ASO Survey Report

Yampa & Elk Rivers, CO

Survey Date: April 12, 2026

Airborne Snow Observatories, Inc. is a public benefit corporation with a mission to provide high-quality, timely, and accurate snow measurement, modeling, and runoff forecasts to empower the world's water managers to make the best possible use of our planet's precious water.

Historical data and reports can be found at:
ava.airbornesnowobservatories.com

Survey date: April 12, 2026
Survey # of Water Year 2026: 2
Report delivery date: April 16, 2026

Full domain SWE: 148 ± 7 TAF
Δ SWE since previous survey: -141 TAF
Estimated snowline: 9060 ft

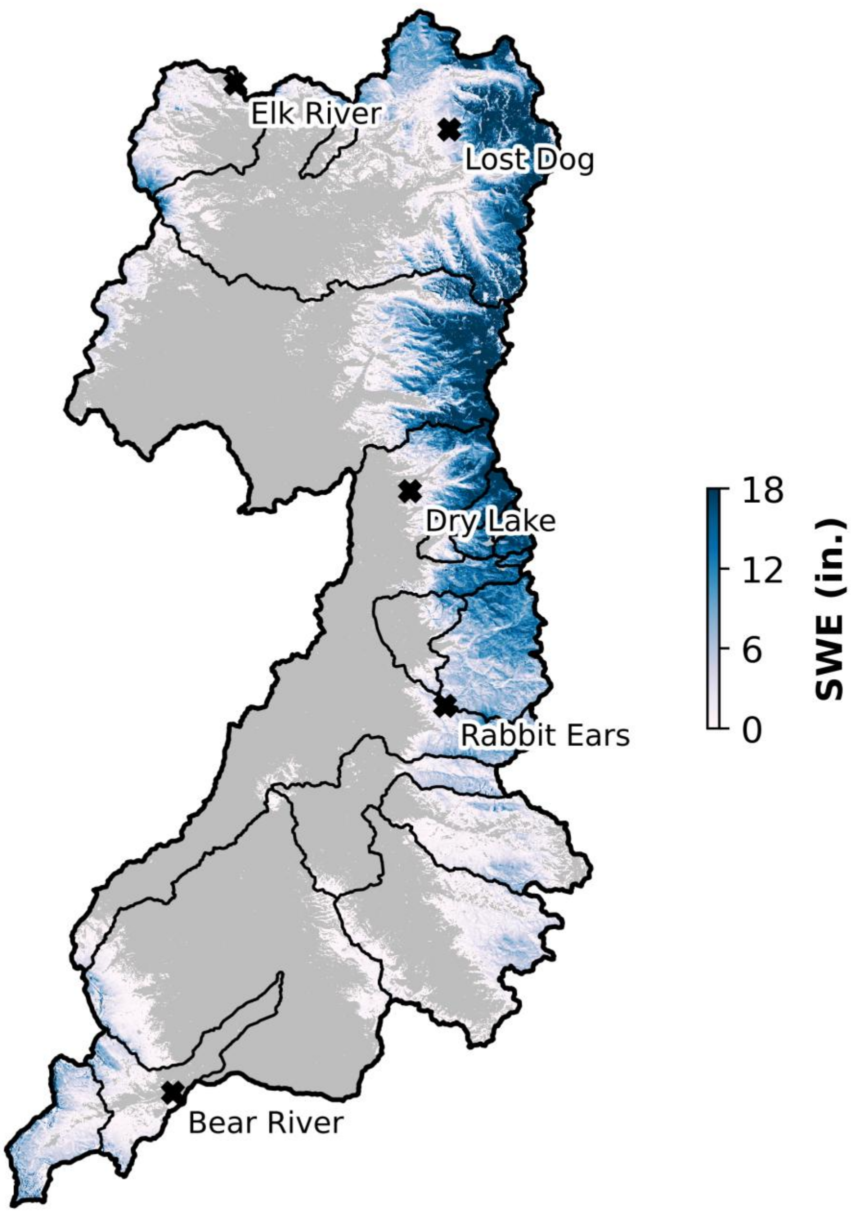


Figure 1. Spatial distribution of Snow Water Equivalent depth (in).

Table 1. Estimated SWE volume in Thousand Acre Feet (TAF) for the full Yampa and Elk Rivers and subbasins for the April 12 survey and for the previous 2026 survey on March 21. Note: subbasins may overlap and/or not fully cover the survey domain, therefore TAF values may not add up to the full-basin SWE. We also do not report SWE values for subbasins that extend beyond the boundary of the survey domain.

Basin	Estimated SWE (TAF)	
	March 21	**April 12**
Full domain	289	148
Uncertainty range	278-300	*141-155*
Yamcolo Inflow	9	5
Bear River below Yampa	14	7
Yampa above Stagecoach	22	9
Morrison Creek	15	3
Sarvis Creek	14	3
Yampa River above Catamount	55	17
Walton Creek Upper	26	15
Walton Creek Lower	29	16
South Fork Fish Creek	1	0.7
Middle Fork Fish Creek above Fish Creek Reservoir	2	1
Granite Creek	4	3
Middle Fork Fish Creek	8	6
North Fork Fish Creek	16	11
Yampa River below Soda Creek at Steamboat	138	64
Pearl Lake	0.9	0.1
Steamboat Lake	9	2
Upper Elk River	99	54
Elk River near Milner	151	84

