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Glacier Change in the North Cascades, Washington: 1900-2009

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by

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Abstract

Glaciers respond to local climate changes making them important indicators of regional climate change. The North Cascades region of Washington is the most glaciated region in the lower-48 states with approximately 25% of all glaciers and 40% of the total ice-covered area. While there are many on-going investigations of specific glaciers, little research has addressed the entire glacier cover of the region. A reference inventory of glaciers was derived from a comparison of two different inventories dating to about 1958. The different inventories agree within 93% of total number of glaciers and 94% of total ice-covered area. To quantify glacier change over the past century aerial photographs, topographic maps, and geologic maps were used. In ~1900 total area was about 533.89 ± 22.77 km^2 and by 2009 the area was reduced by -56% ± 3% to 236.20 ± 12.60 km^2. Most of that change occurred in the first half of the 20th century, between 1900 and 1958, -245.59 ± 25.97 km^2 (-46% ± 5%) was lost, followed by a period of stability/growth in mid-century (-1% ± 3% from 1958-1990) then decline since the 1990s (-9% ± 3% from 1990-2009). The century-scale loss is associated with increasing regional temperatures warming in winter and summer; precipitation shows no trend. On a decadal time scale winter precipitation and winter and summer temperatures are important factors correlated with area loss. Topographically, smaller glaciers at lower elevations with steeper slopes and higher mean insolation exhibited greater loss than higher, gentler more shaded glaciers.

Acknowledgements

I would like to thank my adviser, Andrew G. Fountain for his guidance and support throughout this thesis project and to the committee members, Heejun Chang and Martin Lafrenz for their insights.

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I would also like to thank my S7 officemates for the valuable discussions of all things glacier. Last but not certainly not least, thanks to my family and my husband Aaron for all of their encouragement and support.

Table of Contents

List of Tables

List of Figures

Chapter 1 – Introduction

Glaciers are the result of accumulation of snow and mass loss primarily through melting and exist in locations where accumulation exceeds melting. The controlling variables of snow fall and melting, winter precipitation, summer air temperature vary over space and time. Over the decades, glaciers expand during cool wet periods and retreat during warm dry periods because glaciers respond to local climate changes they are important indicators of regional climate change. Mountain glaciers (km in length) respond to changing climate conditions on a roughly decadal time scale (Johannesson and others, 1989), whereas smaller glaciers respond more quickly (Hoffman and others, 2007). The Intergovernmental Panel on Climate Change (IPCC) has used glaciers as an indicator of climate change since 1990 (Cooper and others, 2002). Glaciers affect alpine streamflow because water is stored upstream as snow/ice, and the timing of runoff is influenced by the percentage of glacier coverage (Fountain & Tangborn, 1985). Downstream effects include alpine ecosystems that depend on glacial runoff (Hall & Fagre, 2003), hydropower, and agricultural uses, and finally sea level rise. Between 1961 and 1998 alpine glaciers and ice caps contributed about 13mm to global sea-level rise, approximately 20% of the total observed sea-level rise (Dyurgerov & Meier, 2000, Dyurgerov and others, 2002).

Glaciers respond to large-scale variations in climate (McCabe & Fountain, 1995, Hodge and others, 1998, Bitz & Battisti, 1999, McCabe and others, 2000, Meier and others, 2003). The temporal variation in the climate of the western United States is influenced by several modes of atmospheric circulation that are characterized by different climate indices. The El-Niño-Southern Oscillation (ENSO-SOI) acts on an interannual period, the average cycle lasts 6-18 months (Zhang and others, 1997). Acting on an interdecadal scale, the Pacific Decadal Oscillation (PDO) produces similar climate anomalies as the ENSO-SOI, although not as extreme (Munn, 2002, Mantua and others, 1997). Warm PDO phases are characterized by cool SSTs over the central North Pacific and warmer SSTs along the west coast, and cool PDO phases are produced by the opposite conditions. A warm phase PDO causes below-average snowpack and streamflow in the western United States, and a cool phase PDO causes an above average effect (Munn, 2002, Bitz & Battisti, 1999, Mote, 2005). McCabe and Dettinger (2002) showed that PDO explains year to year variation in snowpack better than ENSO. The effects of climate variation on the western United States have wide reaching implications for water resources.

The purpose of studying the North Cascades is several fold. First, the region has the highest concentration of ice cover in the continental United States approximately 1,935 glaciers and perennial snowfields with an area of 288.3 km^2 (Fountain and others, 2007b). Second, extensive historic data exists for a few glaciers in the region (NPS, USGS, NCGCP). My thesis provides a comprehensive examination of glacier change, and its magnitude and rate relative to these historic studies of single glaciers.

My thesis initially compares a US Geological Survey topographic map (1:24000) glacier inventory compiled by cartographers to the Post and others (1971) inventory compiled by glaciologists to determine their similarity. If they are similar, I use the topographic attributes from the map inventory to characterize the glacier cover of the region. I then update the inventory with new temporal data to identify glacier area change with time. These changes are compared to climate and topographic variations to determine the important controlling factors.

This thesis is divided into five chapters, after the introduction and site description, there is a glacier population inventory followed by glacier temporal area change; in subsequent analysis of topography and climate and finally, discussions and conclusions are presented.

Study Area

The Cascades are a mountain range that extends from northern California to northern Washington. The North Cascades region, the focus of my study, is in Washington State and stretches from latitude 48ºN to the Canadian Border at 49ºN and between 122° 30' and 121° 30' W for a total area of about 20,000 km^2. The elevation ranges from less than 1,000 m to 3,285 m at the peak of Mount Baker. The North Cascades National Park Complex consists of the North Cascades National Park, Ross Lake Recreation Area, and the Lake Chelan National Recreation Area, and the Okanagan-Wenatchee National Forest and Mt. Baker-Snoqualmie National Forest. The landcover of the area consists of dense evergreen forest in the low-lying areas and alpine ecosystems and exposed rock with ice and snow in the upper elevations.

