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Increasing glacier area loss in the Oregon central Cascades, USA

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Abstract. The Oregon Cascades in the Pacific Northwest of the United States contain six glacierized volcanos. Here we document the 2023 glacier extents on five volcanos in the Oregon central Cascades: Broken Top, the Three Sisters (South, Middle, and North), and Mt. Jefferson. Using prior extent data from 2018 (Three Sisters and Broken Top) or 2020 (Mt. Jefferson) and 1990, we show that the glaciers on these summits lost ~ 20 % of their area between 2018/20 and 2023 and ~ 26 % of their area between 1990 and 2018/20. Glacier area loss thus increased 4.5- to 6.1-fold from ~ 0.6-1.9 % yr^{-1} (1990-2018/20) to ~ 3.2-11.3 % yr^{-1} (2018/20-2023). These rates of recent glacier area loss are unprecedented in each volcano's recorded history. When combined with 2015/16 and 2023 glacier extents for the sixth volcano in the Oregon Cascades (Mt. Hood), we find that recent rates of glacier area loss are only correlated with measures of glacier size: glaciers with a smaller elevation span ($p = 0.0005$) and smaller area ($p = 0.0018$) are losing area faster. Because the Oregon Cascade summers of 2014-2023 were ~ 0.7 °C warmer than the 1985-1994 mean and ~ 1.5 °C warmer than the 1975-1984 mean, warming magnitudes sufficient to raise equilibrium lines above the headwalls of many of Oregon's smaller glaciers, we attribute the increased rate of Oregon Cascade glacier area loss to this warming climate.

1 Introduction

The retreat and mass loss of glaciers in the world's high-elevation and high-latitude regions are one of the clearest indicators of changing regional climates in response to human greenhouse gas emissions, which are predominately from the combustion of fossil fuels (e.g., Marzeion et al., 2014; Zemp et al., 2015; Roe et al., 2021; World Meteorological Organization, 2026; United Nations, 2026). Between 2000 and 2023, glaciers globally lost ~ 5.4 % of their mass (The GlaMBIE Team, 2025) while the six most negative mass balance years have occurred in the last seven years (The WGMS Network, 2026). Under the current climate, glaciers are committed to losing ~ 39 % of their remaining mass (Zekollari et al., 2025). Notably, western Canada and the conterminous United States have the second highest percentage of committed glacier mass loss in the current climate of any glacierized region in the world (Zekollari et al., 2025).

The glaciers in western Canada and the conterminous United States lost ~ 23 % of their mass between 2000 and 2023 (The GlaMBIE Team, 2025) and ~ 12 % of their mass from 2021 to 2024 (Menounos et al., 2025). In 2025, this region had the most negative mass balance of any glacierized region in the world (The WGMS Network, 2026). These glacier mass change data

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for western North America are mostly based on remote sensing and eight reference glaciers (World Glacier Monitoring Service, 2024). Notably, none of the reference glaciers are located on the volcanos of the Oregon Cascades, with the closest reference glacier ~ 290 km north of Oregon's northernmost glacierized volcano, Mt. Hood (Fig. 1a).

