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

Western United States Region

April 13, 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.

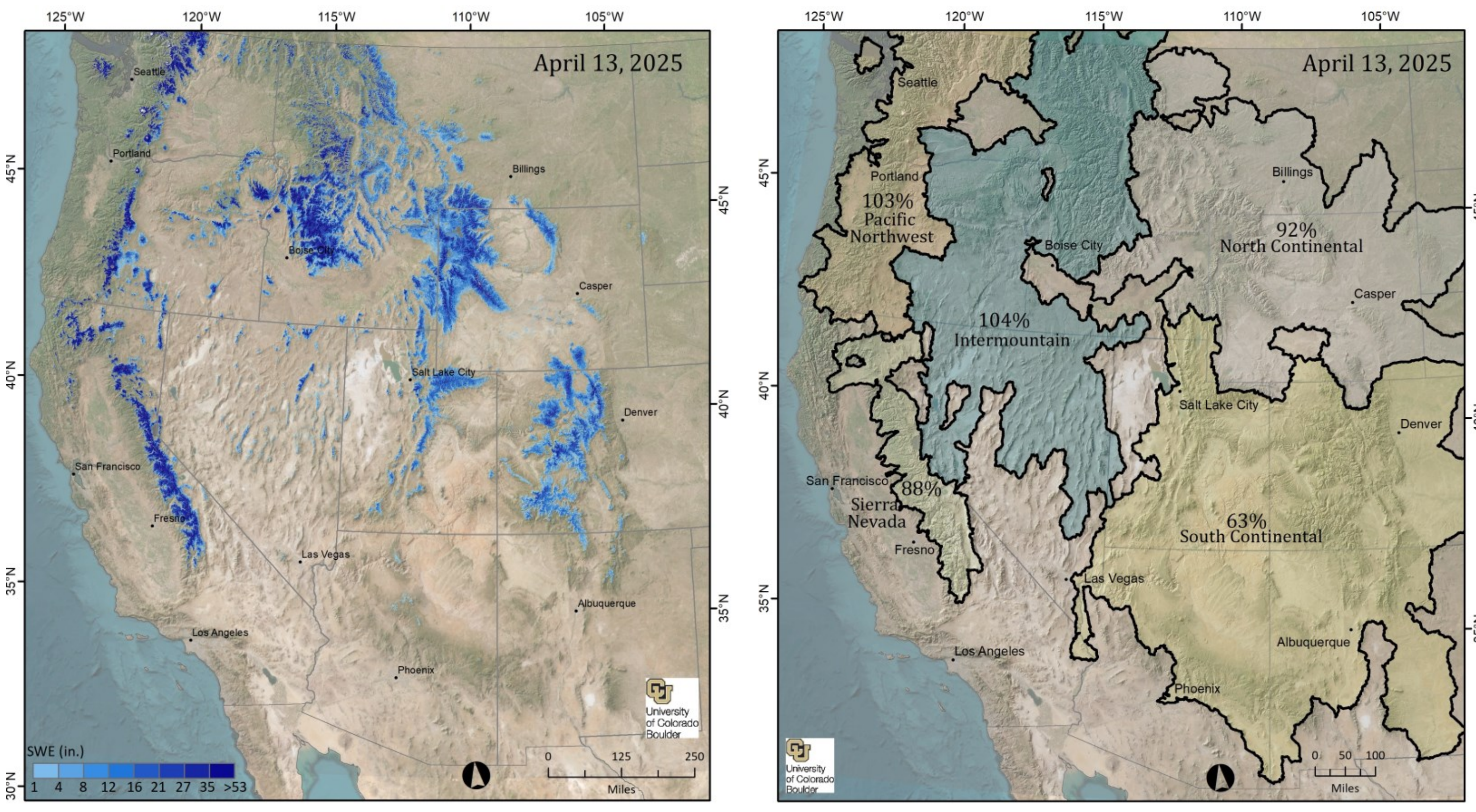

Figure 1. Estimated SWE and % of Average SWE across the Western U.S. SWE amounts across the entire Western region of the United States (left) and percent of long-term average (2001-2021) by five regions (right). Region boundaries are delineated based on Snowpack regimes of the Western United States (Trujillo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