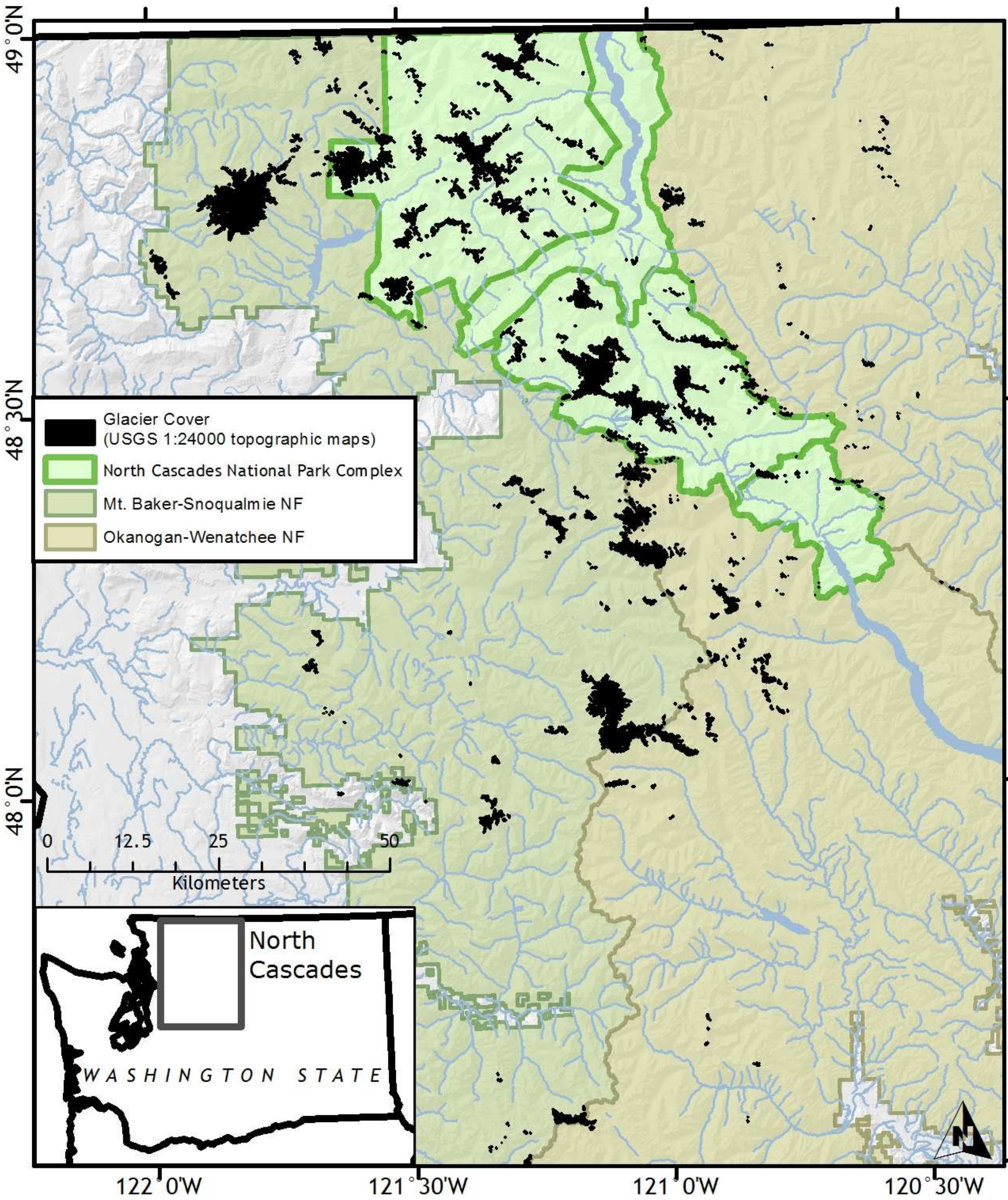


Figure 1 – North Cascades region with administrative boundaries and 24K glacier inventory (in black).

The bedrock of the region consists of Paleozoic and Mesozoic sedimentary, intrusive and metamorphic rocks. About 40 million years ago the Cascade Magmatic Arc developed over the top of the mosaic, covering the older rocks with lava and ash and the volcanic peaks of Mount Baker and Glacier Peak formed (Haugerud & Tabor, 2009).

Throughout the Pleistocene, the Cordilleran ice sheet and alpine glaciers shaped the topography of the North Cascades. Alpine glaciers formed cirques, arêtes and coalesced with the Cordilleran ice sheet through existing river channels and carving large U-shaped valleys. Throughout the Holocene, there have been several glacier advance events at ~7 ka, about 2-3 ka and several small events over the past 700 years (Easterbrook, 1963). The last one was in the 13th-20th centuries and is known as the Little Ice Age.

In the spring and summer, high pressure dominates the North Pacific Ocean and brings dry, cool and stable air in a west/northwest direction. In the fall and winter, the Aleutian low-pressure cell moves south, pushing the high pressure further south, and the dominate wind direction changes to the west and southwest. The moist air from the ocean condenses and is orographically uplifted creating precipitation (Ruffner and others, 1985). The first barrier that forces orographic uplift is the Olympic Mountains and as the air masses move eastward they meet the Cascades Mountains. The majority of precipitation falls on the west side of the Cascades (Figure 2) and the east side is a rain shadow (Figure 2).

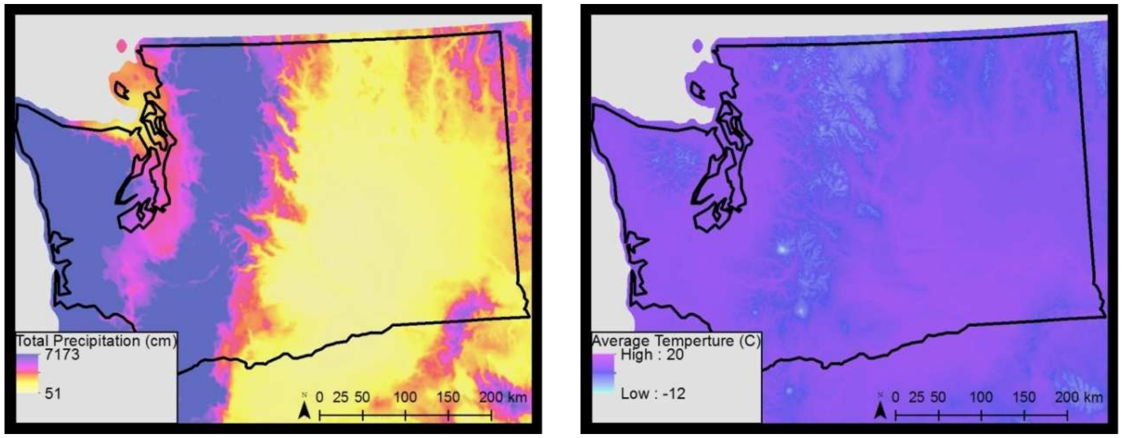


Figure 2 - PRISM Climate averages for the State of Washington from 1971-2000. Precipitation is on the left and temperature is on the right.

The North Cascades consists of several major watersheds, including the Skagit, Stehekin, Nooksak and Cascade rivers. Snow and ice melt are important contributors because runoff is highest when precipitation is low and temperatures are highest. Potential changes to the runoff regimes could have large reaching consequences for the hydroelectric power generation downstream. Glaciers delay the time of maximum seasonal runoff until later on in the summer (Fountain & Tangborn, 1985). Runoff from glacier-free watersheds is controlled by precipitation, while glacierized watersheds are controlled by energy. This is important because glacierized watersheds produce more water during hot, dry periods. The inter-annual variability of runoff decreases with increasing fractional glacier cover, up to about 30-40% due to a buffering influence between ice-free and glacierized portions of the catchment (Moore and others, 2009).