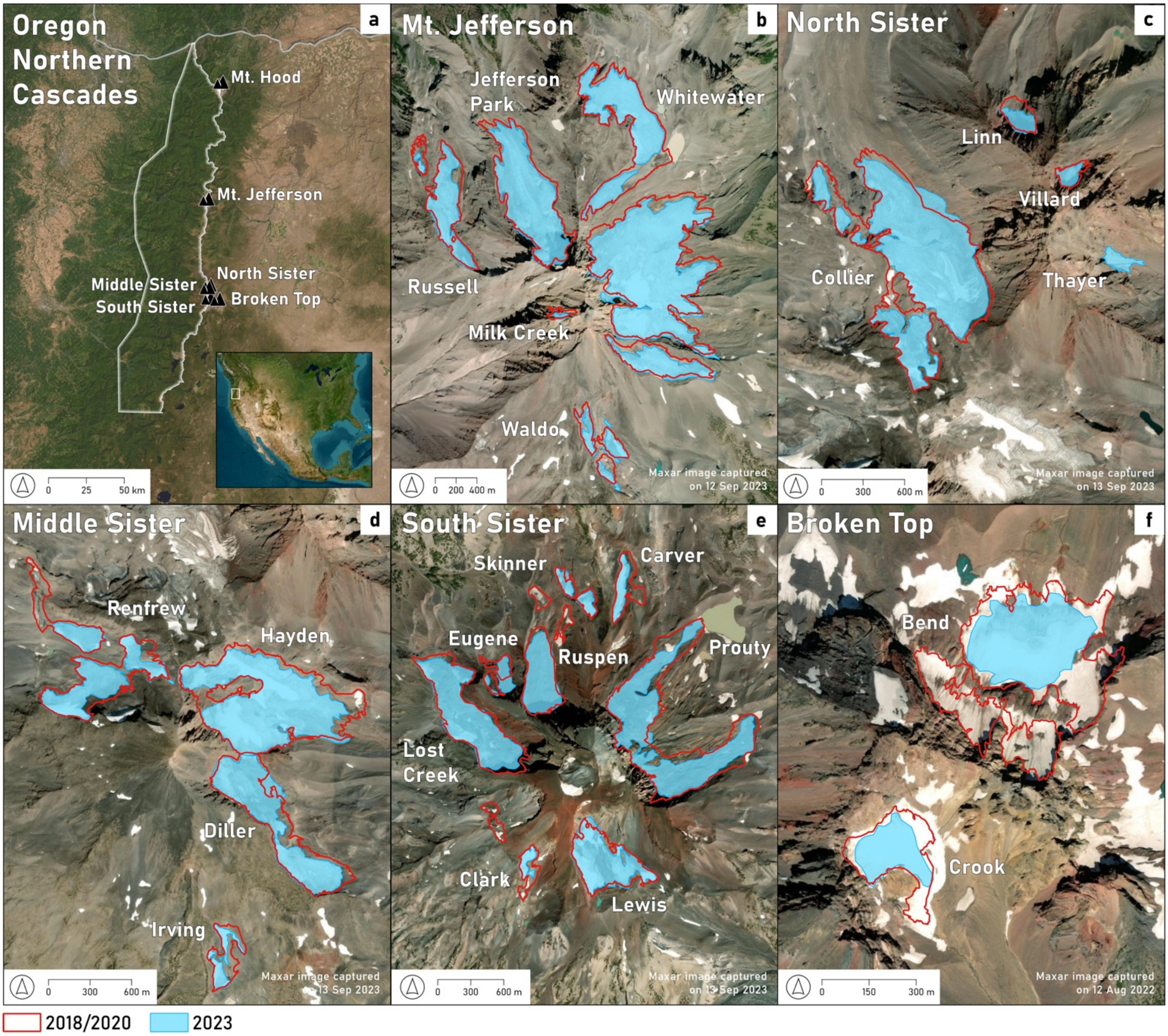

Figure 1: Location map of Oregon and the Oregon Northern Cascades climate division (a), Mt. Jefferson (b), North Sister (c), Middle Sister (d), South Sister (e), and Broken Top (f). 2023 ice extents are from this study (blue shading) while 2018 (Three Sisters and Broken Top) and 2020 (Mt. Jefferson) ice extents are from Fountain et al. (2023) (red lines). Imagery from ESRI (2024).

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The rate of area loss for glaciers on Mt. Hood increased in the 21st century and reached its fastest rate between 2015/16 and 2023 (Bakken-French et al., 2024). These direct field observations of glacier area loss contrasted with remote sensing-alone data that were interpreted to show minimal glacier mass change on Mt. Hood in the 21st century (e.g., Menounos et al., 2019) and even recent glacier mass gains (Hugonnet et al., 2021). However, the volcanos of the Oregon Cascades can produce significant rockfall onto their glaciers, with the growing debris cover requiring field verification of glacier changes measured from remote sensing (Bakken-French et al., 2024; Pelto and Pelto, 2025; Carlson et al., 2026).

South of Mt. Hood, the Oregon central Cascades have five volcanos that are still glacierized: Mt. Jefferson, North, Middle and South Sister (the Three Sisters), and Broken Top (Fountain et al., 2023; Carlson et al., 2026) (Fig. 1a). In the late 1800s, Joseph Diller of the U.S. Geological Survey summarized the Three Sisters: "… as probably affording the most interesting field for glacial studies in the United States, with the exception of Alaska" (O'Connor, 2013). Williams (1916) and Hodge (1925b) mapped and named many of the glaciers on the Three Sisters and Broken Top. The glaciers of Mt. Jefferson were described and named in Hatch (1917) and Hodge (1925a). Phillips (1938) documented the retreat of many of the glaciers up to 1937 on Mt. Jefferson, the Three Sisters and Broken Top, as well as glaciers on the surrounding volcanos of Three Fingered Jack, Mt. Bachelor and Diamond Peak. The glaciers on these latter three volcanos vanished by the late 1970s to early 1980s (O'Connor et al., 2001; O'Connor, 2013; Bruce Johnson, personal communication and August 1971 photograph, 14 May 2021).

The most recent glacier inventory of the five glacierized Oregon central Cascade volcanos is from 2018 for Broken Top and the Three Sisters and 2020 for Mt. Jefferson (Fig. 1b-f), which only used remote sensing without field verification (Fountain et al., 2023). The last inventory for these five volcanos that included fieldwork is from 1990, when glacier extents were mapped and examined in context of downstream moraine-dammed lakes and potential flood and debris flow hazards (O'Connor et al., 2001). Many of the Three Sisters glaciers were mapped with field verification in 1981 as part of a glacierized volcano hazard survey, but this inventory did not include the glaciers on Mt. Jefferson or Broken Top (Driedger and Kennard, 1986). Notably, since the most recent inventory, the Pacific Northwest experienced one of the most extreme heatwaves ever recorded on Earth in late June 2021 (Thompson et al., 2022) and has continued to warm, both of which have impacted glaciers (Pelto et al., 2022; Bakken-French et al., 2024; Carlson et al., 2026).

Here we present 2023 glacier extents based on field mapping and remote sensing for the named glaciers in the Oregon central Cascades and an unnamed glacier on South Sister. Some of these glacier extents were discussed in Carlson et al. (2026) in the context of these glaciers being considered "critically endangered" and thus projected to expire by 2050 (i.e., Howe and Boyer, 2025; Andreassen et al., 2026). In the case of our study here, we place these current glacier extents in context of the two prior glacier inventories (O'Connor et al., 2001; Fountain et al., 2023). We also compare recent rates of area loss against the historical record of these glaciers (O'Connor et al., 2001). Lastly, we combine the Oregon central Cascade glacier inventory with the 2023 glacier inventory on Mt. Hood (Bakken-French et al., 2024) to examine potential geometric and topographic variables associated with the rates of glacier area loss and their relationship to the warming climate.