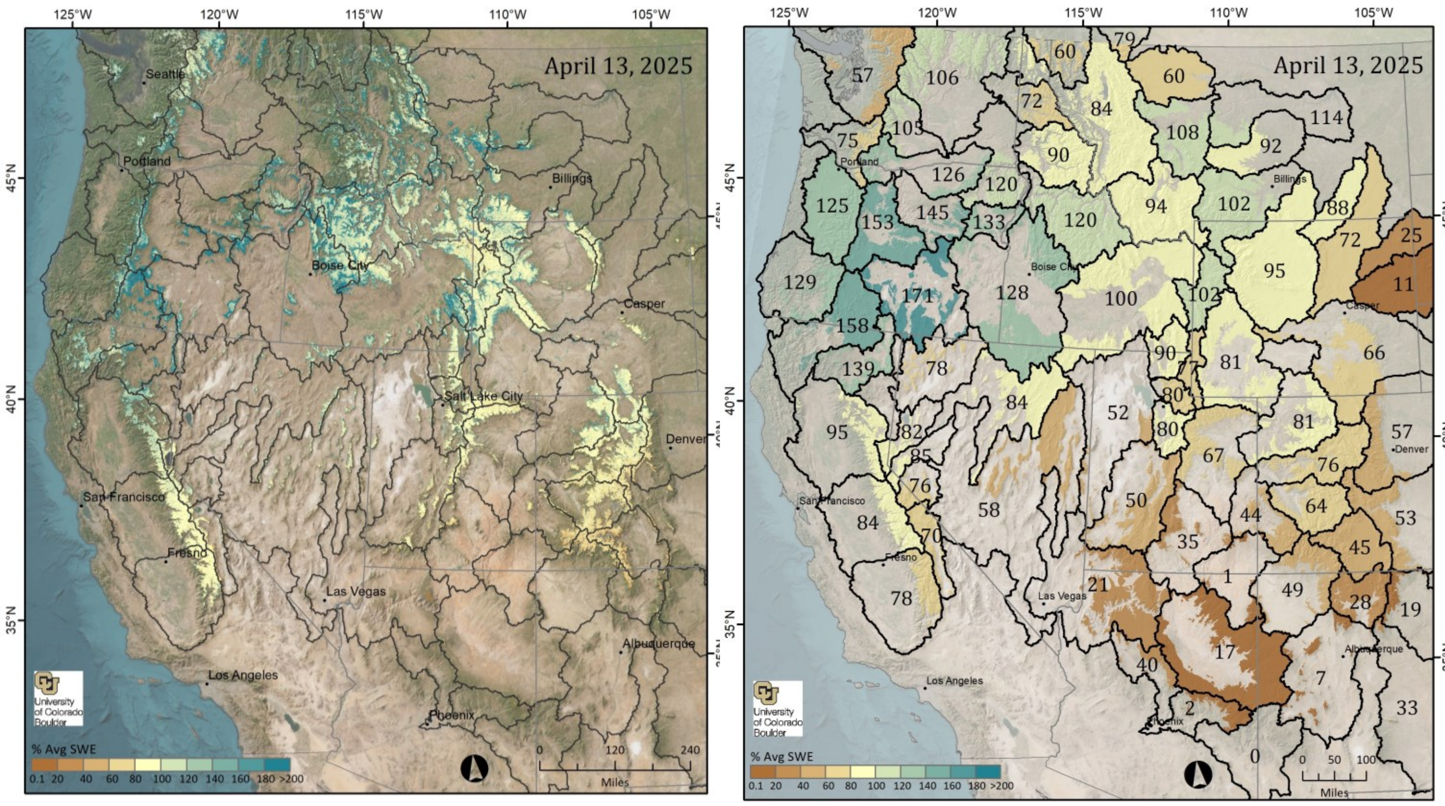

Figure 2. ***Estimated % of Average SWE across the Western U.S.*** Percent of long-term average (2001-2021) from the spatial SWE calculated for each pixel (left) and by HUC-6 basin (right); integer within each watershed represents the percent of average SWE for the report date. Shaded areas (right) correspond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

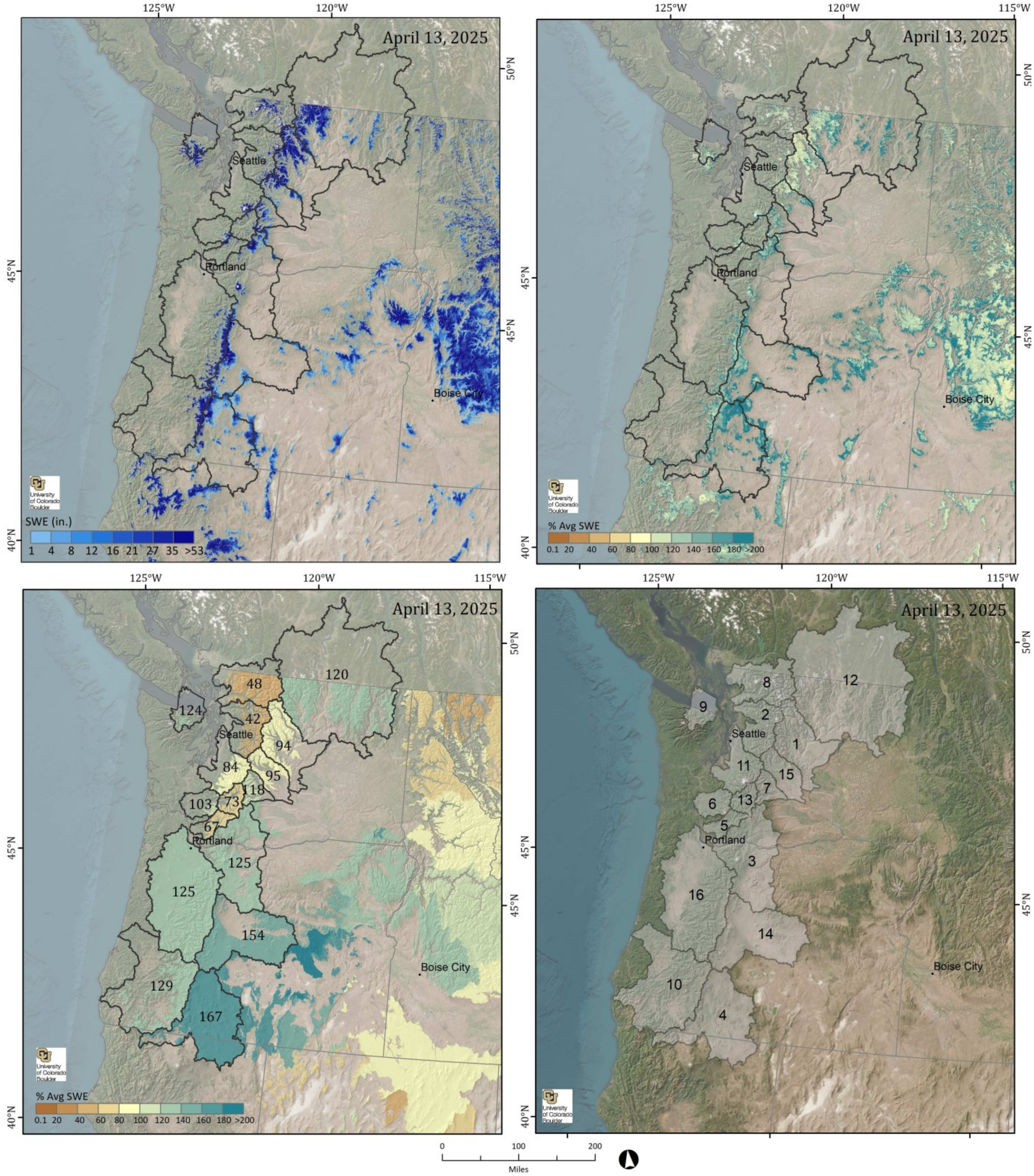

Figure 3. Estimated SWE and % of Average SWE across the Pacific Northwest Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 4/13/2025