2.a

2.b

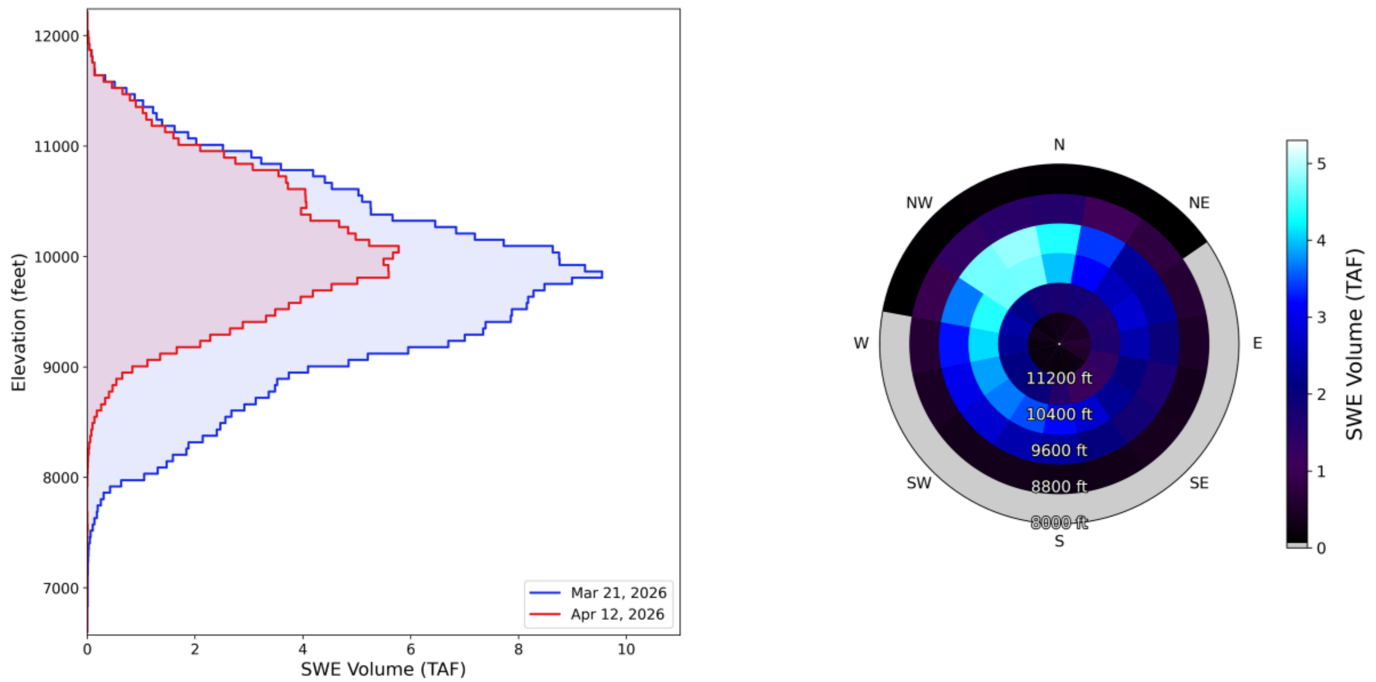


Figure 2.a. Distribution of SWE volume (TAF) by elevation. **2.b.** Distribution of SWE volume (TAF) by aspect and elevation for the April 12 survey. See **Figure 7** and **Figure 8** for additional descriptive plots.

Figure 3. Daily timeseries of modeled SWE volume (TAF) and Surface Water Input (SWI) volume (TAF) for the Yampa and Elk Rivers. In this instance, the ASO SWE (black dot) and the ASO SWE + Water Body SWE (blue dot) are overlapping.

Summary of background conditions

The Yampa and Elk Rivers experienced a below-average start to Water Year 2026, as reflected by snow station observations across the region. At the Tower snow sensor (SNTL 825, 10610 ft), snowpack accumulation remained limited through much of the early season, contributing to overall lower-than-average conditions.

The most recent snowfall recorded at the Tower sensor was April 4th, when 4 inches of snow were deposited on this sensor. Between this precipitation event and the survey, both snow depth and SWE at the Tower sensor showed steady declines, with snow depth decreasing by 16 inches, indicating sustained ablation. The late-season context of the survey and the ongoing snowpack conditions were considered in the density analysis for this survey.