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2 Data and Methods

The 2023 extents of 22 named glaciers on Broken Top, the Three Sisters and Mt. Jefferson were mapped over five years. One unnamed glacier on South Sister is also included, which we informally call here Ruspen glacier. Our methods are described in Bakken-French et al. (2024) and their application to these five volcanos in Carlson et al. (2026). Following standard glacier inventory methodology (Müller et al., 1977), we initially utilized late-summer Sentinal-2 satellite imagery from 2020, 2021, 2022, and 2023 to manually outline the extent of glaciers. Manual mapping was performed due to the presence of high debris cover on some glaciers (Paul et al., 2013). These initial glacier outlines were then field checked by physically walking the glacier margins shortly after the imagery was available each year. Maxar imagery from 8 and 13 September 2023 was then used to finalize glacier extents, with final field verification in summer 2024. Due to the lack of 2023 Maxar imagery, the final glacier extents for Broken Top are based on 12 August 2022 Maxar imagery and 19 September 2023 Sentinal-2 imagery (Carlson et al., 2026). We have determined a conservative uncertainty in this iterative methodology for glacier area of ± 7 % (Bakken-French et al., 2024), which we use here (Carlson et al., 2026). For each glacier, we also calculate maximum, minimum and mean elevation, elevation span, surface slope and aspect, which are provided in Table S1 along with the same data for the glaciers of Mt. Hood (Bakken-French et al., 2024).

We compare the 2023 glacier extents to the prior two inventories for these five volcanos. Fountain et al. (2023) provides remote sensing-based glacier extents for Broken Top and the Three Sisters from 2018 and for Mt. Jefferson from 2020. O'Connor et al. (2001) mapped the glacier extents on these volcanos for 1990. We determine rates of percent area change between 2023 and 2018/20 and 2018/20 and 1990, propagating area uncertainty through in quadrature (Bakken-French et al., 2024). O'Connor et al. (2001) also used aerial photographs to map glacier extents on the Three Sisters for 1974, 1957, 1949 and 1925, on Broken Top in 1949, and on Mt. Jefferson in 1967. We use these additional observations to compare the post-1990 rates of area change to earlier historic rates of area change. Note that O'Connor et al. (2001) did not provide estimates of area uncertainty. We thus apply our conservative ± 7 % to their extents.

We compare rates of glacier area change to changes in the regional climate of the National Oceanic and Atmospheric Administration Oregon Northern Cascades climate division (U.S. NOAA, 2026). This climate division encompasses the glacierized Oregon Cascade volcanos (Fig. 1a). Mean May through October temperature is utilized because it represents the maximum length of the ablation season and cumulative November through April precipitation is used because it is the maximum length of the accumulation season (Bakken-French et al., 2024; Carlson et al., 2026). We also estimate the impact that decadal-change in temperature would have on equilibrium line altitude (ELA) using the regional lapse rate of 4.8 °C km^{-1} from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) product (PRISM Group, 2026).

3 Results

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The 2023 extents of the Oregon central Cascade glaciers are shown in Figure 1 and with their area listed on Table 1. Compared to their 2018 and 2020 extents (Fountain et al., 2023), every glacier in the Oregon central Cascades lost area over this 5- or 3-year period (Table 1). The smallest percentage of area lost was Lewis Glacier on South Sister at ~ 4 % (~ 0.26 km^2 to ~ 0.25 km^2). The largest percentage of area lost was Clark Glacier at ~ 69 % (~ 0.08 km^2 to ~ 0.03 km^2), which is just to the west of Lewis Glacier on South Sister (Fig. 1e). Conversely, the largest amount of area lost was from Whitewater Glacier on Mt. Jefferson, which shrank by ~ 0.23 km^2 between 2020 and 2023 (Fig. 1b). The second largest amount of area lost was for Prouty Glacier on South Sister, which lost ~ 0.20 km^2 between 2018 and 2023 (Fig. 1e). The smallest amounts of area lost were for Ruspen glacier on South Sister (Fig. 1e) and Milk Creek Glacier on Mt. Jefferson (Fig. 1b), with each losing ~ 0.01 km^2 between 2018 or 2020 and 2023, respectively.

Volcano	**Glacier**	**1990 Area (km^2)**	**2018/20 Area (km^2)**	**2023 Area (km^2)**	**1990-2018/20 (% yr^{-1})**	**2018/20-2023 (% yr^{-1})**	**Rate Change (x-fold)**
Broken Top	Crook	0.074	0.051	0.033	1.12	7.06	6.30
Broken Top	Bend	0.486	0.219	0.084	1.96	12.33	6.28
Broken Top	*Sum*	*0.560*	*0.270*	*0.117*	*1.85*	*11.33*	*6.12*
South Sister	Clark	0.161	0.081	0.025	1.77	13.83	7.81
South Sister	Lewis	0.325	0.259	0.247	0.73	0.89	1.22
South Sister	Prouty	1.046	0.734	0.531	1.07	5.53	5.19
South Sister	Carver	0.180	0.131	0.067	0.98	9.77	10.02
South Sister	Skinner	0.247	0.099	0.050	2.14	9.87	4.61
South Sister	Ruspen†	-	0.194	0.182	-	1.21	-
South Sister	Eugene	0.092	0.049	0.034	1.68	6.06	3.61
South Sister	Lost Creek	0.520	0.419	0.376	0.69	2.07	2.99
South Sister	**Sum*	*2.572*	*1.772*	*1.330*	*1.11*	*4.99*	*4.50*
Middle Sister	Irving	0.150	0.068	0.033	1.95	10.29	5.29
Middle Sister	Diller	0.503	0.307	0.265	1.39	2.74	1.97
Middle Sister	Hayden	0.725	0.601	0.492	0.61	3.62	5.92
Middle Sister	Renfrew	0.381	0.310	0.215	0.66	6.13	9.22
Middle Sister	*Sum*	*1.758*	*1.286*	*1.005*	*0.96*	*4.37*	*4.55*
North Sister	Thayer	0.091	-	0.022	-	-	-
North Sister	Villard	0.050	0.023	0.018	1.91	4.54	2.37
North Sister	Linn	0.150	0.040	0.025	2.62	7.50	2.87
North Sister	Collier	0.827	0.799	0.683	0.12	2.89	23.46
North Sister	**Sum*	*1.027*	*0.862*	*0.726*	*0.57*	*3.15*	*5.53*
Mt. Jefferson	Waldo	0.282	0.123	0.097	1.88	7.05	3.74
Mt. Jefferson	Whitewater	2.392	1.859	1.632	0.74	4.06	5.46
Mt. Jefferson	Jefferson Park	0.549	0.551	0.508	0.00	2.60	-
Mt. Jefferson	Russell	0.451	0.279	0.226	1.27	6.33	4.99