	% of Average		SWE (in)					Pillows	
Basin	4/6	4/13	4/6	4/13	SCA	Vol. (AF)	Area (mi. sq)	4/6	4/13
1. Central Columbia	93	94	19.1	17.1	47.7	1,949,170	2,136	20.0 (7)	18.4 (7)
2. Central Puget Sound	45	42	8.2	5.2	13.4	345,013	1,238	36.5 (5)	35.9 (5)
3. Hood-Sandy-Lower Deschutes	119	125	2.9	2.6	9.7	698,919	5,080	22.1 (11)	20.5 (11)
4. Klamath	210	167	5.4	3.6	19.3	1,400,056	7,199	21.4 (15)	17.8 (15)
5. Lewis	58	67	3.3	3.1	9.8	95,710	581	36.5 (7)	42.6 (6)
6. Lower Cowlitz	104	103	8.9	6.9	26.2	68,479	185	21.9 (2)	21.3 (2)
7. Naches	123	118	11.8	10.3	39.9	333,853	610	40.4 (4)	40.5 (4)
8. North Puget Sound	50	48	7.1	5.1	13.3	627,129	2,313	37.6 (9)	37.9 (9)
9. Olympic	106	124	24.6	26.8	65.4	339,615	238	31.4 (3)	32.2 (3)
10. Rogue-Umpqua	114	129	5.7	5.2	15.9	938,879	3,371	16.1 (6)	13.4 (6)
11. South Puget Sound	76	84	5.7	4.9	11.3	298,058	1,148	20.8 (14)	20.3 (14)
12. Upper Columbia	130	120	8.7	6.8	26.5	1,981,425	5,502	14.0 (7)	11.9 (7)
13. Upper Cowlitz	69	73	7.8	6.0	14.8	226,523	714	37.5 (3)	36.1 (3)
14. Upper Deschutes-Crooked	161	154	5.4	4.3	17.9	1,289,788	5,608	30.5 (7)	26.8 (7)
15. Upper Yakima	110	95	11.4	8.8	30.7	482,833	1,033	19.4 (3)	17.7 (3)
16. Willamette	101	125	1.7	1.7	5.4	1,038,851	11,356	15.5 (18)	13.1 (18)