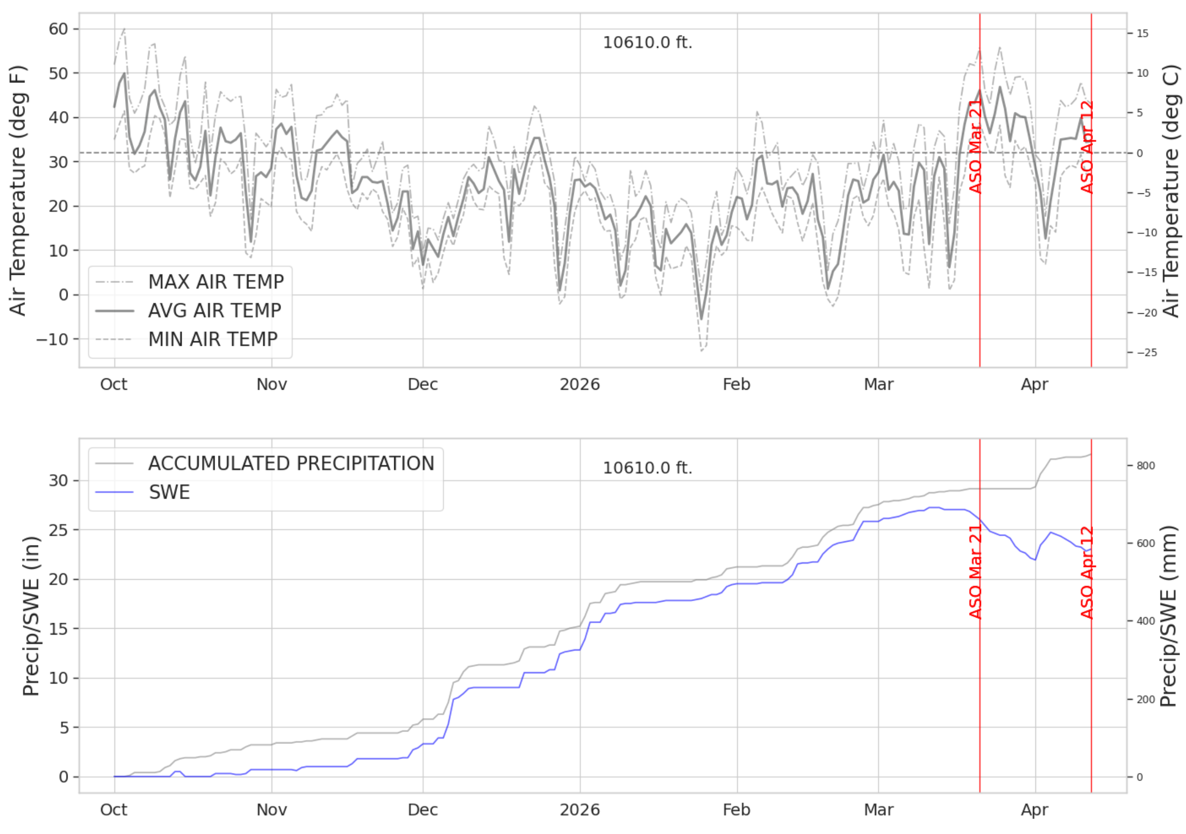


Figure 4. Daily meteorological conditions at the Tower SNOTEL site (SNTL 825; elevation 10610 ft). Note: the raw daily data shown have been downloaded directly from the Natural Resources Conservation Service (NRCS) and have not been quality checked for this report. Noise or incorrect data may be present. Precipitation data are shown only if the featured station records such data, and the air temperature plot shows daily maximum, mean, and minimum values. ASO surveys are marked with red vertical lines.

Evaluation of ASO snow depth measurements

Snow-free, planar surfaces, common between the snow-on and snow-off datasets, are used to co-register the elevation datasets. This relative registration process ensures that in areas without snow, we measure a snow depth of 0, and enforces snow depth accuracy throughout the survey area.

At 3 m resolution, the standard deviation of snow depth distribution at 67 locations was 1 cm, unbiased based on a rigorous bare surface evaluation. At 50 m resolution the snow depth uncertainty was less than 1 cm.

Point-to-point comparison of in-situ snow depths with ASO 3 m resolution snow depth is shown in Table 2.

These depth comparisons are typically performed at stations and/or field measurement locations for which we are confident in 1) the location and 2) the depth data being reported at the time of the ASO survey. Because we are directly comparing a point to a 3 m pixel in our data, we need to be certain that the station location is accurate to within 1.5 m. For reference, GPS data are usually only accurate to within 5 m, but we are often able to pinpoint locations using other means, thereby enabling these comparisons. For these reasons, specific sites might not be included in the comparison. Please contact the ASO team to converge on accurate and precise coordinates and/or investigate data quality issues for any sites of interest.

At these known and trusted station locations in the Yampa and Elk Rivers, the mean snow depth uncertainty was 0 cm.

Table 2. Comparison of ASO and high-quality snow station snow depths.
Note: the ASO long-term depth uncertainty is ±5 cm. All depths are rounded to the nearest whole number.

Site	Elevation (ft)	Date	ASO depth (cm)	Site depth (cm)	Depth difference (cm)
BEAR RIVER (1061)	9100	4/12/2026	0	0	0
TOWER (825)	10610	4/12/2026	149	145	4
LOST DOG (940)	9350	4/12/2026	28	30	-2
BUFFALO PARK (913)	9250	4/12/2026	0	0	0
RABBIT EARS (709)	9390	4/12/2026	19	18	1
ELK RIVER (467)	8710	4/12/2026	0	0	0
DRY LAKE (457)	8240	4/12/2026	0	0	0
CROSHO (426)	8960	4/12/2026	0	0	0
COLUMBINE (408)	9170	4/12/2026	0	0	0
LYNX PASS (607)	8910	4/12/2026	0	0	0
				Mean	0

In-situ measurements

Note: "±" values represent standard deviation.

Supplemental field collections

- To better understand the current snow density conditions, the ASO field team conducted field work in the Yampa and Elk Rivers domain on April 13th, one day after the survey. Two snow pits were dug, and the mean snow density reported was 373 ± 22 kg/m^3.
- The ongoing densification of the snowpack affected snow density between the collection date and the ASO survey. The densification rate was estimated at -5 $kg/m^3/day$. Following this adjustment, the average bulk density from field measurements was 368 ± 22 kg/m^3.

Sensor measurements

- The mean snow density reported on April 12th at one pillow location was 403 kg/m^3 (Tower).
- Density estimates at 11 in-situ sites within or near the Yampa and Elk Rivers were omitted from our analysis due to lack of snow or unrealistic values (Columbine, Crosho, Dry Lake, Lost Dog, Lynx Pass, Rabbit Ears, Elkhead Divide, Zirkel, Buffalo Park, Elk River, Bear River).

Snow course measurements

- The April snow course measurements from two locations, collected on March 30th, were available from NRCS at the time of processing.
- However, these measurements were collected prior to the snowfall event that started on April 3rd; thus, all courses were omitted from our density analysis.
- Refer to Figure 5 for snow density changes that occurred since the April snow course measurement window.