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Mt. Jefferson	Milk Creek	-	0.016	0.006	-	20.83	-
Mt. Jefferson	**Sum*	*3.674*	*2.811*	*2.463*	*0.78*	*4.13*	*5.29*

Table 1: Oregon central Cascades glacier observations from 1990, 2018/2020 and 2023. Total glacier area in 1990 (O'Connor et al., 2001), 2018/2020 (Fountain et al., 2023) and 2023 (this study), the rates of area change between these three time periods, and then the changes in rate. An asterisk by the Sum notes that this quantity, and associated rates for the volcano, does not include glaciers that are missing an observation from one of the three inventories, which is denoted by a dash. The † is to signify that Ruspen is an informal name for this glacier.

Looking at the total glacier area change for each volcano (Fig. 2a) identifies Broken Top as losing ~ 57 % of its glacier area (~ 0.27 km^2 to ~ 0.12 km^2) between 2018 and 2023. South Sister lost ~ 23 % of its glacier area (~ 1.97 km^2 to ~ 1.51 km^2; note these sums include Ruspen glacier), Middle Sister lost ~ 22 % of its glacier area (~ 1.29 km^2 to ~ 1.01 km^2), and North Sister (not including Thayer Glacier due to lack of 2018 data) lost ~ 16 % of its glacier area (~ 0.86 km^2 to ~ 0.73 km^2) between 2018 and 2023. Mt. Jefferson's glacier area declined by ~ 13 % (~ 2.83 km^2 to ~ 2.47 km^2; note these sums include Milk Creek Glacier) between 2020 and 2023. In total, these volcanos lost ~ 20 % of their glacier area between 2018/20 and 2023.