Previous Glacier Studies

The first published account of glaciers in the North Cascades was by I.C Russell when he recognized glaciers in the mountains of the North Cascades (Russell, 1897). The first glacier inventory of the North Cascades was subset of a general glacier inventory of the western United States and identified 519 features with a total area of 251.7 km^2 (Meier, 1961). A comprehensive inventory of the North Cascades was completed by Post and others (1971) and included all glacial features greater than 0.1 km^2. This inventory covers the entire North Cascades range from Snoqualmie Pass to the Canadian border. It identified 756 glaciers for a total area of 275 km^2. Granshaw and Fountain (2006) updated the Post and others (1971) inventory within the North Cascades National Park Complex using 1998 aerial imagery (Granshaw & Fountain, 2006) they used glacier outlines from the U.S Geological Survey (USGS) 1:24000 topographic maps dated to 1958 imagery because as a baseline because Post and others (1971) did not attempt to reproduce glacier shape accurately. The 1998 glacier extents were derived by modifying the mapped outlines using aerial imagery. They identified 321 glaciers in 1958 with a total area of 117.3 ± 1.0 km^2 and 316 glaciers in 1998 with a total area of 109.1 ± 1.1 km^2 for a total area change of -7%. In addition, they found that small glaciers lost relatively more area than larger glaciers. Other studies on Mount Baker provide an extensive time series of glacier change (Harper, 1993, Kovanen, 2003, Pelto, 1993, Fountain and others, 2007a). Mount Baker has a more maritime climate and is at a higher elevation than other glaciers in the North Cascades region and experiences more variability (Harper, 1993). Kovanen (2003) concluded that the glacier terminus fluctuations were related to PDO regime changes

The second longest glacier mass balance program in the world (since 1958) is located on South Cascade Glacier in the North Cascades. Between 1958 and 2003, the South Cascade Glacier has retreated about 0.6 km from its 1958 terminus position and the average net balance has been -0.55 m water equivalent (Bidlake and others, 2007). The North Cascades National Park currently monitors four glaciers in the park complex starting in 1994 (Riedel & Larrabee, 2011). These measurements include annual and seasonal mass balance. The North Cascades Glacier Climate Project (NCGCP) monitors net mass balance on eight glaciers, with two more glaciers added in 1994 (Pelto, 1988, Pelto, 2008).

Although surface mass balance measurements are most useful in understanding how glaciers are changing, they are a costly and labor intensive method (Fountain and others, 1997). Consequently, few glaciers can be measured. Aerial and satellite imagery provide a relatively inexpensive alternative to monitor many glaciers but at this time limited to area change assessment not mass balance. The use of a geographic information system (GIS) technology is an efficient way to create and update temporal glacier inventories (Mennis & Fountain, 2001, Mool and others, 2001, Paul and others, 2002, Granshaw & Fountain, 2006). I utilize this this format to store and update the glacier inventory for the North Cascades.

Chapter 2 – Glacier Population Inventory

Introduction

The purpose of this chapter is to test the fidelity of a glacier inventory derived from published topographic maps compiled by cartographers against an inventory compiled by glaciologists (Post and others, 1971). I address two questions:

1) If Post and others (1971) is the 'true' inventory, then how accurate are the features derived from topographic maps?
2) If there is a mismatch between the inventories are there any obvious remedies?

Comparison between these two inventories is important because Post and others (1971) do not contain detailed topographic information. However, if they correspond, then the topographic data from the maps can be used to characterize the population attributes of the glaciers and perennial snowfields to create a template for comparison of future changes. Granshaw and Fountain (2006) addressed the same questions, however their inventory was limited to the North Cascades Park Complex which is a subset of the full inventory of the North Cascades. I reexamined the questions using the full inventory.

Methods

Glacier outlines were derived from U.S. Geological Survey (USGS) 7.5 minute topographic maps at the scale of 1:24000 which are based on aerial imagery acquired in different years. This dataset is abbreviated as '24K'. Glaciers are depicted on the maps with blue outlines and blue contour lines with a white background. We assume that the cartographers only mapped features they deemed perennial. Although I refer to the mapped features as 'glaciers', in fact they are a combination of glaciers and perennial snowfields. The digital glacier outlines were obtained from the USGS, and compared against the digitally scanned maps and corrections made (Fountain and others, 2007b). The attributes include 'official' glacier name, USGS quadrangle name, latitude, longitude, area, topographic characteristics and photography year. The topographic characteristics for each feature were calculated by overlaying the glacier outline on a 10m digital elevation model (DEM) and calculating the zonal statistics using ArcGIS (ESRI, 2012). The calculated topographic characteristics included mean aspect, and mean, minimum, and maximum of both slope (degrees) and elevation (meters).

The inventory by Post and others (1971) is based on vertical aerial photographs at a scale of 1:38000 and were acquired over the North Cascades in late summer 1958. Oblique photographs, USFS topographic maps, and personal observations supplemented the vertical aerial photographs. The features were then drawn on maps and their location, latitude/longitude to the nearest minute, was calculated. Additional attributes of each glacier included area, length, accuracy, nature of terminus and activity. Post and others (1971) defined a glacier as *"any perennial ice that has an area of at least 0.10 km^2. Included are (1) active glaciers, (2) ice patches derived from direct snow accumulation, wind drift, or snow avalanches, without regard for evidence of glacier flow, and (3) relict ice from former active glaciers. Ice patches derived from avalanching of ice from hanging glaciers are considered to be part of the parent glacier."*

Estimating uncertainty in glacier area is important for defining the significance of area change. Three types of uncertainty are identified: position, digitizing, and interpretation (Sitts and others, 2010). Positional uncertainty is the horizontal error of the image or map to the surface topography. The digitizing uncertainty is the deviation of the digitized outline from the actual glacier perimeter presuming it is sharp and easy to follow. Interpretation uncertainty is caused by shadows, debris-covered ice, and seasonal snow that mask the true outline of the glacier. The total uncertainty (km^2) is the root sum of squares of position (P), digitizing (D), and interpretation (I) uncertainties.

$$U_{total} = \sqrt{P^2 + D^2 + I^2} \quad (1)$$

For the 24K maps, the positional uncertainty is 12.2 m, the relative accuracy of 95% of the points that fall within that range (Fountain and others, 2007b), however I assume the value is zero because any shifting in the horizontal accuracy will not affect glacier area. Although, the digitizing uncertainty is considered to be the width of the line on the 24K maps, 2.4 m, (Granshaw & Fountain, 2006) that value results in a conservative overall uncertainty and I used the positional uncertainty value, 12.2 m, as the digitizing uncertainty.

This digitizing uncertainty is evaluated using the method developed by Ghilani (2000) and applied by Hoffman and others (2007). The Ghilani method (2) provides a less conservative, more realistic uncertainty value than applying a buffer because it ignores the covariance of the error between vertices.

$$D = \sqrt{A} \times DU \times \sqrt{2} \quad (2)$$

where A is glacier area, km^2, and DU, km, is the linear digitizing uncertainty value. The value of D is used in equation 1 to calculate overall uncertainty. The interpretation uncertainty is unknown for the 24K dataset. Post and others (1971) estimate the accuracy in two categories, category 1 is excellent (95 percent) and category 2 is fair (5 percent). I calculated uncertainty based on those two categories estimating that the uncertainty for category 1 is 5 percent times glacier area and for category 2 is 95 percent.