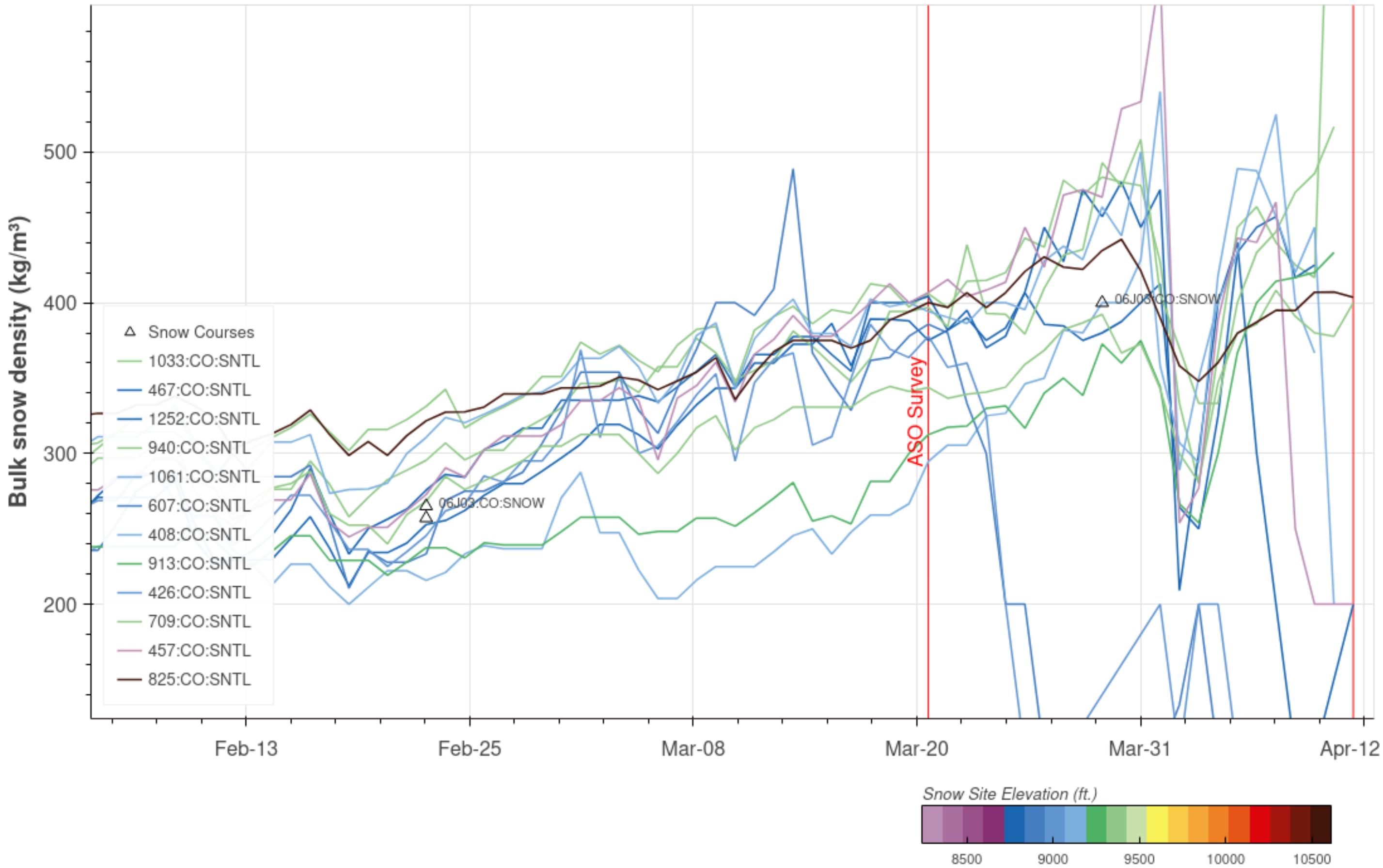


Figure 5. Snow density timeseries at automated sensor locations and snow courses within and nearby the Yampa and Elk Rivers (data source: NRCS).

Evaluation of snow density

Model evaluation

- The iSnobal model was last updated with data from the previous survey of the Yampa and Elk Rivers on March 21st.
- A comparison of the measurements with the model was conducted accounting for model representation of vegetation type, canopy height, and canopy density. The direct and proximal grid cell comparison with the in-situ measurements at three locations revealed a mean difference of 17 kg/m^3 or 4%, and a mean absolute difference of 35 kg/m^3 or 9%.
- For more information on the iSnobal model evaluation, see iSnobal model state update on page 16.