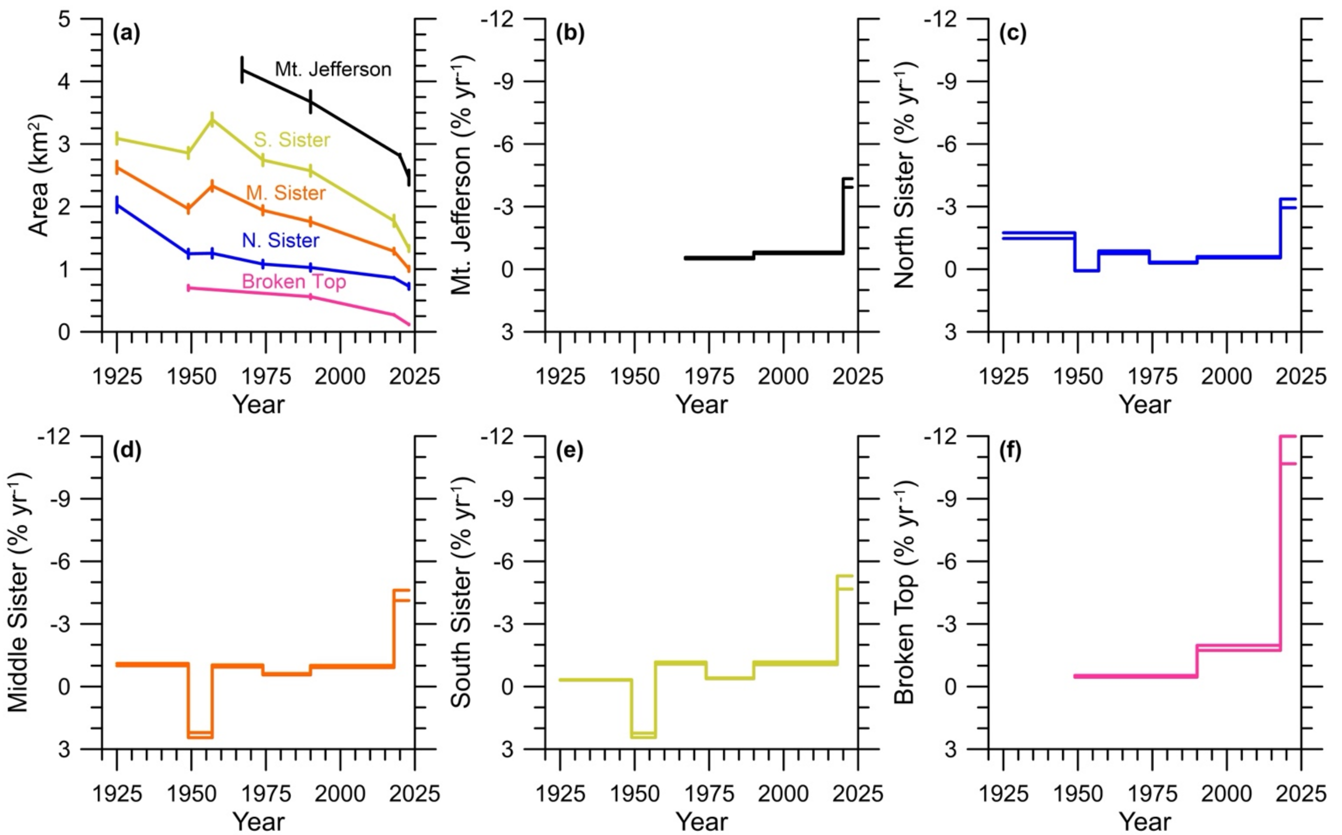

Figure 2: Glacier area changes in the Oregon central Cascades. (a) Glacier area on the five volcanos with vertical bars denoting uncertainty (O'Connor et al., 2001; Fountain et al., 2023). Maximum and minimum rates of glacier area change for Mt. Jefferson (b), North Sister (c), Middle Sister (d), South Sister (e), and Broken Top (f).

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We now examine the rate of glacier area loss for the five volcanos. In so doing, we exclude glaciers that do not have area data in each of the three inventories (Table 1): Milk Creek on Mt. Jefferson (missing 1990), Thayer on North Sister (missing 2018), and Ruspen on South Sister (missing 1990). As the smallest glacier in the Oregon central Cascades in 2023 and 2020, Milk Creek could have been overlooked in 1990. Fountain et al. (2023) listed Thayer Glacier as gone as of 2018, but we found glacier ice remaining as of 2024, which was likely missed in 2018 due to debris cover (Carlson et al., 2026). Lastly, Ruspen glacier is not on U.S. Geological Survey maps (Fountain et al., 2017), probably due to its debris covered terminus and location in a cirque on the north side of the volcano in the summit's shadow.

Between 2018 and 2023, glaciers lost area at 11.33 ± 0.66 % yr^{-1} on Broken Top, 4.99 ± 0.31 % yr^{-1} on South Sister, 4.37 ± 0.25 % yr^{-1} on Middle Sister, and 3.15 ± 0.21 % yr^{-1} on North Sister, while Mt. Jefferson lost glacier area at 4.13 ± 0.21 % yr^{-1} between 2020 and 2023 (Table 1, Fig. 2b-f). These most recent rates are about 4.5- to 6.1-fold faster than for 1990 to 2018 at 1.85 ± 0.12 % yr^{-1}, 1.11 ± 0.07 % yr^{-1}, 0.96 ± 0.05 % yr^{-1}, 0.57 ± 0.03 % yr^{-1}, and 1990 to 2020 at 0.78 ± 0.04 % yr^{-1}, respectively (Table 1, Fig. 2b-f). Given the resolution of observations (O'Connor et al., 2001), these most recent rates of area loss are also the fastest since 1949 for Broken Top, 1925 for the Three Sisters, and 1967 for Mt. Jefferson (Fig. 2b-f).

We combine the 2018/20-2023 rates of area loss for the Oregon central Cascades with the area loss data for 11 glaciers on Mt. Hood for 2015 or 2016 to 2023 to then compare the rates of area loss of these 33 glaciers to their geometric and topographic data (Table S1). Note that Ladd Glacier on Mt. Hood is excluded because its 2015 extent from remote sensing did not include a significant portion of the glacier that was underneath debris (Bakken-French et al., 2024). We do not find a significant relationship between rate of glacier area loss and latitude ($p = 0.1941$), mean aspect ($p = 0.7465$), mean slope ($p = 0.0836$), or mean elevation ($p = 0.6623$). We do find significant relationships between rate of glacier area loss and metrics of glacier size. The strongest correlation is with the span in glacier elevation from headwall to terminus, with a smaller elevation span correlated with faster area loss ($r = 0.5744$; $p = 0.0005$) (Fig. 3a). The rate of glacier area loss also correlates with glacier area, with smaller glaciers losing area faster ($r = 0.5218$, $p = 0.0018$) (Fig. 3b). Glaciers with higher elevation termini are losing area faster ($r = 0.3707$, $p = 0.0337$) and glaciers with lower elevation headwalls are losing area faster ($r = 0.3684$, $p = 0.0349$). These glacier size metrics are related. Elevation span significantly correlates with area, headwall elevation and terminus elevation. Glacier area significantly correlates with headwall elevation and terminus elevation. However, headwall elevation and terminus elevation do not have a significant correlation.

