	0.0	0.0	0.0	256	4,924	0.0 (6)	0.0 (6)
9. Gunnison§	64	71	3.7	3.7	39.7	1,262,164	6,433	9.2 (11)	7.1 (11)
10. Little Colorado	17	71	0.0	0.0	1.0	11,574	16,379	2.2 (5)	2.2 (5)
11. Lower Colorado Mainstream	18	35	0.0	0.0	3.4	22,733	10,695	2.2 (5)	1.6 (5)
12. Lower Green§	67	81	3.7	3.7	37.4	1,124,610	5,647	7.7 (24)	6.9 (24)
13. Lower Rio Grande	7	41	0.0	0.1	1.2	5,464	1,795	0.1 (6)	0.3 (6)
14. Lower Sevier	56	107	0.8	1.0	17.3	46,784	897	9.8 (4)	8.3 (4)
15. Pecos	33	61	0.5	0.7	14.1	12,716	331	0.3 (2)	0.4 (2)
16. Provo-Utah Lake-Jordan§	80	88	3.3	3.2	29.4	452,098	2,681	18.3 (17)	16.3 (17)
17. Rio Chama-Upper Rio Grande	28	46	0.4	0.4	10.1	120,956	5,207	2.4 (13)	1.9 (13)
18. Rio Grande Headwaters	45	69	1.3	1.8	25.6	724,006	7,595	4.9 (14)	4.2 (14)
19. Roaring Fork§	73	75	7.7	8.4	54.2	608,218	1,359	12.9 (7)	11.4 (7)
20. Salt	2	20	0.0	0.0	1.2	2,551	2,361	0.0 (7)	0.1 (7)
21. San Juan	48	62	1.3	1.5	18.3	512,922	6,406	6.8 (15)	5.4 (15)
22. San Pitch	71	80	2.6	2.4	22.0	110,415	857	11.1 (6)	9.9 (6)
23. South Platte§	57	74	1.9	2.4	22.0	721,460	5,620	12.3 (21)	12.1 (21)
24. Southwestern Utah	34	57	0.2	0.3	6.3	20,558	1,440	2.2 (5)	2.1 (5)
25. Toole Valley-Vernon Creek	68	101	0.6	0.7	7.8	32,018	906	8.9 (4)	7.9 (4)
26. Upper Arkansas	53	72	1.3	1.7	18.4	522,935	5,875	5.1 (7)	4.3 (6)
27. Upper Colorado-Dirty Devil	35	62	0.8	1.0	14.7	135,043	2,597	3.0 (7)	2.2 (7)
28. Upper Colorado-Dolores§	44	56	1.4	1.4	18.1	263,354	3,434	7.4 (8)	5.7 (8)
29. Upper Sevier	43	70	1.0	1.1	17.3	216,944	3,758	5.2 (16)	4.4 (16)
30. Verde	40	304	0.0	0.1	7.8	6,700	1,816	0.6 (7)	0.4 (7)
31. Weber-Ogden	80	99	3.5	3.6	33.0	396,977	2,041	15.0 (17)	13.3 (17)
32. White-Yampa§	81	92	4.7	4.5	35.3	1,436,532	5,948	16.5 (15)	15.4 (15)

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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.