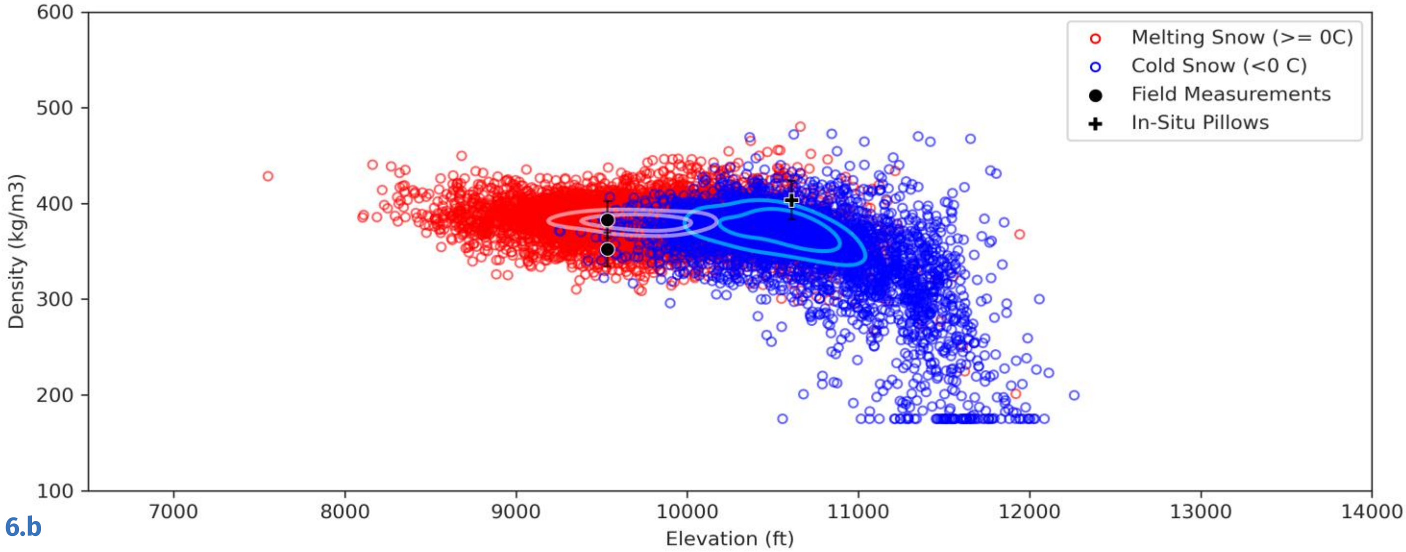
Model adjustment

- When compared to the available in-situ measurements in the Yampa and Elk Rivers, the iSnobal model was overestimating warm snow densities in shallow snow. To account for this overestimation bias, snow densities were decreased using a depth based linear equation, with a maximum reduction of 7.5%.
- To account for the underestimation of densities in deeper snow, all snow densities with depths above 1.1 m were increased by 3%
- Finally, based on regional and historical snow density trends, minimum allowable snow densities were constrained to 175 kg/m^3.
- After adjustment, the direct and proximal grid cell comparison with in-situ measurements showed a mean difference of 4 kg/m^3 or 1%, and a mean absolute difference of 18 kg/m^3 or 5%.
- The spread of adjusted modeled densities is shown with snow depth and elevation in Figure 6 alongside considered in-situ values.

SWE sensitivity to snow density

- Using the open-loop model density and applying ASO snow depths, the full domain SWE was 148.2 TAF; after snow density adjustments were applied, the domain SWE estimate remained 147.8 TAF. The snow density adjustments decreased the domain SWE estimate by 0.3%.
- To encompass the full spread of the considered in-situ measurements, we generated two additional SWE scenarios: a low-density scenario (Scenario L) and a high-density scenario (Scenario H).
- For Scenario L, an additional snow density reduction of 5% was applied, while Scenario H saw an additional snow density increase of 5%, reflecting the variation in field and station density values.
- The resulting full-domain SWE outcomes for these scenarios were 140 TAF and 155 TAF, respectively. These scenarios span and exceed the full range of the in-situ measurements and thus should be interpreted more as possible snow density extremes rather than equally probable SWE outcomes.
- We have factored uncertainty based on these outcomes into the values reported on page 3 of this report.

6.a



6.b

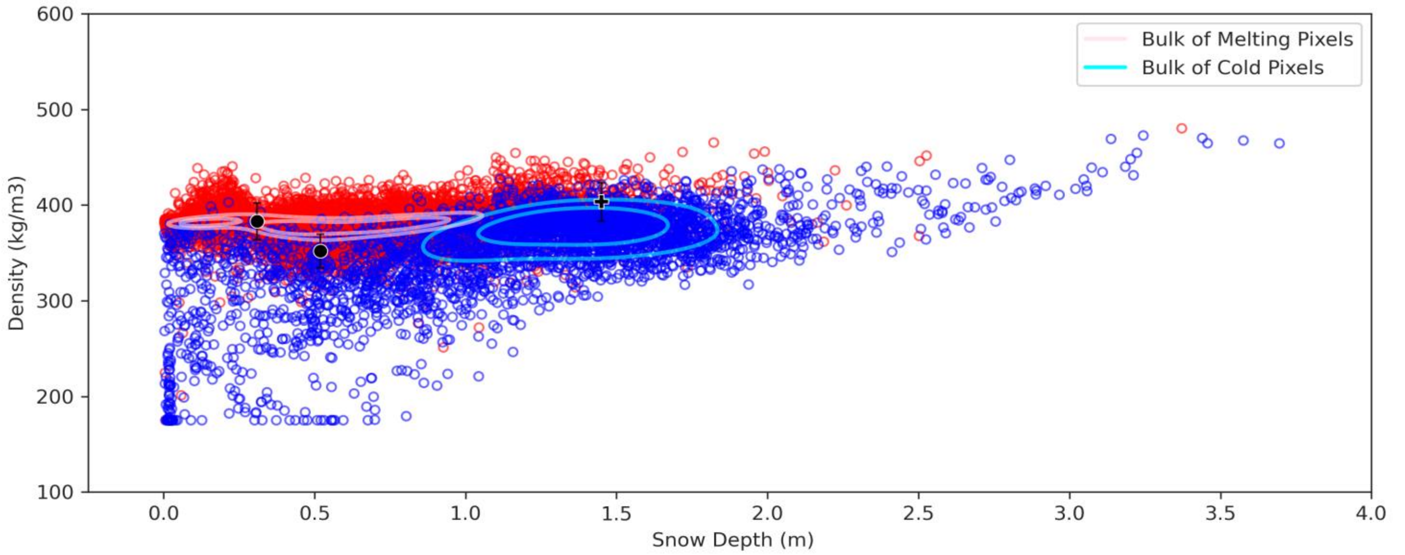


Figure 6. Observed and modeled bulk snow density (kg/m³) by **6.a.** elevation (ft) and **6.b.** depth (m). These plots show densities following the adjustment process.