§ 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

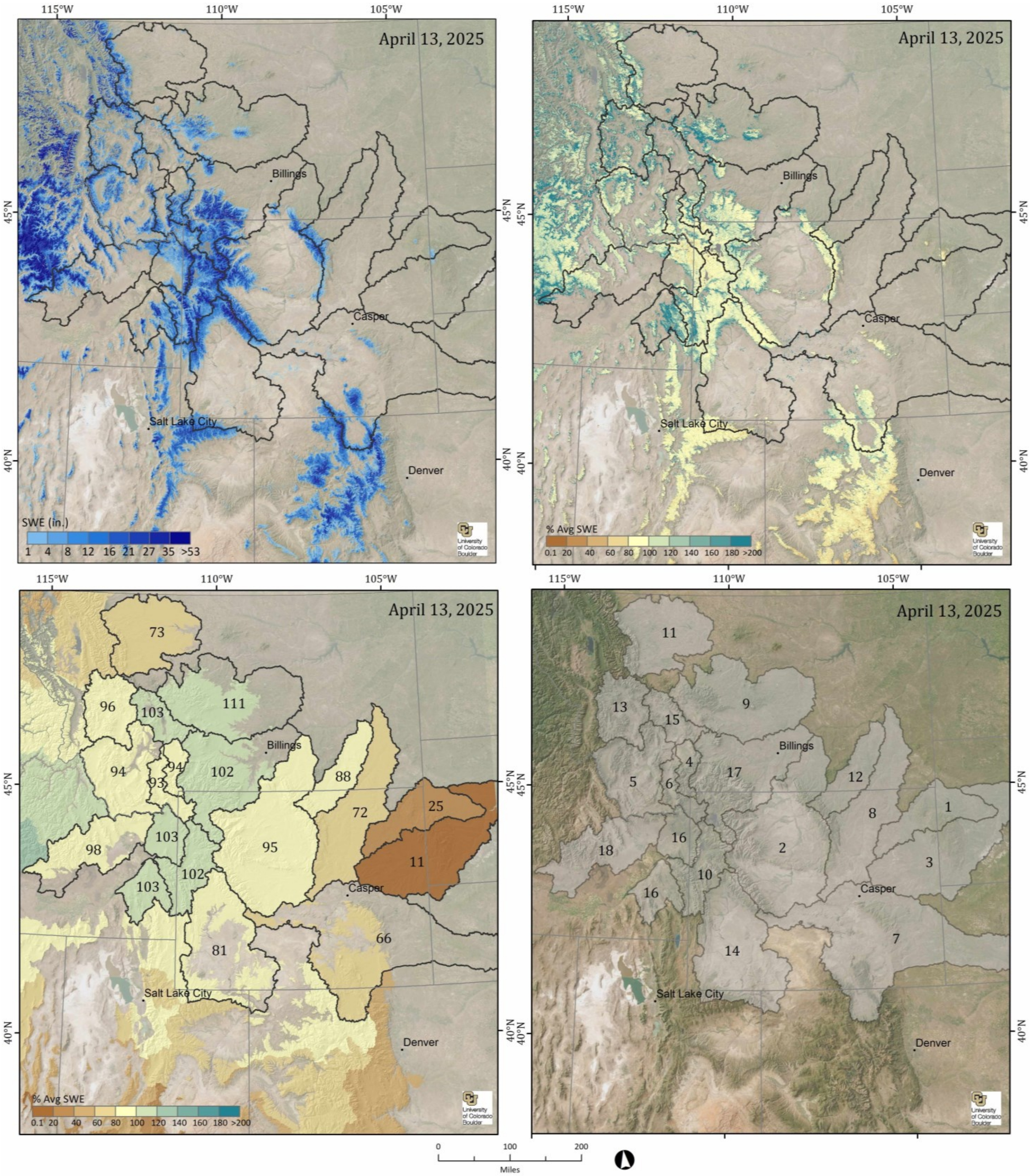

Figure 4. Estimated SWE and % of Average SWE across the North Continental Region. *SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left)* shaded areas correspond to the elevation bands used 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 4/13/2025

	% of Average		SWE (in)					Pillows	
Basin	4/6	4/13	4/6	4/13	SCA	Vol. (AF)	Area (mi. sq)	4/6	4/13
1. Belle Fourche	168	25	0.3	0.0	1.0	19,141	7,200	5.8 (1)	2.7 (1)
2. Bighorn	122	95	3.2	2.2	15.0	2,640,384	22,740	12.4 (21)	11.1 (21)
3. Cheyenne	120	11	0.1	0.0	0.1	5,066	15,348	3.6 (2)	0.3 (2)
4. Gallatin	128	94	8.0	5.2	38.0	512,061	1,846	23.9 (3)	24.8 (3)
5. Jefferson	130	94	6.8	3.6	26.5	1,710,525	8,788	13.5 (14)	12.9 (14)
6. Madison Headwaters in WY	110	93	8.6	5.9	43.5	793,852	2,524	18.3 (7)	18.2 (7)
7. North Platte	100	66	4.2	2.4	19.3	1,316,966	10,281	19.0 (22)	17.0 (22)
8. Powder	132	72	0.6	0.2	2.3	173,971	13,385	7.0 (5)	5.4 (5)
9. Smith-Judith-Musselshell	175	111	3.8	1.6	14.8	689,745	8,335	15.8 (9)	15.1 (9)
10. Snake	107	102	14.0	11.4	74.0	3,418,631	5,626	22.6 (11)	20.8 (11)
11. Sun-Teton-Marias	90	73	1.7	1.0	7.0	583,486	10,463	8.1 (5)	6.7 (5)
12. Tongue	87	88	0.9	0.8	6.0	216,283	5,400	10.3 (6)	9.1 (6)
13. Upper Clark Fork	142	96	6.3	3.2	24.3	1,009,101	5,981	12.2 (12)	11.6 (12)
14. Upper Green	125	81	6.4	4.0	28.1	2,021,074	9,539	15.0 (21)	13.0 (21)
15. Upper Missouri	209	103	4.2	1.4	14.0	219,896	2,951	8.0 (2)	6.5 (2)
16. Upper Snake Basins	117	103	7.1	4.6	35.6	1,689,505	6,875	21.7 (11)	18.9 (11)
17. Upper Yellowstone	122	102	7.3	5.8	37.8	3,442,200	11,070	16.1 (20)	16.3 (18)
18. Wood and Lost Basins	128	98	6.4	3.6	22.9	1,439,027	7,420	13.2 (16)	10.3 (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.