Results

The glaciers in the 24K inventory are found from 48.25° to 49° N at the Canadian border, and from 120.42° W to 121.99° W (Figure 3). Based on the map collar the year of imagery acquisition is defined for that specific quadrangle. The largest number of glaciers (37%) is from 1958 aerial photography (Figure 4), with the remaining features over a 28 year period from 1957 to 1985. From these maps a total of 1935 glaciers are identified, of which 102 are named, with a total area of 288.3 ± 12.5 km^2. The area of individual glaciers ranges from 0.0004 km^2 (unnamed) to 6.83 km^2 (Coleman Glacier) on Mount Baker, with an average of 0.15 km^2 and a median of 0.03 km^2. The frequency distribution of glacier area is highly skewed towards small glaciers (Figure 5). Most of the ice-cover spans 1500 m to 2500 m reaching a maximum of about 2000m. Relative to the total area of the entire region, ice covers most of the elevations higher than about 2400 m (Figure 6a). The total range in glacier elevation is between 593 m to 3282 m at the summit of Mount Baker. The average elevation of the glaciers is 1948 m with a median of 1972 m (Figure 6b). Glacier slope is steep averaging 29.7^{o} with a median of 29.2^{o} (Figure 6c). The glaciers face all directions, with most in the N and NE direction (Figure 6d) as one would expect in the northern hemisphere. The 'typical' glacier for the North Cascades may be characterized as small, 0.03 km^2, facing NNE at an elevation of 1972 m with a slope of 29.2^{o}.

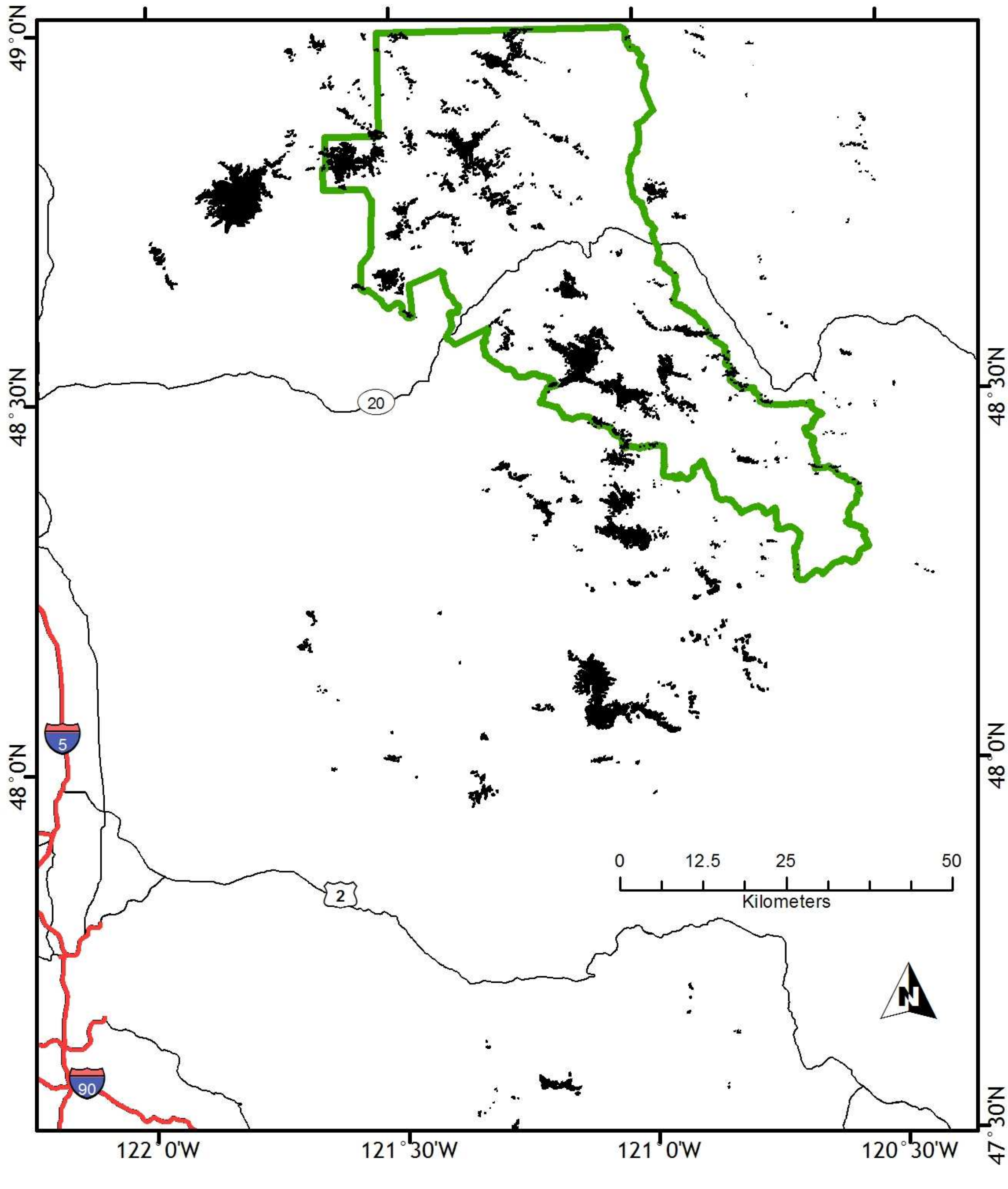


Figure 3- Map of the North Cascades glacier inventory (in black) with the North Cascades Park Complex outlined in green. Major highways are shown for reference.

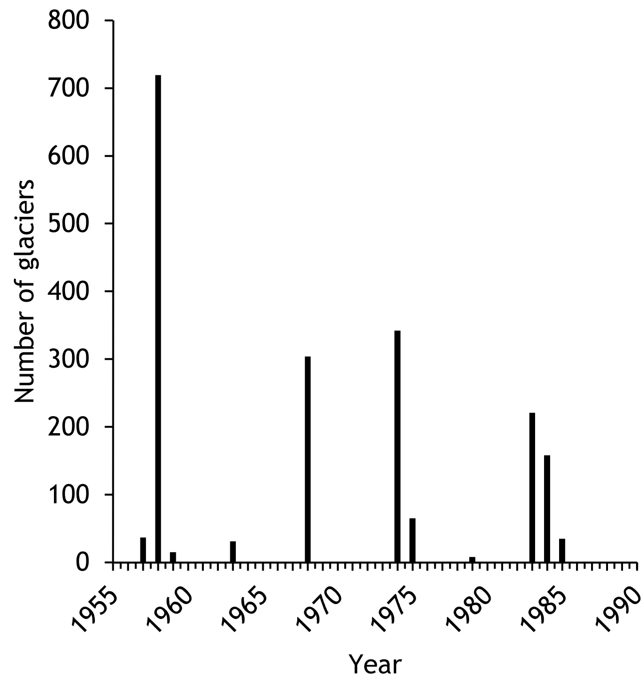


Figure 4 - Number of glaciers in the 24K inventory per year of imagery acquisition.