Snow albedo

- Challenging weather conditions over the Yampa and Elk Rivers in recent weeks have pushed us to conduct operations during suboptimal conditions for snow albedo measurements, though the lidar retrievals remain robust. The April 12th survey of the Yampa and Elk Rivers was conducted with cloud cover above survey altitude, clouds below survey altitude, and late in the afternoon; under these conditions, we cannot produce robust albedo products.

Additional data and remarks

Clouds

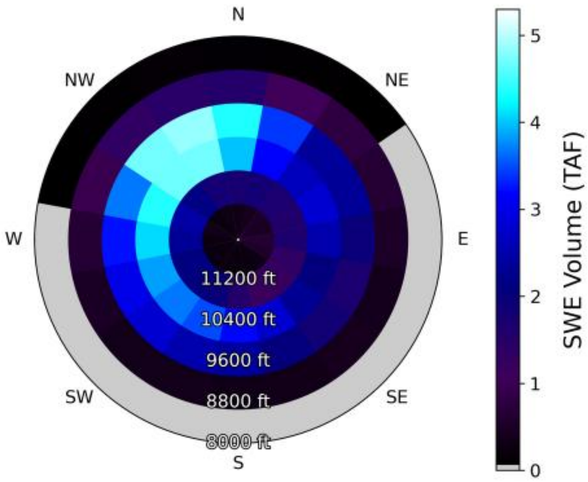
- ASO survey operations target clear-sky days, however, clouds can encroach into the target area during the period of survey. The survey techniques are such that we can often get valid retrievals under clouds, but this is not always possible.
- During the window for the April 12th Yampa and Elk Rivers survey, we encountered several minor clouds across the domain.
- Flight line overlap and penetration through clouds enabled us to retrieve a snow depth signal in many of these clouded areas. However, remaining clouds were estimated to mask <4% (~42 km^2) of the snow-covered area.
- Based on observed snow depth distributions nearby, the SWE contained in the clouded areas is estimated at 11 TAF. This estimate has been added to the full domain SWE provided on page 4 and has been factored into our uncertainty values.
- There are some spatial artifacts in the snow depth data associated with this backfilling procedure, though we expect this to have very little impact on total domain SWE and on the spatial distribution of SWE.

Other

- The following additional data products are available in the product zip pack downloadable via the ASO, Inc. data portal:
    - SWE extractions for the River Forecast Center basins/polygons that were 100% covered by the ASO survey (*swe_RFC_aggregate.csv).
    - Full-resolution PDF versions of the images and figures in this report.
- Please refer to the text files included in the data package for SWE volume per elevation band and other summary statistics.

Additional figures

7.a



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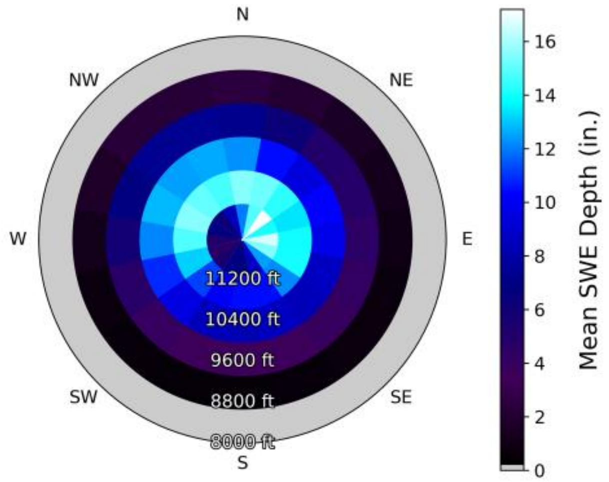

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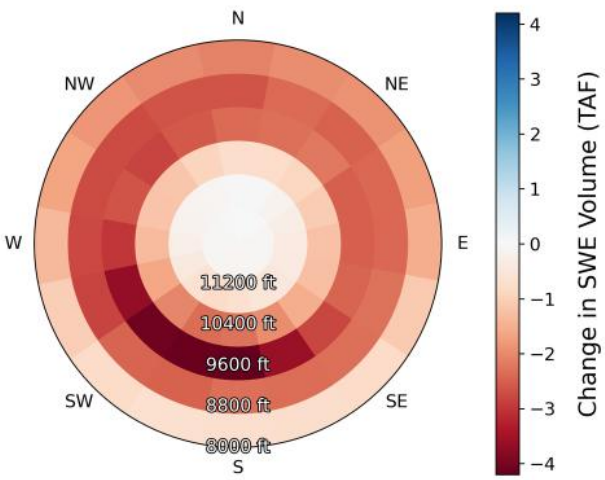