South Continental

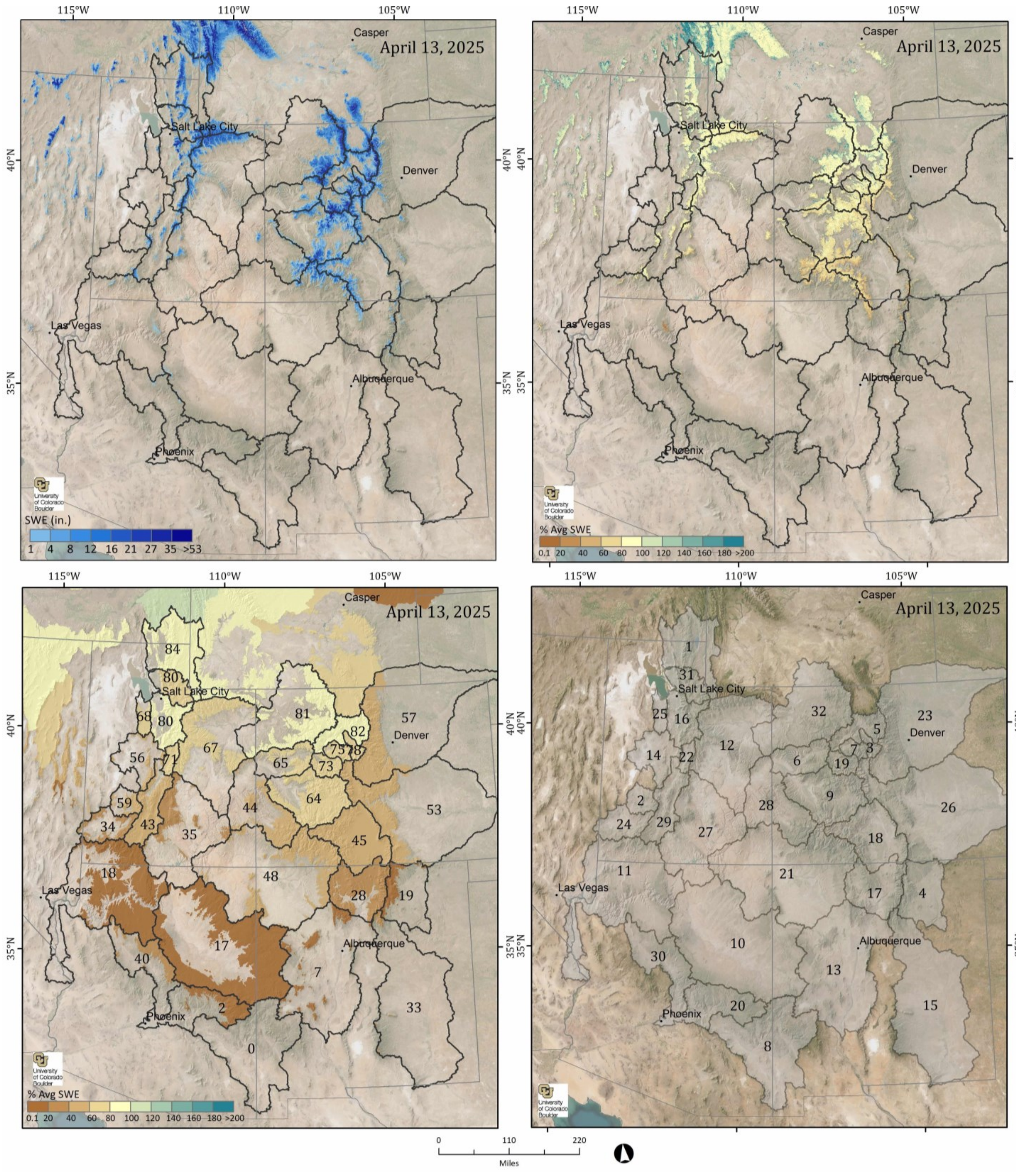

Figure 5. Estimated SWE and % of Average SWE across the South Continental Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in 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 4/13/2025

	% of Average		SWE (in)					Pillows	
Basin	4/6	4/13	4/6	4/13	SCA	Vol. (AF)	Area (mi. sq)	4/6	4/13
1. Bear	117	84	6.1	3.3	24.6	1,091,228	6,181	17.4 (18)	13.3 (18)
2. Beaver	82	59	1.7	0.9	7.6	39,278	836	13.0 (2)	11.2 (2)
3. Blue	100	78	11.1	7.8	59.4	279,177	670	17.6 (5)	16.4 (5)
4. Canadian	35	19	0.4	0.1	2.7	9,738	1,265	1.4 (1)	0.3 (2)
5. Colorado Headwaters§	105	82	8.6	6.4	48.4	975,406	2,874	16.3 (13)	14.4 (13)
6. Colorado Headwaters-Plateau	94	65	5.0	3.2	25.8	303,163	1,801	13.5 (1)	11.8 (1)
7. Eagle	92	75	8.6	6.1	43.8	299,222	921	13.7 (3)	11.2 (3)
8. Gila	5	0	0.0	0.0	0.0	0	4,924	0.0 (6)	0.0 (6)
9. Gunnison§	98	64	7.0	3.7	34.0	1,281,644	6,433	12.1 (11)	9.2 (11)
10. Little Colorado	60	17	0.0	0.0	0.2	3,211	16,379	3.4 (5)	2.2 (5)
11. Lower Colorado Mainstream	54	18	0.2	0.0	0.7	16,949	10,695	4.1 (5)	2.2 (5)
12. Lower Green	98	67	6.7	3.7	30.1	1,115,424	5,647	10.3 (24)	7.7 (24)
13. Lower Rio Grande	14	7	0.1	0.0	0.3	1,647	1,795	1.1 (6)	0.1 (6)
14. Lower Sevier	126	56	3.4	0.8	7.7	40,432	897	13.4 (4)	9.8 (4)
15. Pecos	40	33	1.0	0.5	8.8	9,271	331	1.1 (2)	0.3 (2)
16. Provo-Utah Lake-Jordan	123	80	6.8	3.3	24.9	470,501	2,681	21.6 (18)	18.3 (17)
17. Rio Chama-Upper Rio Grande	40	28	0.7	0.4	5.4	101,568	5,207	3.3 (13)	2.4 (13)
18. Rio Grande Headwaters	65	45	2.3	1.3	14.4	525,022	7,595	6.9 (14)	4.9 (14)
19. Roaring Fork	93	73	10.7	7.7	50.4	560,236	1,359	15.3 (7)	12.9 (7)
20. Salt	20	2	0.1	0.0	0.2	617	2,361	0.0 (7)	0.0 (7)
21. San Juan	60	48	2.1	1.3	11.3	445,217	6,406	9.1 (15)	6.8 (15)
22. San Pitch	103	71	4.8	2.6	18.8	119,422	857	14.8 (6)	11.1 (6)
23. South Platte§	85	57	3.3	1.9	15.0	558,869	5,620	13.4 (21)	12.3 (21)
24. Southwestern Utah	51	34	0.6	0.2	2.4	18,873	1,440	3.8 (5)	2.2 (5)
25. Toole Valley-Vernon Creek	129	68	2.0	0.6	4.7	28,970	906	13.8 (4)	8.9 (4)
26. Upper Arkansas	73	53	2.2	1.3	11.3	406,772	5,875	6.9 (7)	5.1 (7)
27. Upper Colorado-Dirty Devil	67	35	2.4	0.8	8.1	116,221	2,597	5.5 (7)	3.0 (7)
28. Upper Colorado-Dolores§	79	44	3.2	1.4	13.4	263,702	3,434	10.6 (8)	7.4 (8)
29. Upper Sevier	75	43	2.6	1.0	9.2	201,300	3,758	7.4 (16)	5.2 (16)
30. Verde	246	40	0.3	0.0	2.1	1,316	1,816	1.1 (7)	0.6 (7)
31. Weber-Ogden	134	80	7.3	3.5	27.7	385,336	2,041	18.9 (17)	15.0 (17)
32. White-Yampa	108	81	6.6	4.7	35.7	1,493,161	5,948	19.2 (15)	16.5 (15)