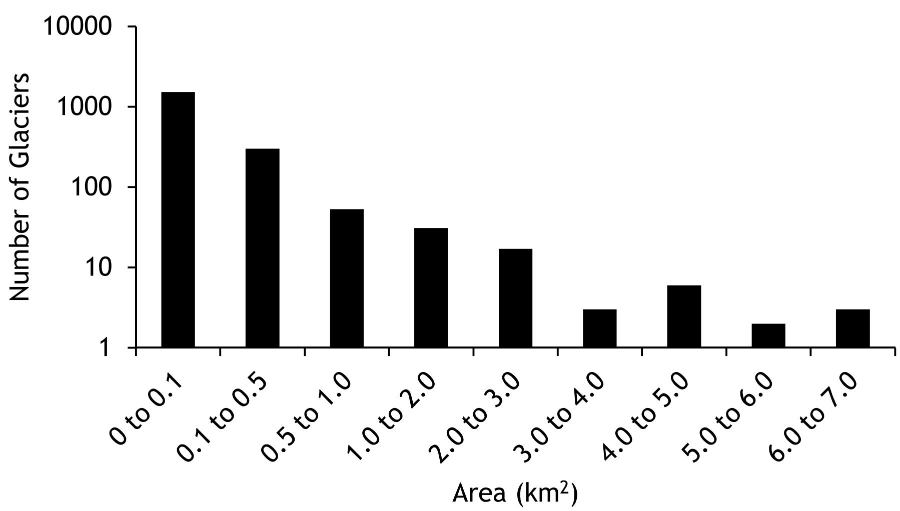


Figure 5 - The frequency distribution of 24K glaciers and perennial snowfields grouped by area. The maximum value for each area range is included in that group.

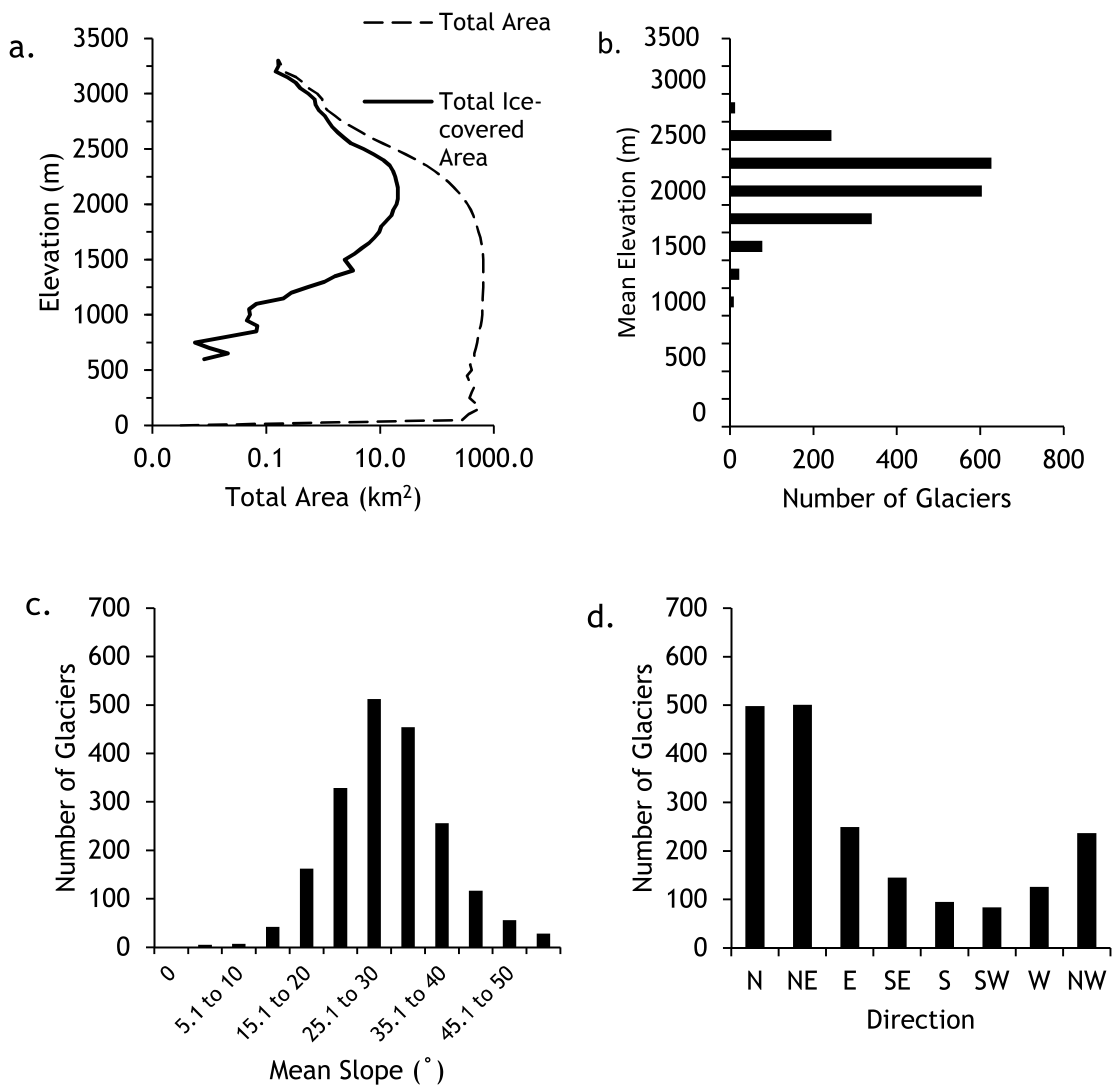


Figure 6 - Topographic characteristics of the 24K glaciers and perennial snowfields. (a) elevation of the entire region and all ice-covered areas at 50m contour intervals; (b) mean elevation for each feature grouped by 100m intervals; (c) mean slope for each feature grouped by 5 degrees; (d) mean aspect grouped by 8 directions (N=0-22.5; NE=22.5-67.5; E=67.5-112.5; SE=112.5-157.5; S=157.5-202.5; SW=202.5-247.5; W=247.5-292.5; NW=292.5-337.5; and N=337.5-360).

As mentioned, the 24K quadrangles were originally mapped by the USGS using aerial photographs acquired over different years. Although the map collar may indicate that the original map was 'revised' to a more modern date, the glacier outlines were not and date to the original photographs. I verified the image year for all 24K maps within the North Cascades using single frame aerial photographs from the USGS EarthExplorer (www.earthexplorer.usgs.gov) (Figure 7). The 24K maps have been recently revised in a digital format, however none of the glacier outlines were updated (Cooley and others, 2011).