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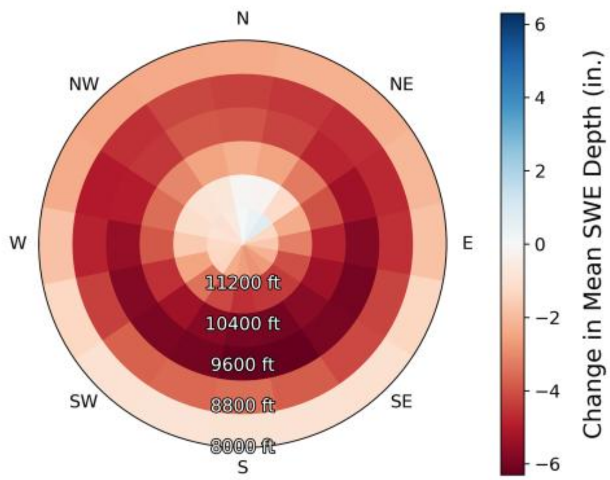
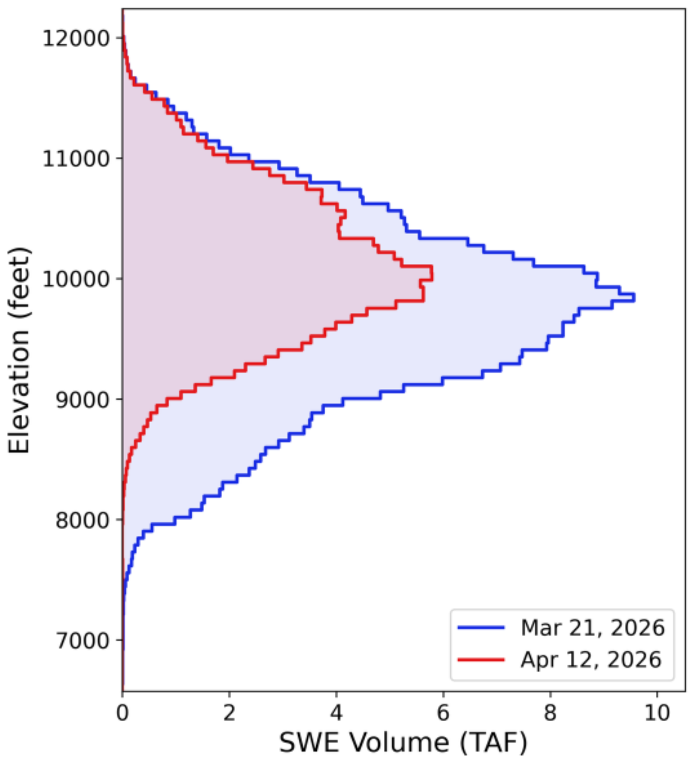


Figure 7. Aspect/elevation SWE and SWE difference plots: **7.a.** SWE volume (TAF) and **7.b.** SWE depth (in) for the April 12 survey. **7.c.** SWE volume (TAF) and **7.d.** SWE depth (in) change from the March 21 survey to the April 12 survey.

8.a



8.b

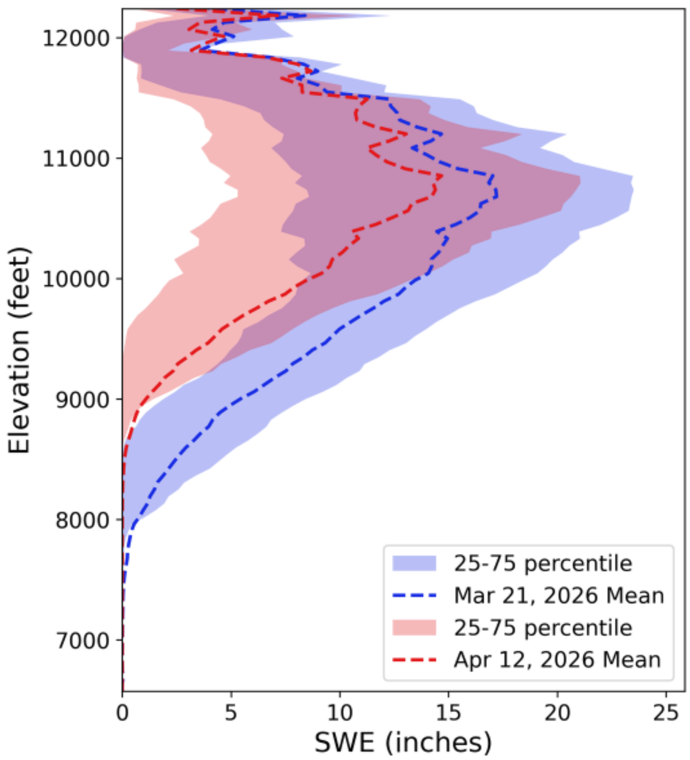


Figure 8. Plots of SWE volume (TAF) and depth (in) by elevation. **8.a.** Distribution of SWE volume (TAF) across elevations. **8.b.** Distribution of SWE depth (in) across elevations.

iSnobal model state update

In this section, we show the changes* to the iSnobal model following the ingestion of the ASO measured snow depth and adjusted snow density product from the April 12th survey.

Prior to ingesting the April 12th ASO survey data, the model showed a smaller snow-covered-area (SCA). The update increased the domain SCA from 22% to 43% coverage, and the domain total SWE in the model increased by 4 TAF.

Change in total SWE: +4 TAF
Change in mean SWE: +0.1 ± 2.0 in
*comparison of non-waterbody pixels