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

Intermountain

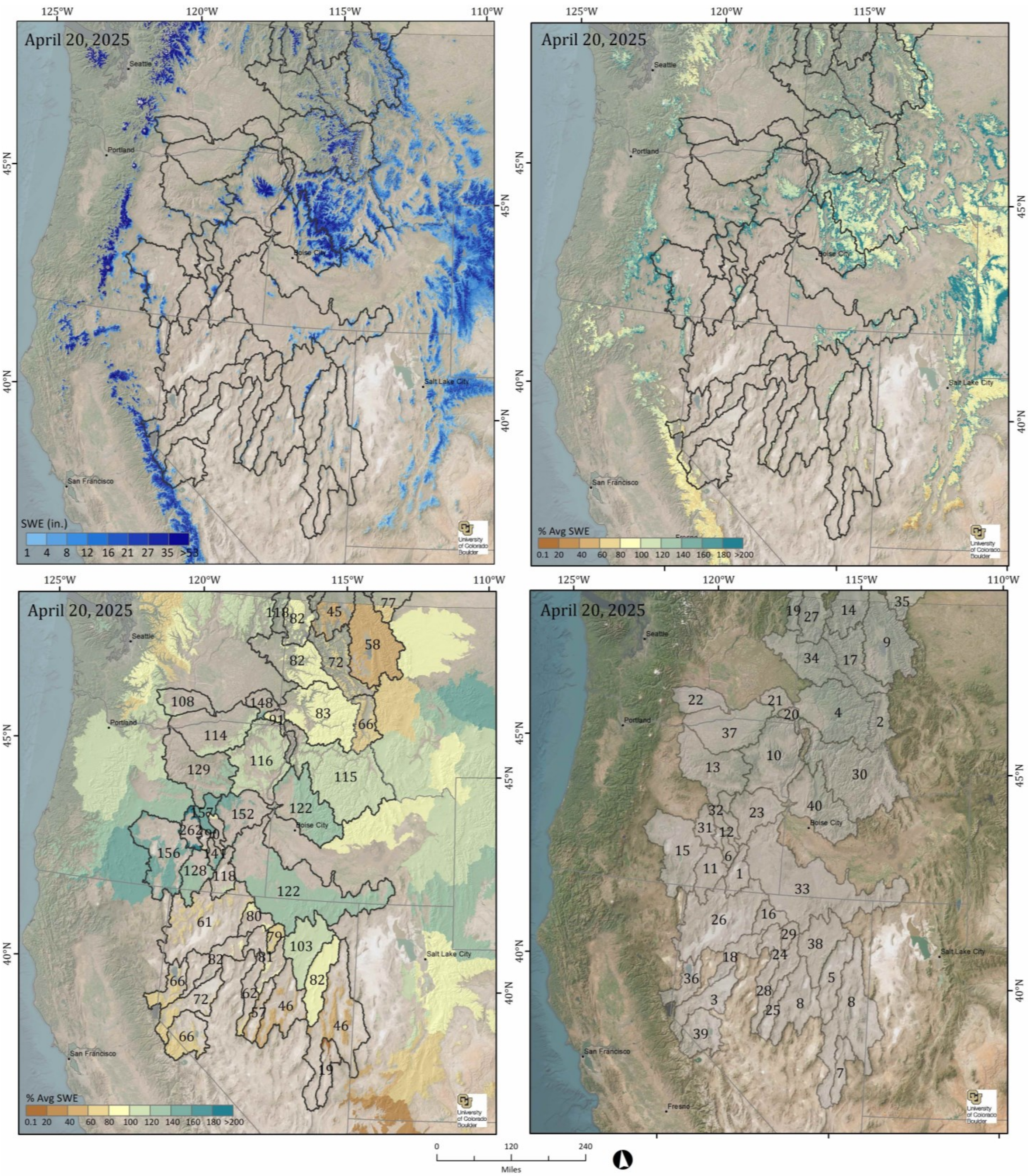

Figure 6. Estimated SWE and % of Average SWE across the Intermountain Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in the 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 4/20/2025