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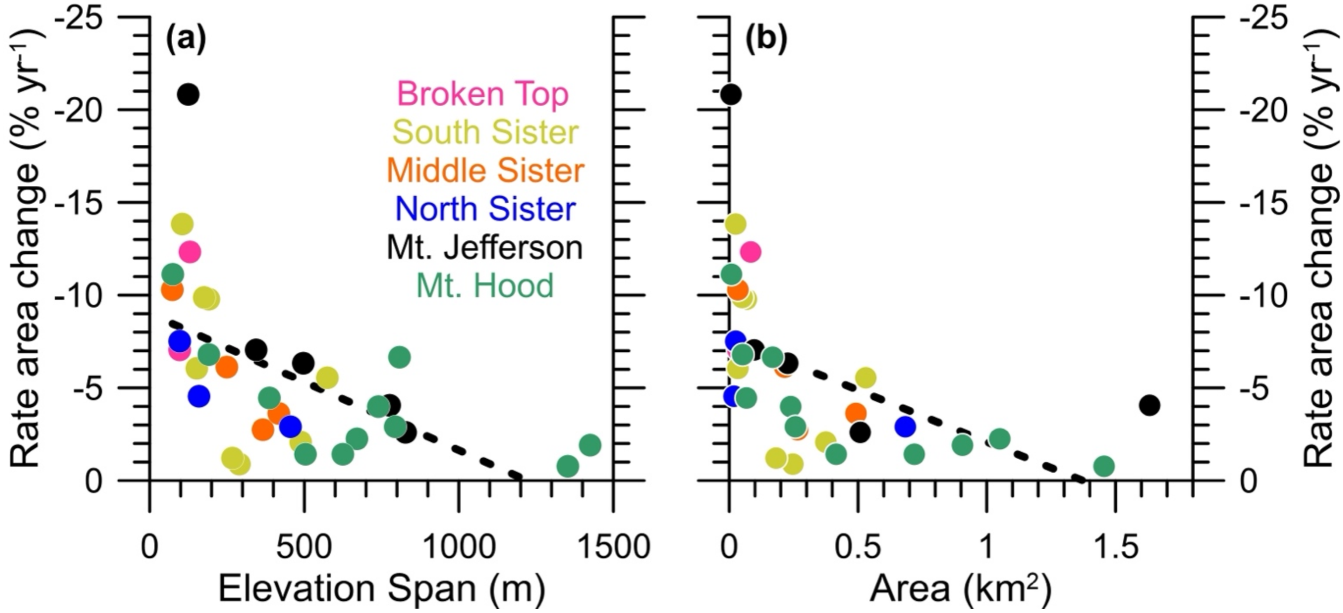

Figure 3: Rate of glacier area change in the Oregon Cascades versus glacier elevation span (a) and glacier area (b). Dashed lines are significant relationships (r = 0.5744; p = 0.0005 for elevation span and r = 0.5218, p = 0.0018 for area). Data are in Table S1.

4 Discussion

The recent Oregon central Cascade rates of glacier area loss of 3.15 ± 0.21 % yr^{-1} (North Sister) to 11.33 ± 0.66 % yr^{-1} (Broken Top) are faster than many recently recorded rates of area loss for other glacierized regions of western Canada and the conterminous United States. Between 2015/16 and 2023, Mt. Hood's glaciers lost area at 2.13 ± 0.12 % yr^{-1} (Bakken-French et al., 2024). In Washington state to the north of Oregon, glaciers on Mt. Rainier lost area at 0.69 ± 0.05 % yr^{-1} for 2015-2021 while glaciers in the Olympic Mountains lost area at 2.75 ± 0.04 % yr^{-1} for 2009-2015 (Fountain et al., 2022), but the Olympic Mountain data end in 2015. For 2005-2015, Glacier National Park glaciers in Montana, to the northeast of Oregon, lost area at ~ 0.83 % yr^{-1} (Fagre et al., 2017) but those data also end in 2015. Farther north, the three glaciers in the Whistler Blackcomb ski area of southwest British Columbia lost area at 4.36 ± 1.60 % yr^{-1} between 2018 and 2024 (Monty et al., 2026), which is comparable to the rates of glacier area loss in the Oregon central Cascades. The other region with comparable glacier loss rates to the Oregon central Cascades is the Trinity Alps of northern California to the south of Oregon, which largely deglaciated by 2015 (Garwood et al., 2020). Here, glacier area loss for 1994-2015 at 3.89 ± 0.02 % yr^{-1} (Garwood et al., 2020) was around the rates of glacier loss on North Sister and Mt. Jefferson.

Our observation of glacier area loss in the Oregon Cascades since 2015 contrasts with geodetic mass balance measurements for these same glaciers. Hugonnet et al. (2021) documented that 25 of the 30 glaciers we used for determining area loss rates gained mass from 2015 to 2019, which our field observations contradict. This disagreement highlights the difficulty in using

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remote sensing alone to document glacier change in regions with high rock fall (Bakken-French et al., 2024; Pelto and Pelto, 2025; Carlson et al., 2026).

Menounos et al. (2025) found similarities between recent rates of glacier mass loss in western North America and the Swiss Alps in Europe. We find these similarities extend to a smaller regional scale for glacier area change using our observations from the Oregon central Cascades and similar data from western Austria. Conzelmann et al. (2026) documented the change in area for 25 glaciers in the westernmost state of Vorarlberg, Austria, which is adjacent to easternmost Switzerland. Between 2017 and 2023, glacier area in four regions of Vorarlberg declined from 7.52 ± 0.07 km^2 to 5.27 ± 0.06 km^2 while the glacier area on the five volcanos in the Oregon central Cascades shrank from 7.03 ± 0.11 km^2 in 2018/20 to 5.66 ± 0.15 km^2 in 2023. Rates of area loss for the four Vorarlberg regions ranged from 3.84 ± 0.51 % yr^{-1} to 14.37 ± 3.99 % yr^{-1}, which are comparable to the Oregon central Cascade rates of 3.15 ± 0.21 % yr^{-1} to 11.33 ± 0.66 % yr^{-1}.