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Intermountain

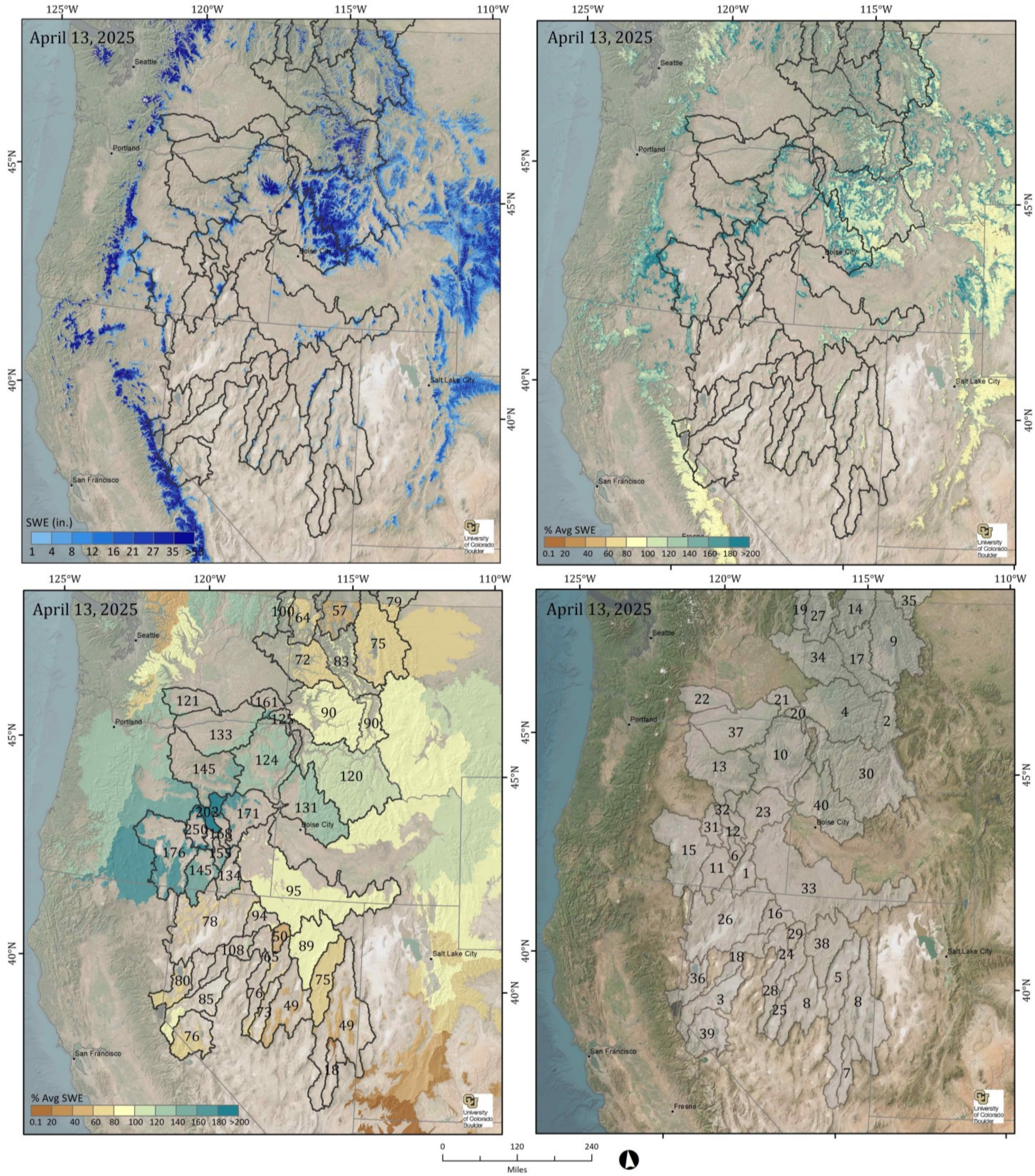

Figure 6. Estimated SWE and % of Average SWE across the Intermountain Region. SWE amounts (upper left), percent of long-term average (2001-2021) SWE calculated for each pixel (upper right), basin-wide percent of long-term average (lower left) shaded areas correspond to the elevation bands used in the 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 4/13/2025