	% of Average		SWE (in)					Pillows	
Basin	4/13	4/20	4/13	4/20	SCA	Vol. (AF)	Area (mi. sq)	4/13	4/20
1. Alvord Lake	134	118	2.7	1.7	10.8	28,581	324	NA	NA
2. Bitterroot	90	66	7.5	4.4	24.1	460,972	1,952	18.5 (4)	15.8 (4)
3. Carson	85	72	3.7	2.4	13.4	180,137	1,405	15.8 (7)	13.3 (7)
4. Clearwater Basin	90	83	5.8	4.8	22.0	1,909,367	7,488	29.2 (11)	27.1 (11)
5. Clover Valley and Franklin	75	82	0.4	0.3	2.8	63,927	4,048	16.2 (2)	12.8 (2)
6. Donner und Blitzen	155	141	10.4	7.5	49.1	88,809	222	38.2 (2)	36.2 (2)
7. Dry Lake Valley	18	19	0.2	0.1	1.2	1,043	289	NA	NA
8. Eastern Nevada	49	46	0.6	0.4	4.3	91,580	4,372	4.3 (8)	3.5 (8)
9. Flathead	75	58	3.7	2.7	16.1	1,087,286	7,526	22.3 (13)	22.7 (12)
10. Grande Ronde-Burnt-Powder_Imnaha	124	116	5.6	4.7	22.7	1,342,279	5,312	16.9 (10)	14.1 (10)
11. Guano	145	128	0.2	0.1	1.1	13,209	2,036	NA	0.0 (1)
12. Harney-Malheur Lakes	168	90	0.9	0.2	1.8	2,989	276	NA	NA
13. John Day	145	129	5.5	4.4	27.0	349,680	1,502	15.8 (2)	11.2 (2)
14. Kootenai	57	45	2.6	2.3	11.8	201,004	1,673	21.4 (5)	20.9 (5)
15. Lake County-Goose Lake	176	156	3.5	2.4	17.8	459,063	3,602	21.7 (2)	19.9 (2)
16. Little Humboldt	94	80	1.3	0.7	6.2	15,922	419	11.4 (3)	8.2 (3)
17. Lower Clark Fork	83	72	6.1	5.0	26.7	393,462	1,465	41.3 (4)	40.8 (4)
18. Lower Humboldt	108	82	0.7	0.3	3.7	5,029	274	0.0 (1)	0.0 (1)
19. Lower Pend Oreille	100	118	8.9	11.6	49.3	79,947	129	27.5 (1)	26.3 (1)
20. Lower Snake-Asotin	125	91	1.1	0.8	6.1	14,343	328	4.9 (2)	2.8 (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 4/20/2025									
	% of Average		SWE (in)					Pillows	
Basin	4/13	4/20	4/13	4/20	SCA	Vol. (AF)	Area (mi. sq)	4/13	4/20
21. Lower Snake-Tucannon	161	148	5.5	4.5	30.4	26,028	109	NA	NA
22. Lower Yakima	121	108	3.4	2.2	12.4	57,942	489	19.8 (2)	15.5 (2)
23. Malheur	171	152	4.5	2.8	19.7	147,169	992	8.8 (3)	5.1 (3)
24. Middle Humboldt	65	81	0.2	0.2	1.9	5,113	633	NA	NA
25. Northern Big Smoky Valley	73	57	1.4	0.8	9.0	25,140	570	NA	NA
26. Northern Great Basin	78	61	0.5	0.3	1.9	29,773	2,226	4.7 (2)	2.7 (2)
27. Panhandle Basins	64	82	2.9	4.5	20.2	392,724	1,644	30.4 (3)	30.0 (3)
28. Reese	76	62	1.6	0.9	9.4	23,003	491	13.5 (2)	10.2 (2)
29. Rock	50	79	0.1	0.1	0.8	3,894	835	14.8 (1)	12.2 (1)
30. Salmon Basin	120	115	11.2	9.8	52.5	6,206,208	11,932	21.7 (11)	20.6 (11)
31. Silver	250	262	0.7	0.2	2.2	5,586	431	NA	NA
32. Silvies	202	157	1.3	0.6	5.1	41,425	1,316	8.9 (2)	14.2 (1)
33. Southern Snake Basins	95	122	0.8	0.7	5.6	448,999	12,500	10.7 (12)	7.7 (13)
34. Spokane	72	82	1.8	1.9	9.3	311,153	3,146	16.1 (8)	14.1 (7)
35. St. Mary	79	77	7.3	7.9	52.7	272,326	648	6.1 (1)	3.7 (1)
36. Truckee	80	66	3.9	2.6	14.5	194,661	1,420	18.3 (8)	15.5 (8)
37. Umatilla-Walla Walla-Willow	133	114	1.2	1.0	6.9	75,761	1,434	18.2 (6)	14.1 (7)
38. Upper Humboldt	89	103	1.0	0.9	6.1	231,401	5,032	12.9 (8)	11.0 (8)
39. Walker	76	66	2.7	1.9	12.7	192,815	1,939	17.6 (7)	15.8 (7)
40. West Central Basins	131	122	12.1	9.7	48.8	2,907,378	5,620	25.5 (15)	22.8 (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.