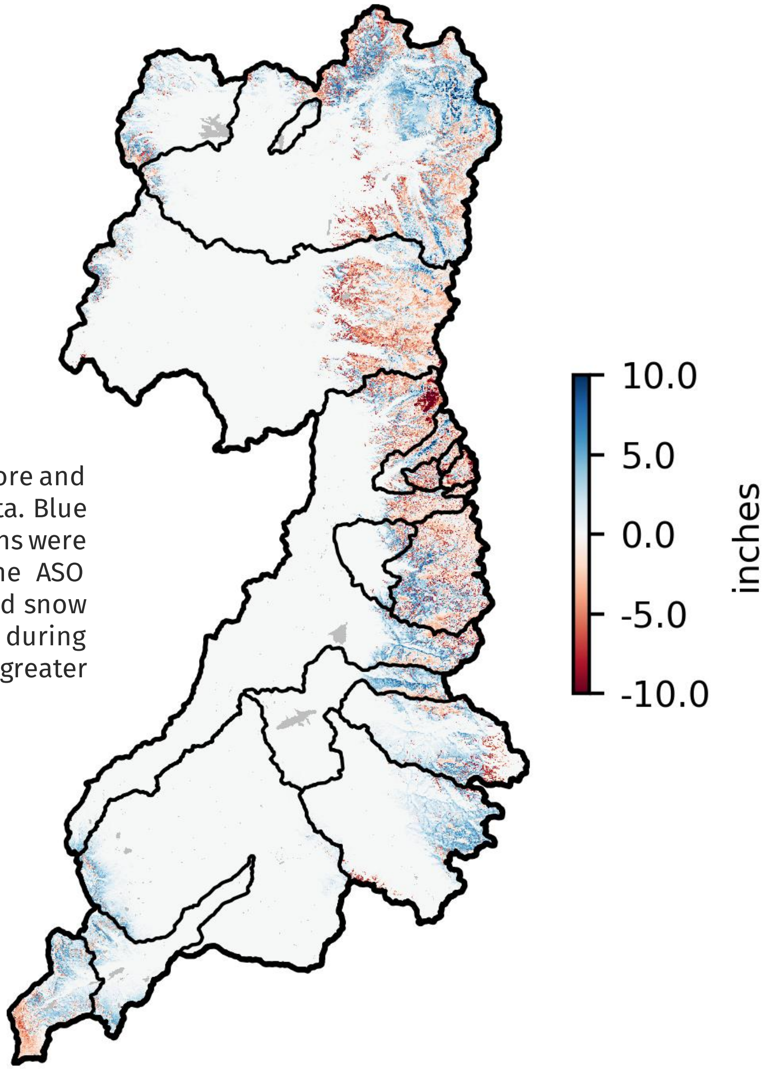


Figure 9. Change in iSnobal SWE depth (in) before and after ingestion of the April 12 ASO survey data. Blue represents areas in which modeled snow depths were lower than the depths measured during the ASO survey; red represents areas in which modeled snow depths were higher than the depths measured during the ASO survey. Darker colors represent a greater magnitude of change.

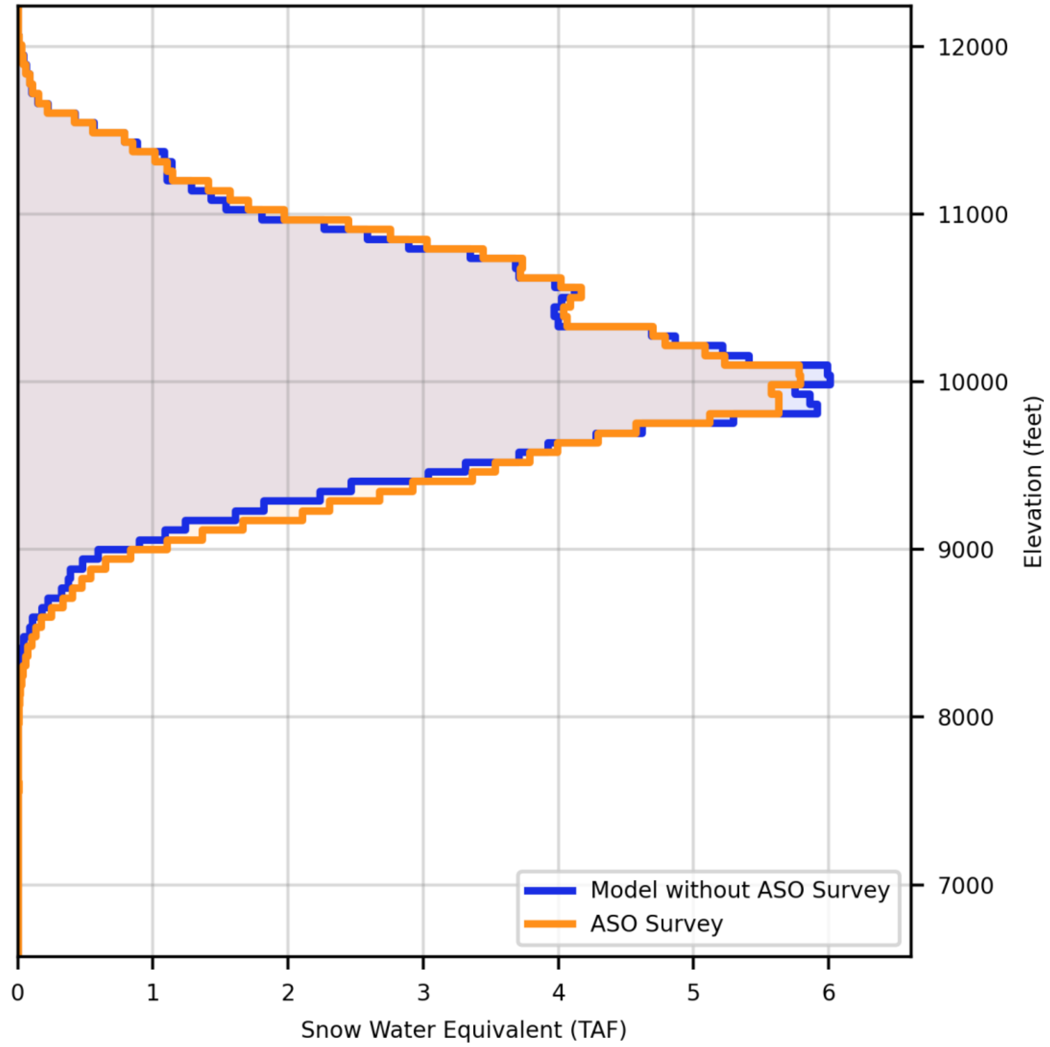


Figure 10. Distribution of iSnobal SWE volume (TAF) by elevation before and after ingestion of the April 12 ASO survey data. Blue represents the model state before the ASO survey, and orange represents the model state following the ASO survey.