	% of Average		SWE (in)					Pillows	
Basin	4/6	4/13	4/6	4/13	SCA	Vol. (AF)	Area (mi. sq)	4/6	4/13
1. Alvord Lake	188	134	6.0	2.7	16.6	47,186	324	NA	NA
2. Bitterroot	112	90	10.2	7.5	40.6	777,517	1,952	19.7 (4)	18.5 (4)
3. Carson	114	85	5.3	3.7	16.9	274,753	1,405	18.5 (7)	15.8 (7)
4. Clearwater Basin	108	90	7.0	5.8	27.4	2,318,958	7,488	28.4 (10)	29.2 (11)
5. Clover Valley and Franklin	136	75	1.1	0.4	4.4	85,250	4,048	21.3 (2)	16.2 (2)
6. Donner und Blitzen	171	155	14.9	10.4	64.7	122,611	222	39.1 (2)	38.2 (2)
7. Dry Lake Valley	60	18	0.9	0.2	1.4	2,499	289	NA	NA
8. Eastern Nevada	112	49	2.7	0.6	6.2	140,933	4,372	8.4 (8)	4.3 (8)
9. Flathead	96	75	6.1	3.7	21.0	1,465,358	7,526	23.0 (13)	22.3 (13)
10. Grande Ronde-Burnt-Powder_Imnaha	127	124	6.1	5.6	26.3	1,575,363	5,312	20.1 (11)	16.9 (10)
11. Guano	377	145	0.7	0.2	1.8	21,223	2,036	0.0 (1)	NA
12. Harney-Malheur Lakes	269	168	3.1	0.9	8.7	13,476	276	NA	NA
13. John Day	126	145	6.0	5.5	33.7	437,364	1,502	19.9 (2)	15.8 (2)
14. Kootenai	54	57	3.1	2.6	14.7	230,030	1,673	21.4 (5)	21.4 (5)
15. Lake County-Goose Lake	226	176	5.8	3.5	23.7	662,823	3,602	23.2 (2)	21.7 (2)
16. Little Humboldt	157	94	3.9	1.3	9.4	27,969	419	14.9 (3)	11.4 (3)
17. Lower Clark Fork	97	83	8.2	6.1	34.7	478,950	1,465	40.1 (4)	41.3 (4)
18. Lower Humboldt	269	108	3.7	0.7	7.0	10,005	274	3.8 (1)	0.0 (1)
19. Lower Pend Oreille	71	100	6.6	8.9	38.6	61,270	129	27.7 (1)	27.5 (1)
20. Lower Snake-Asotin	138	125	1.8	1.1	8.9	19,472	328	6.6 (2)	4.9 (2)

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Intermountain SWE Report for 4/13/2025									
	% of Average		SWE (in)					Pillows	
Basin	4/6	4/13	4/6	4/13	SCA	Vol. (AF)	Area (mi. sq)	4/6	4/13
21. Lower Snake-Tucannon	151	161	6.4	5.5	39.1	32,211	109	NA	NA
22. Lower Yakima	149	121	4.3	3.4	18.7	88,370	489	21.4 (2)	19.8 (2)
23. Malheur	210	171	7.3	4.5	30.9	239,161	992	12.5 (3)	8.8 (3)
24. Middle Humboldt	255	65	2.7	0.2	2.3	7,527	633	NA	NA
25. Northern Big Smoky Valley	132	73	5.5	1.4	13.8	43,340	570	NA	NA
26. Northern Great Basin	207	78	2.5	0.5	3.3	55,489	2,226	6.2 (2)	4.7 (2)
27. Panhandle Basins	54	64	2.9	2.9	14.0	253,570	1,644	29.6 (3)	30.4 (3)
28. Reese	147	76	6.4	1.6	14.5	41,276	491	16.6 (2)	13.5 (2)
29. Rock	163	50	0.6	0.1	0.9	5,515	835	18.8 (1)	14.8 (1)
30. Salmon Basin	125	120	12.8	11.2	56.5	7,150,637	11,932	22.5 (11)	21.7 (11)
31. Silver	453	250	3.3	0.7	6.4	15,586	431	NA	NA
32. Silvies	279	202	3.4	1.3	11.9	91,236	1,316	13.1 (2)	8.9 (2)
33. Southern Snake Basins	149	95	2.0	0.8	5.3	503,326	12,500	13.0 (13)	10.7 (12)
34. Spokane	88	72	2.6	1.8	9.4	301,480	3,146	18.1 (8)	16.1 (8)
35. St. Mary	85	79	10.0	7.3	43.9	253,921	648	8.9 (1)	6.1 (1)
36. Truckee	121	80	6.9	3.9	18.4	295,260	1,420	21.3 (9)	18.3 (8)
37. Umatilla-Walla Walla-Willow	109	133	1.3	1.2	9.0	93,320	1,434	18.2 (7)	18.2 (6)
38. Upper Humboldt	142	89	2.0	1.0	6.5	265,747	5,032	15.6 (8)	12.9 (8)
39. Walker	111	76	4.3	2.7	15.4	281,254	1,939	19.9 (7)	17.6 (7)
40. West Central Basins	140	131	14.3	12.1	57.3	3,616,079	5,620	27.0 (15)	25.5 (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.