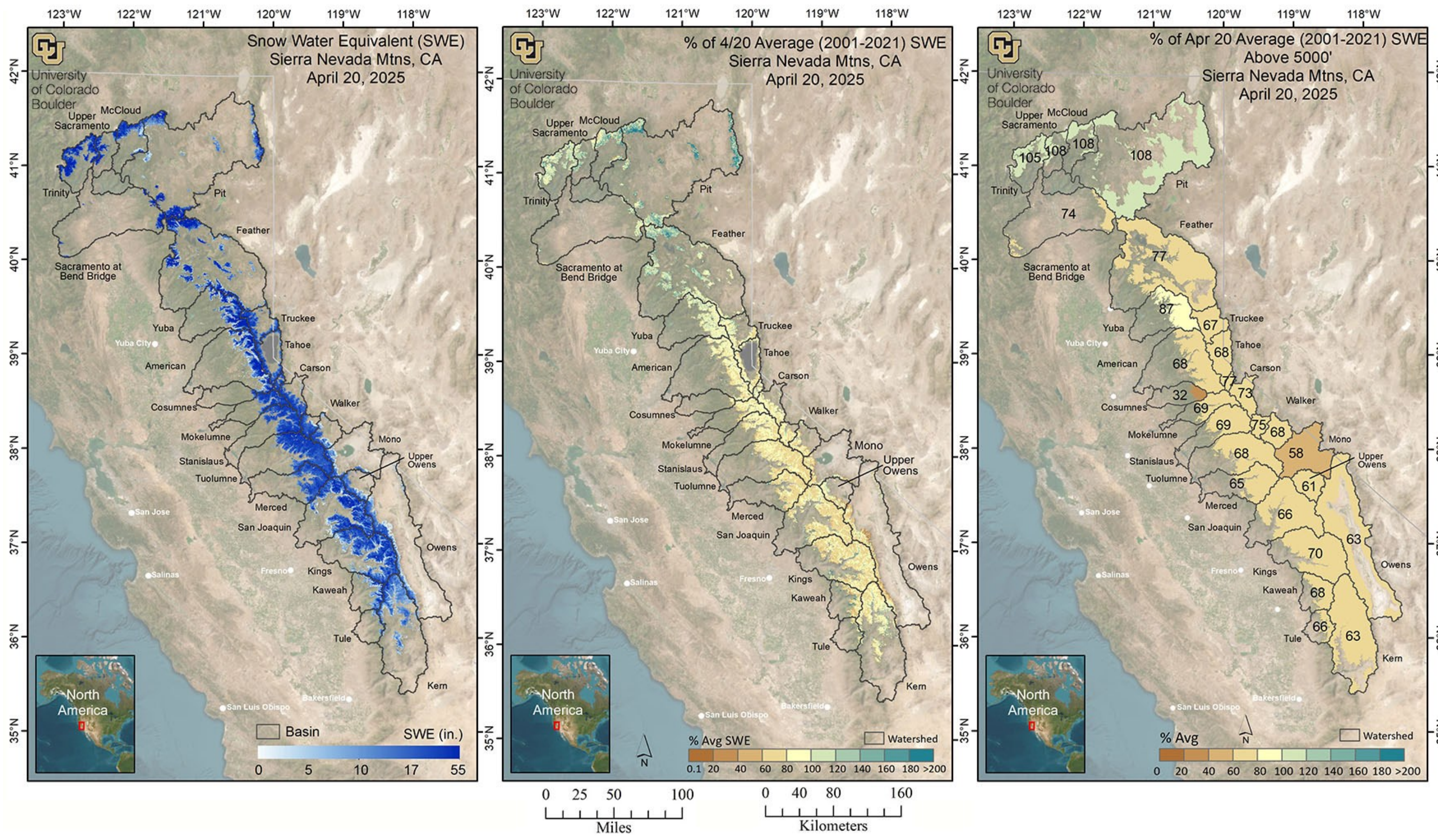

Figure 7. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts (left), and percent of average (2001-2021) SWE for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