Within the last decade, the rate of glacier area loss in the Oregon central Cascades has increased to historically unprecedented rates (Fig. 2b-f), similar to the glaciers on Mt. Hood (Bakken-French et al., 2024). For 1990-2018/20, glaciers in the Oregon central Cascades lost area at 0.57 ± 0.03 % yr^{-1} (North Sister) to 1.85 ± 0.12 % yr^{-1} (Broken Top) while Mt. Hood's glaciers lost area at 0.81 ± 0.05 % yr^{-1} for 1981-2015/16 (Fig. 4c). Compared to their rates from 2018/20-2023 or 2015/16-2023 noted above, the rate of area loss of Oregon central Cascade glaciers recently increased about 4.5- to 6.1-fold while Mt. Hood's rate of glacier area loss increased about 2.6-fold. The summers of 2014-2023 averaged ~ 0.7 °C warmer ($p = 0.0199$) than the 1985-1994 mean and ~ 1.5 °C warmer ($p < 0.0001$) than the 1975-1984 mean (Fig. 4b), while winter precipitation (Fig. 4c) is not significantly different between 2014-2023 and these two early decades ($p = 0.5916$ and 0.5860, respectively). We therefore attribute this multi-fold increase in the rate of glacier area loss in the Oregon Cascades to warmer summers.

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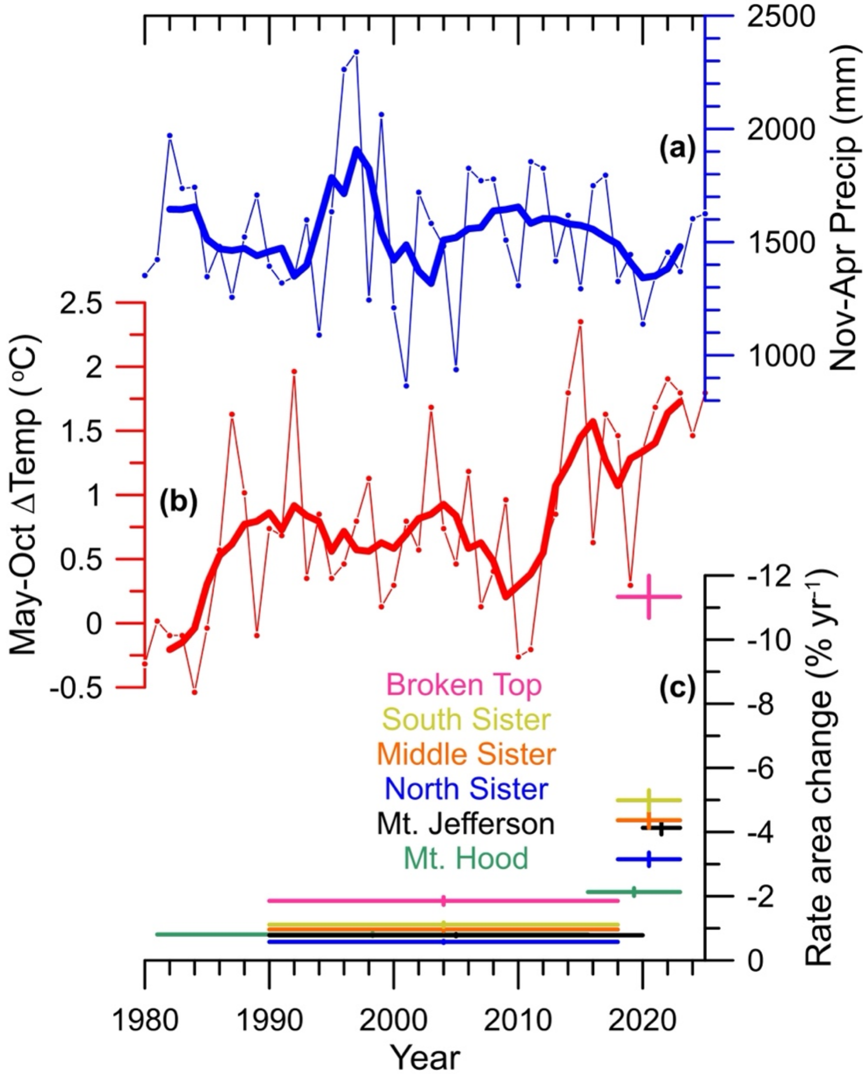

Figure 4: November-April precipitation (a) and May-October temperature change relative to 1975-84 mean (b) for the Oregon Northern Cascades climate division (NOAA, 2026). Symbols are individual years and thick lines are the 5-year running mean. (c) Rates of glacier area change for the six glacierized volcanos in the Oregon Cascades. The length of the bar is the period over which the rate is calculated while the vertical bar is the uncertainty.

The significant relationship between rate of glacier area loss and glacier elevation span for Oregon Cascade glaciers (Fig. 3a) supports the attribution of recent Oregon glacier area loss to a warming climate (Bakken-French et al., 2024; Carlson et al., 2026). That is because, for the same increment of warming and attendant rise in the ELA, a glacier with a smaller elevation span will have a higher fraction of its extent exposed to melt than a glacier with a larger elevation span, which should result in the glacier with a smaller elevation span losing a greater percentage of its area and having a faster rate of area loss. We make a first-order approximation of the impact that warming would have on the ELA.

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The ~ 0.7 °C of warming between 1984-1994 and 2014-2023 and ~ 1.5 °C of warming between 1975-1984 and 2014-2023 (Fig. 4b) would raise the ELA by ~ 150 m and ~ 310 m, respectively. Figure 5 shows the elevation span of each Oregon Cascade glacier relative to its latitude, with that glacier's rate of area loss indicated by the symbol heat colour. Notably, all but two glaciers with area loss rates of ~ 10 % yr^{-1} or greater have elevation spans less than 150 m (Table S1). The two exceptions are Skinner Glacier that spans ~180 m and Carver Glacier that spans ~190 m (Table S1), both of which are considered critically endangered glaciers (Howe and Boyer, 2025; Andreassen et al., 2026; Carlson et al., 2026). Consequently, summer warming over the last several decades may have been sufficient to greatly diminish the accumulation areas of smaller glaciers in the Oregon Cascades (Carlson et al., 2026), which is one of the indicators that a glacier is no longer sustainable in the current climate (Pelto, 2010). Not surprising then, half of Oregon's Cascade glaciers are considered critically endangered, with many of them already ceasing to flow, and are projected to disappear by 2050 unless the current climate warming trend is reversed (Carlson et al., 2026).