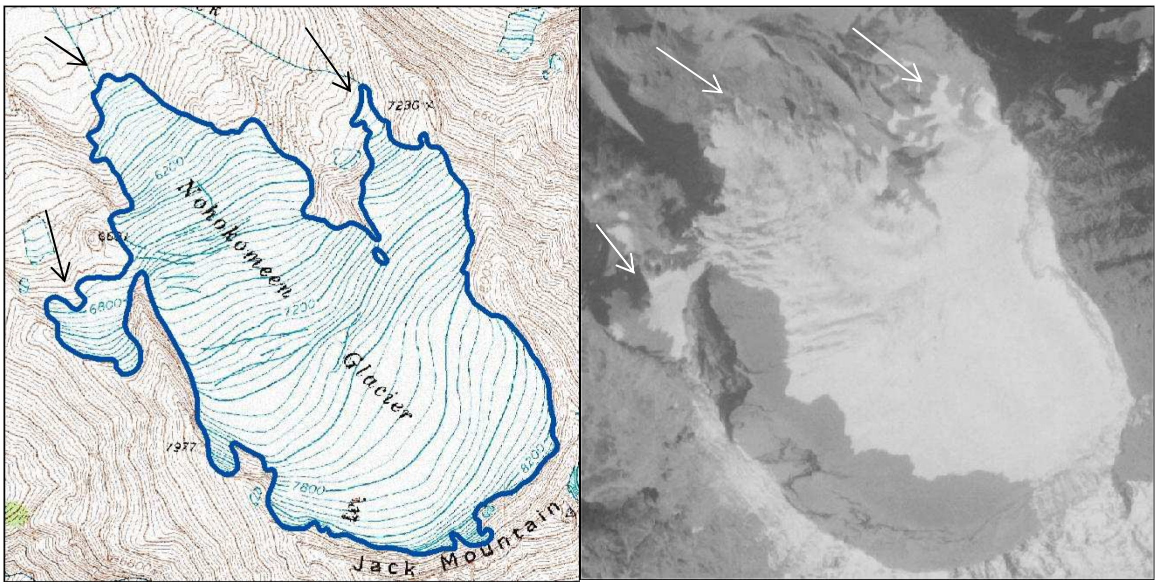


Figure 7 - Example of date checking the glacier outlines from 24K quadrangle glacier outline (on right) with more than one source year. Image on left is from 1968, and the arrow points to obvious similarities in the features.

The Post and others (1971) inventory reported 756 glaciers for a total area of 275.2 ± 19.5 km^2. However, 14 of the 756 glaciers found on their inventory map were not included in their report tabular data, Post estimated the total area of these 14 features to be less than 1.0 km^2. The reason given is that they were discovered too late to be included in the 1971 report. The glacier shapes on the paper maps included in the report were highly generalized.

Analysis

The timing of the aerial photography was quite different for the two inventories. The Post and others (1971) images were taken solely in 1958, whereas only about 1/3 of the images used in the 24K were taken in 1958 and the rest over the 28 year range from 1957 – 1985. However, this is not an important difference because the 1957 – 1985 period was a time of glacier stability (Chapter 3), therefore difference between the inventories should not be caused by differences in imagery dates.

The numbers of glaciers between inventories are quite different. The total number of glaciers in the 24K inventory is almost three times that of Post and others (1971) but the area is only 4% larger (Table 1). Most of the difference (+ 79% number, -13% area) is caused by the smallest glaciers, less than or equal to 0.1 km^2. The glaciers between 0.1 and 0.5 km^2 explains a further + 16% number (+ 21% area) of the difference. Clearly, the major difference between inventories is the identification and inclusion of small glaciers. The remaining difference in number (5%) is due to how large continuous ice masses are divided into individual glaciers (Figure 8).

Table 1 – Number and area of glaciers and perennial snowfields for each inventory. 'Post' refers to the Post and others (1971) inventory; 24K refers to the entire 24K inventory in the North Cascades, the 24k minus Post is the difference between those two inventories. The 24K subset is included for comparison purposes also. Only glaciers equal to 0.1 km^2 included in the Post inventory. Largest number in each area range is included in that group. Additional overall uncertainty values were added to the Post and 24K subset datasets due to additional information, and therefore the sum area uncertainty will not add up down the row.

Area (km^2)	*Post n*	*Post Area (km^2)*	*24K n*	*24K Area (km^2)*	*24K minus Post n*	*24K minus Post Area (km^2)*	*24K Subset n*	*24K Subset Area (km^2)*
≤ 0.1	411	41.1 ± 4.0	1519	37.9 ± 5.5	*1108*	*-3.2*	287	15.3 ± 1.7
0.1 - 0.5	222	60.1 ± 4.8	301	59.8 ± 3.4	*97*	*8.7*	288	60.1 ± 3.3
0.5 – 1.0	58	46.4 ± 3.2	53	38.2 ± 1.2	*-15*	*-9.2*	64	46.6 ± 1.4
1.0 – 2.0	28	39.9 ± 2.0	31	40.8 ± 0.9	*-4*	*-5.1*	31	42.4 ± 0.9
2.0 - 3.0	8	21.1 ± 1.1	17	42.8 ± 0.7	*9*	*22.7*	12	29.3 ± 0.5
3.0 - 4.0	5	16.8 ± 0.8	3	10.7 ± 0.1	*-3*	*-9.1*	8	28.8 ± 0.4
4.0 - 5.0	5	22.4 ± 1.1	6	27.6 ± 0.3	*2*	*10.2*	4	19.3 ± 0.2
5.0 - 6.0	4	20.8 ± 1.0	2	10.7 ± 0.1	*-3*	*-15.1*	2	10.5 ± 0.1
6.0 - 7.0	1	7.0 ± 0.4	3	19.9 ± 0.2	*2*	*12.9*	1	6.8 ± 0.1
Sum:	756	275.6 ± 21.7	1935	288.4 ± 12.5	*1193*	*12.7*	697	259.1 ± 10.4
Average:		0.4		0.15				0.37
Median:		0.1		0.03				0.12

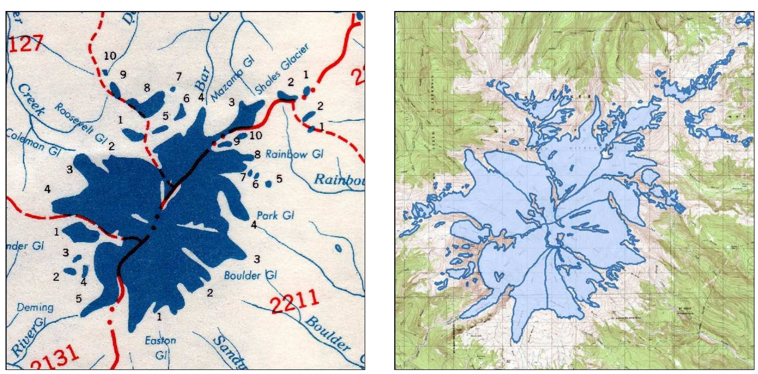


Figure 8 – The differences between how glaciers are demarcated in the Post and others (1971) and the 24K inventory. On the left Post and others (1971) do not clearly identify glacier outlines on Mount Baker, the glaciers were numbered implying a division. On the right the derived glaciers clearly show the outlines that are included in the 24K topographic map. There are 31 glaciers on the left and 104 glaciers on the right with the main difference being the number of small glaciers.