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 (mi²) 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 4/20/2025

	% of Average		SWE (in)					Pillows		
	4/13	4/20	4/13	4/20	SCA	Vol. (AF)‡	Area (mi. sq)	4/13	4/20	SNODAS* (in)
Trinity	131	105	27.2	21.6	77.7	370,926	321.4	35.5 (4)	25.9 (4)	31.4
Upper Sacramento	127	108	23.7	20.1	70.9	123,259	115.2	28.6 (1)	21.1 (1)	29.1
McCloud	116	108	19.6	17.0	79.3	149,654	164.9	36.3 (1)	32.6 (1)	39.5
Pit	139	108	5.2	4.2	18.5	460,602	2065.9	23.4 (7)	17.9 (7)	5.2
Sacramento at Bend Bridge	110	74	11.2	8.4	26.7	107,870	239.8	NA	NA	11.5
Feather§	94	77	8.1	6.8	24.9	751,722	2087.7	28.1 (6)	21.9 (6)	9.3
Yuba§	106	87	18.6	14.3	58.2	394,740	516.4	48.9 (5)	44.6 (5)	24.5
American§	87	68	14.6	10.8	48.7	457,117	795.3	20.4 (11)	16.2 (11)	14.6
Cosumnes	57	32	4.7	3.1	14.1	15,322	91.9	NA	NA	4.6
Mokelumne	88	69	15.1	12.3	52.0	207,062	315.1	34.5 (2)	34.5 (2)	15.9
Stanislaus	89	69	14.8	12.3	51.3	367,152	557.4	29.6 (5)	26.5 (5)	14.5
Tuolumne	87	68	15.2	12.9	57.0	626,168	910.3	25.1 (7)	18.7 (6)	18.4
Merced	86	65	14.0	11.6	53.3	333,523	538.8	28.2 (2)	27.2 (2)	15.5
San Joaquin§	80	66	13.1	11.2	53.0	721,539	1208.5	14.4 (7)	9.6 (7)	11.4
Kings§	81	70	14.1	11.7	57.4	755,257	1207.3	17.0 (5)	14.4 (5)	12.3
Kaweah§	79	68	9.4	7.5	43.9	125,950	314.1	18.8 (2)	16.4 (2)	9.9
Tule	91	66	3.9	3.5	18.5	25,663	137.6	1.5 (1)	0.7 (1)	1.1
Kern§	73	63	3.9	3.8	21.8	345,030	1682.1	15.3 (6)	12.5 (6)	3.6
Truckee	83	67	10.9	9.5	38.9	208,953	412.0	18.4 (6)	15.3 (6)	11.9
Tahoe	84	68	12.8	10.9	48.5	177,296	306.0	20.8 (7)	16.6 (7)	11.1
W Carson	98	77	17.6	14.9	60.6	51,775	65.0	19.7 (3)	16.9 (3)	13.0
E Carson	86	73	9.8	8.7	35.3	163,621	354.3	12.8 (4)	10.6 (4)	8.8
W Walker	88	75	14.9	12.8	60.7	123,059	179.6	20.8 (4)	18.9 (4)	18.9
E Walker	80	68	5.3	4.7	25.8	88,660	351.0	15.9 (1)	15.5 (1)	6.1
Mono	72	58	2.4	1.9	11.3	104,292	1004.4	NA	NA	2.2
Upper Owens	72	61	5.1	4.8	24.7	95,403	374.5	38.9 (1)	37.0 (1)	3.1
Owens	68	63	2.6	2.7	14.5	251,630	1772.0	11.2 (5)	8.1 (5)	1.4

§ 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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