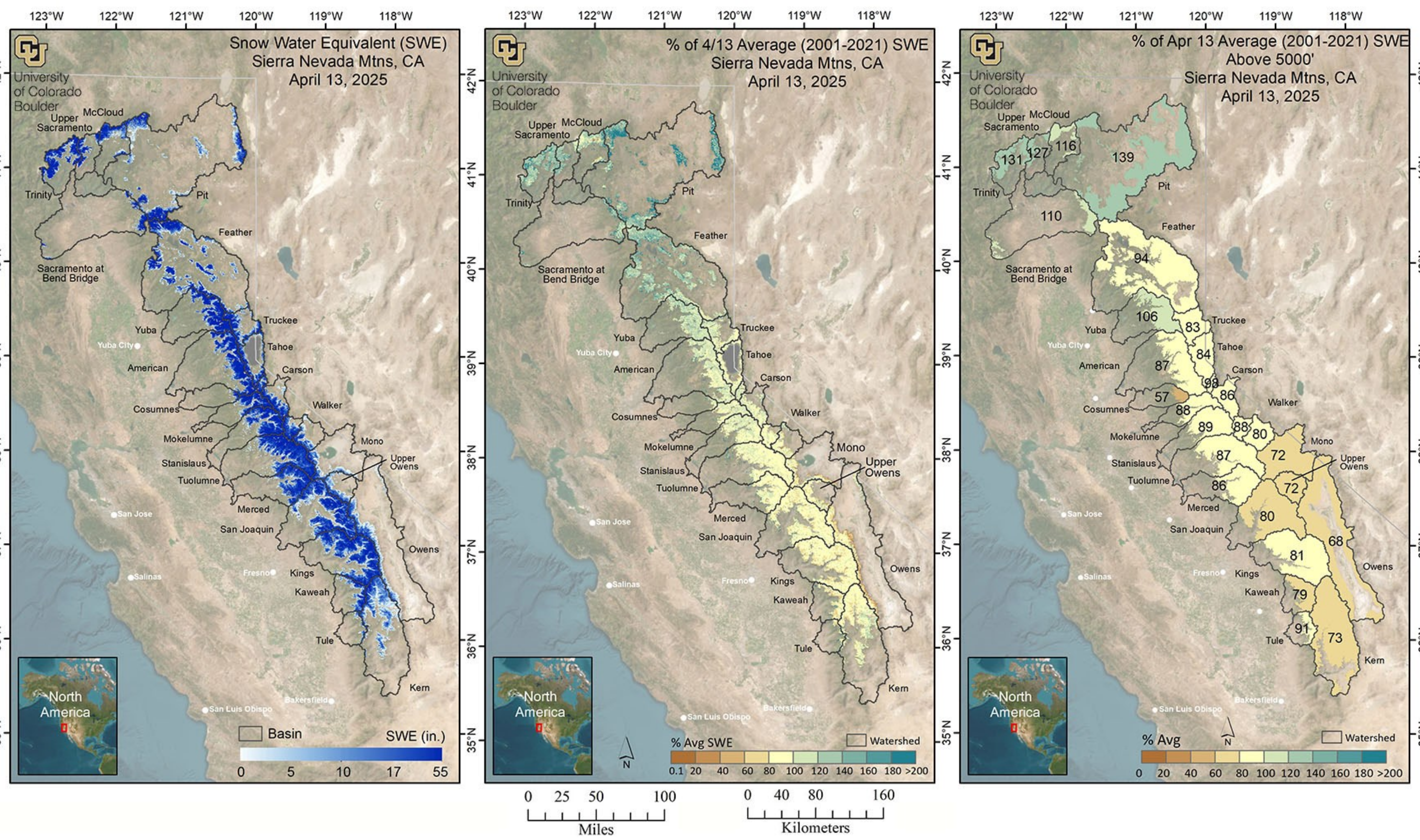

Figure 7. Estimated SWE and % of Average SWE across the Sierra Nevada. SWE amounts (left), and percent of average (2001-2021) SWE for the Sierra Nevada, calculated for each pixel (middle) and basin-wide (right). Basin-wide percent of average is calculated across all model pixels >5000' elevation.

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 4/13/2025

	% of Average		SWE (in)					Pillows		
	4/6	4/13	4/6	4/13	SCA	Vol. (AF)‡	Area (mi. sq)	4/6	4/13	SNODAS* (in)
Trinity	149	131	33.6	27.2	84.2	465,814	321.3	38.8 (4)	35.5 (4)	39.7
Upper Sacramento	149	127	30.1	23.7	77.3	145,283	115.2	33.4 (1)	28.6 (1)	34.4
McCloud	135	116	23.4	19.6	86.5	172,398	164.9	40.0 (1)	36.3 (1)	41.2
Pit	176	139	8.0	5.2	24.8	567,870	2064.7	27.5 (7)	23.4 (7)	6.7
Sacramento at Bend Bridge	139	110	17.9	11.2	39.2	143,456	239.8	NA	NA	14.8
Feather§	137	94	12.4	8.1	35.2	902,779	2086.7	33.0 (6)	28.1 (6)	11.4
Yuba	123	106	20.3	18.6	69.6	511,755	515.6	52.9 (5)	48.9 (5)	28.0
American	118	87	16.4	14.6	59.4	619,085	794.9	23.9 (11)	20.4 (11)	17.9
Cosumnes	135	57	16.7	4.7	22.4	22,842	91.9	NA	NA	6.5
Mokelumne	113	88	20.9	15.1	60.7	253,613	314.8	38.3 (2)	34.5 (2)	18.3
Stanislaus	113	89	20.9	14.8	61.1	440,759	557.0	33.6 (5)	29.6 (5)	16.6
Tuolumne	114	87	19.3	15.2	62.8	739,203	909.8	28.7 (7)	25.1 (7)	19.7
Merced	110	86	18.8	14.0	63.2	403,244	538.8	29.9 (2)	28.2 (2)	17.9
San Joaquin§	101	80	14.8	13.1	61.9	844,659	1207.1	19.8 (7)	14.4 (7)	14.5
Kings	103	81	17.9	14.1	63.2	906,617	1207.0	20.7 (5)	17.0 (5)	16.1
Kaweah	113	79	13.4	9.4	46.1	157,238	314.1	21.9 (2)	18.8 (2)	12.3
Tule	171	91	10.7	3.9	24.2	28,640	137.6	8.2 (1)	1.5 (1)	1.9
Kern§	104	73	6.7	3.9	27.3	350,015	1682.0	17.3 (6)	15.3 (6)	4.8
Truckee	115	83	18.0	10.9	49.5	240,070	411.5	21.8 (6)	18.4 (6)	14.4
Tahoe	102	84	17.0	12.8	60.0	208,192	304.9	24.6 (7)	20.8 (7)	13.3
W Carson	112	98	21.1	17.6	76.5	60,897	65.0	22.8 (3)	19.7 (3)	15.6
E Carson	112	86	13.6	9.8	44.0	185,626	354.3	15.3 (4)	12.8 (4)	9.5
W Walker	106	88	18.4	14.9	67.6	142,624	179.6	23.3 (4)	20.8 (4)	19.2
E Walker	105	80	7.8	5.3	32.0	99,420	350.7	17.5 (1)	15.9 (1)	6.1
Mono	93	72	3.4	2.4	14.9	126,651	1002.9	NA	NA	2.2
Upper Owens	93	72	7.6	5.1	32.8	101,573	373.7	39.8 (1)	38.9 (1)	3.9
Owens	89	68	3.8	2.6	17.0	242,089	1772.0	13.9 (5)	11.2 (5)	2.1

§ 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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