To reconcile the inventories presuming that Post and others (1971) correctly identified glacial features, the 24K inventory is filtered to estimate the number of 'true' glaciers using two methods. First, I use an area threshold, common to many inventories (Basagic & Fountain, 2011, Granshaw & Fountain, 2006, Raub and others, 2006, Spicer, 1986, Paul and others, 2009, Abermann and others, 2009, DeBeer & Sharp, 2007) and secondly a shear stress threshold (Granshaw & Fountain, 2006, Basagic & Fountain, 2011).

Post and others (1971) identified glacial features greater than 0.1 km^2. To match Post and others (1971) the 24K inventory was filtered to remove all features less than 0.1 km^2 resulting in 416 glaciers with a total area of 250.4 ± 6.96 km^2 (Table 1). This is closer to the Post and others (1971) inventory of 756 glaciers with 9% less area (25.18 km^2). However, the difference in the number of glaciers is huge ~326 (44%) fewer than found in Post and others (1971). To explore this more closely, I compared each glacier in Post and others (1971) to its mirror glacier in the full 24K inventory to track correspondence between inventories. The Post and others (1971) map was digitally scanned and overlaid on the 24K maps. The differences between the unique identifiers in Post and others (1971) and the 24K is problematic because unique identifier (RECNO) in the 24K inventory is based on one polygon equals one glacier, whereas the unique identifier (Basin ID) in Post and others (1971) is based on hydrology and drainage divides which provides most of the boundaries between glaciers. That is to say, Post and others (1971) grouped glaciers according to watersheds. To convert from RECNO to Basin ID any multi-part glaciers from the 24K were assigned to one Basin ID, and any glaciers that spanned more than one Basin ID were split apart. Any glacier in the 24K that could not be assigned to a Post – identified glacier was deleted. The resulting inventory is hereafter referred to as the '24K subset'. In the end, 711 glaciers from the 24K were recombined into 697 glaciers (259.1 ± 8.6 km^2) common to both inventories using the Basin ID classification of Post and others (1971) (Table 1). The difference is 59 fewer 24K subset glaciers (16.5 km^2) than Post and others (1971). Consequently, 1224 glaciers (34.08 km^2) from the 24K inventory, do not match Post and other's (1971), and all are smaller than 0.5 km^2 with most (1175 or 61%) smaller than 0.1 km^2.

Seventy-two glaciers (8.05 km^2) identified in the Post and others (1971) inventory were not found in the 24K inventory, 11 of which were identified by Granshaw and Fountain (2006) as glaciers within the North Cascades Park Complex. A visual inspection of all 72 features against aerial photography of that period indicates that the 11 features identified by Granshaw and Fountain (2006) are indeed glacial, and are included in the 24K subset above since their outlines were digitized by Granshaw and Fountain (2006). Of the remaining 61 glaciers, 32 glaciers (4.4 km^2) could not be found due to the mis-match of the 24K to the coarser scale paper map of Post; 29 features were determined to be glacial with a total area of 3.5 km^2. The 32 missing glaciers from Post with an area of 4.4 km^2 (±16, ±2.2 km^2) adds to the uncertainty of Post and others

(1971) while the 29 missing glaciers from the 24K dataset (± 15, ± 1.75 km^2) adds to the uncertainty of the 24K subset.

The 24K subset shows that 287 glaciers are smaller than 0.1 km^2, and these glaciers are identified in Post and others (1971) who claimed a 0.1 km^2 threshold. Presumably, Post included these small glaciers and if the area is rounded to 0.1 km^2. To correct the 24K inventory for Post and others (1971) suspected inclusion of these small glaciers (< 0.1 km^2), I subtract the glaciers less than or equal to 0.1 km^2, 1519, from the total 1935 (Table 1) and add back the 287, resulting in 703 (265.8 km^2), a value close to both the Post and others (1971) of 756 ± 16 (275.6 ± 21.7 km^2) and to the 24K subset of 697 ± 15 (259.1 ± 10.4 km^2).

The comparison of the 24K and Post and others (1971) inventory revealed differences in both number and area. By correcting the 24K by eliminating the small glaciers that Post did not count as glaciers, and adding back the small glaciers that Post did count, the result of 703 glaciers is only 39 (7%) smaller than Post, and the area 265.8 km^2 is only 9.8 km^2 (4%) smaller. Therefore, once the counting methods are corrected for the differences in approach the two inventories are very similar.

A more process-based way to define a glacier is to infer movement. ‘True’ glaciers are defined as perennial snow and ice that moves (Cuffey & Paterson, 2010). The threshold for glacier movement is whether the critical shear stress for ice, 10^5 Pa (Cuffey & Paterson, 2010) is achieved. This approach provides a more objective classification rather than the arbitrary area threshold. The shear stress at the base of the glacier is defined as

$$\tau_b = \rho_i g h \sin\gamma \tag{3}$$

where ρ_i is ice density (900 kg m^{-3}), g is gravitational acceleration (9.81 m s^{-2}), *h* is ice thickness (m), and γ is the ice surface slope.

Surface slope is a topographic characteristic already derived for all 24K glaciers and I use the maximum slope of all grid cells as a liberal estimate of slope for each feature. To estimate volume, I use the scaling relationship between area and volume (Chen & Ohmura, 1990, Bahr and others, 1997) of the form,

$$\mathrm{V} = \propto \mathrm{A}^{\beta} \tag{4}$$

where *V* is glacier volume (km^3), $\propto$ and β are constants, and *A* is the glacier area (km^2). The average thickness of the feature <*h*>, is estimated by dividing the volume by the surface area,

$$< h >= \propto A^{\beta-1} \tag{5}$$

The $\propto$ and β are scaling parameters that can be determined from empirical data (Chen & Ohmura, 1990). I applied two different sets of scaling parameters from Chen and Ohmura (1990) ‘Cascade and other areas’ (A) $\propto$= 30.83 and β=1.406 and the scaling parameters for ‘Cascade, small glaciers’ (B), $\propto$=21.35 and β=1.145. Results are summarized in Table 2.

Table 2 – Estimates of 'true' glaciers using a shear stress threshold for the 24K inventory for the two sets of parameters (A) and (B). The Post and others (1971) total inventory values are included for comparison.

Inventory Name and Filter	Number	Area(km^2)
24K - Scaling Parameters (A)	334	240.2 ± 6.21
24K - Scaling Parameters (B)	601	259.7 ± 8.04
Scaling Parameters (B) Shear Stress threshold 0.8 x 10^5	1050	277.5 ± 10.2
Scaling Parameters (B) Shear Stress threshold 0.925 x 10^5	753	267.4 ± 8.88
Post and others (1971)	*756*	*275.6 ± 21.7*

The different scaling parameters produce quite different results and both underestimate the population compared to the entire Post and others (1971) inventory. The results of scaling parameters (–B-) resulted in a match of 81% (601) of the number of glaciers and 94% (258.72 km^2) of total area. With the uncertainty of Post and others (1971) overlapping the (-B-) estimate of area. To improve the match I adjusted the value of shear stress to gain a better match of both area and glacier number. Using scaling parameters (–B-) and reducing the critical shear stress to 0.925 x 10^5 Pa the number of glaciers had the best match with 753 glaciers (756 glaciers ~100%) and 95% of area. The best match for glacier area was achieved when shear stress threshold was reduced to 0.8 x 10^5 Pa with an area of 277.5 km^2 (275.6 km^2~100%) and 142% of number. I feel the overall best match is with the –B- parameters and a shear stress of 0.925 x 105 Pa because the number of glaciers is very close, within 9, to that of Post and others (1971) which represents 95% of the area, well within the uncertainty of Post.