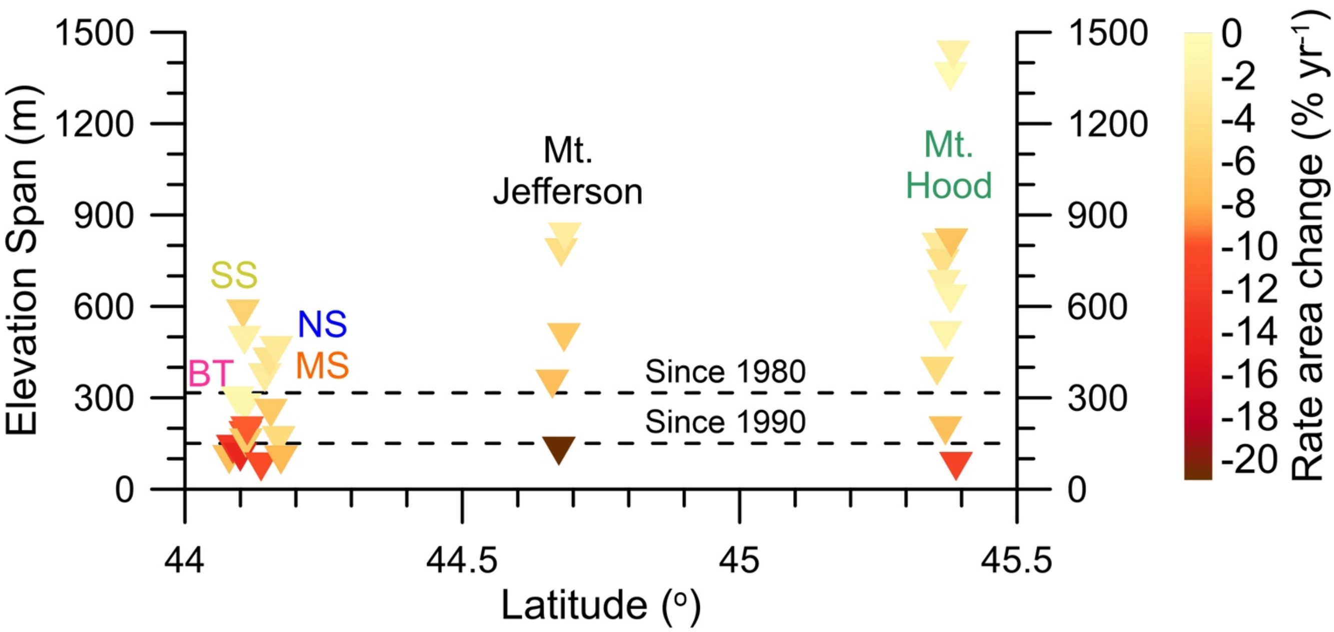

Figure 5: Elevation span of Oregon Cascade glaciers relative to their latitude. Color heat denotes rate of area change. The dashed horizontal lines indicate the rise in equilibrium line altitude of ~ 150 m from ~ 0.7 °C of warming since 1990 and of ~ 300 m from ~ 1.5 °C of warming since 1980. BT = Broken Top, SS = South Sister, MS = Middle Sister, NS = North Sister.

5 Conclusions

We document with field mapping and remote sensing the 2023 extent of glaciers on the five glacierized volcanos in the Oregon central Cascades. Compared to prior extents from 2018/20 and 1990, we find that rates of glacier area loss have increased to some of the fastest rates in western North America and rival recent rates in the western Austrian Alps. The rate of glacier area loss in the Oregon Cascades is related to glacier elevation span and area: glaciers with a smaller elevation span and less area

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are losing area faster. Regional summer warming over the last three to four decades of ~ 0.7 °C to ~ 1.5 °C, respectively, is sufficient to have largely removed accumulation areas from many of the smaller glaciers that are undergoing the fastest rates of area loss in the Oregon Cascades, which will ultimately lead to their disappearance in the absence of actions to reverse global warming.

Data availability

The data referred to in this paper have all been provided within the tables and figures in the main text and supplement or as an asset available on a FAIR-aligned data repository (available at XXXXX that will be all glaciers in OR).

Supplement

The supplement related to this article is available online at: XXXXX

Author contributions

The author contributions, following the CRediT authorship guidelines, are as follows: MT, NB-F, and AEC: conceptualization; MT, NB-F, SP, DHR, and AEC: methodology; NB-F, SP, AK, EE, NK, and AEC: validation; MT, NB-F, DHR, and AEC: analysis; MT, NB-F, DHR, and AEC: investigation; MT, NB-F, DHR, and AEC: resources; MT, DHR, and AEC: data curation; AEC: original draft; MT, NB-F, SP, AK, EE, NK, DHR, and AEC: review and editing; MT, DHR, and AEC: visualization; MT, NB-F, DHR, and AEC: administration; MT, NB-F, DHR, and AEC: funding acquisition.

Competing interests

The authors declare that they have no conflict of interest.

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