Discussion & Conclusions

I attempted to match the 24K inventory to the Post and others (1971) inventory using both an area threshold and shear stress criteria. An area threshold of 0.1 km^2 resulted in 416 glaciers (55%), an underestimate of the Post and others (1971) glacier population by 340 glaciers (45%) (Table 3). Using a shear stress threshold of 1.0×10^5 Pa and the –B- parameters resulted in an underestimate of the Post and others (1971) inventory by 141 (19%). Reducing the shear stress threshold to 0.925×10^5 Pa had a better match the Post and others (1971) inventory in the number of glaciers with 753 (100%).

The differences between the 24K and Post inventories may be influenced by cartographic misidentification of seasonal snow patches as perennial glacial features. I assumed Post and others (1971) are absolutely correct, however, features may also be misidentified. Unfortunately, we have no way to assess these errors in either inventory.

Table 3 - Comparison of inventories using different methods. The 'features' column shows the division of the inventory based on the different methods of analysis. If the feature did not meet the threshold it is assumed to be a perennial snowfield. B indicates features (glaciers) that meet the shear stress threshold defining movement using the B-set of scaling parameters.

Inventory	Filter	Feature	Number	Total Area
24K	None	All	1935	288.36 ± 12.49
	< 0.1 km^2	Perennial Snowfields	1519	37.94 ± 5.53
	> 0.1 km^2	Glaciers	416	250.42 ± 6.96
	(-B-)	Perennial Snowfields	1334	28.64 ± 4.45
		Glaciers	601	259.72 ± 8.04
24K subset	None	Glaciers	697	259.07 ± 10.35
	< 0.1 km^2	Perennial Snowfields	283	15.32 ± 1.67
	> 0.1 km^2	Glaciers	414	243.75 ± 6.95
Post and others (1971)	None	Glaciers	756	275.6 ± 21.7
	= 0.1 km^2	Perennial Snowfields	411	41.1 ± 4.0
	> 0.1 km^2	Glaciers	345	255.3 ± 15.5

Within the North Cascades Park Complex, the comparison of 24K features that matched Post and others (1971) eliminated many of the 24K features less than 0.1 km^2 and the total area was only 1.7 km^2 different (Granshaw & Fountain, 2006). Basagic and Fountain (2011) in the Sierra Nevada, California also used both area and shear stress thresholds to estimate 'true' glaciers from a California 24K glacier inventory compared to a Post and others (1971)-like inventory (Raub and others, 2006). The removal of glaciers smaller than 0.005 km^2 resulted in a 102% area match in number of glaciers, which was better than using a 0.01 km^2 threshold which resulted in a 69% area match. Using a shear stress threshold of 10^5 Pa, a match of only 14% in the number of glaciers, but reducing the threshold to 0.4 x 10^5 Pa, the number of glaciers matched at ~100% and the threshold to 0.5 x 10^5 Pa to match area to ~100%. The North Cascades has larger glaciers compared to Sierra Nevada and

Raub and others (2006) had a smaller area threshold of 0.01 km^2. The smaller features in the Sierra Nevada may account for more reduction in the shear stress threshold. When I reduced the shear stress to 0.8×10^5 Pa, I had a 100% match in area. To get a better match in the number of glaciers, I reduced the shear stress value to 0.925×10^5 Pa and that resulted in a 100% match in the number of glaciers.

To answer the original questions of this chapter, the comparison between inventories showed the most difference in the features less than 0.1 km^2. The inventories are nearly identical for features greater than 0.1 km^2, 83% number and 102% of area, with the main differences in number being the methodology used to catalog each feature. Based on my correction to the Post and others (1971) inventory using the 24K area values for the features that Post and others (1971) identified as equal to 0.1 km^2, the two inventories are comparable in number (93%) and in total area (94%). This finding supports that of Granshaw and Fountain (2006) and Basagic and Fountain (2011) and provides confidence in using the topographic variables derived from the 24K to characterize the glaciers and perennial snowfields of the North Cascades.

Chapter 3 – Temporal Glacier Inventory

Introduction

The glacier inventories presented in Chapter 2 are updated to define area change across the region. Additionally, a small subset of glaciers have been frequently monitored over the past century, including six on Mount Baker from 1900 to 2006 (Harper, 1993, Kovanen, 2003, Fountain and others, 2007a, Pelto, 1993, Pelto & Brown, 2012, O'Neal, 2005), for which I updated for 2009. South Cascade Glacier has been monitored annually by the US Geological Survey since 1958 (Bidlake and others, 2007, 2012, Krimmel, 2001b, 2002b).

Methods

I compiled nine different inventories derived from a variety of data sources including aerial photography (1989-2009), topographic maps (Chapter 2), and Little Ice Age (LIA) extents based on glacial geology (Table 4). Orthorectified aerial photography was available in black and white for 1989, 1990, 1992, 1993, and 1998 and in color for 2006 and 2009. The 1989 imagery has a resolution of 2 m and the rest are 1 m resolution.

Table 4 - Data sources and spatial coverage for glacier inventories and temporal data sets.

Year	Data Source	Spatial Extent
LIA (~1900)	North Cascades National Park (Dr. Jon Riedel, personal communication)	NOCA Park Complex
1953 - 1985	USGS 1:24,000 Topographic Maps (Fountain et al. 2007)	North Cascades Entire Region
1989 - 1998	USGS Digital Ortho Quads Aerial Imagery (DOQs)- Black and white - (http://rocky2.ess.washington.edu/data/raster/doqs/index.html)	Variable
1998	(Granshaw & Fountain, 2006)	NOCA Park Complex
2006, 2009	National Agricultural Imagery Program Aerial Imagery (NAIP) -Color- (http://gis.ess.washington.edu/data/raster/doqs_naip.html)	North Cascades Entire Region
1900 - 2006	(Fountain and others, 2007a, O'Neal, 2005)	Mount Baker
1958 - 2009	(Meier & Tangborn, 1965, Krimmel, 1989, 1993, 1994, 1995, 1997, 1996, 1998, 1999, 2000, 2001a, 2002a, Elsberg and others, 2001, Bidlake and others, 2004, 2005, 2007, 2010, 2012)	South Cascade Glacier

The glacier outlines were manually digitized in ArcGIS at a 1:2000 scale with the streaming vertices editing tool placing vertices every 10 m. This scale and vertex distance was chosen to balance accuracy with productivity. Once the outlines were digitized, the area within each outline was calculated using ArcGIS software. The area was calculated using an Albers-equal area projection to minimize any distortion relative to other projections. Glacier outlines were also obtained from the 24K topographic maps (Chapter 2). In addition, maximum glacier extent during the LIA was mapped within the North Cascades National Park Complex by Dr. Jon Riedel (personal communication).

Radiocarbon, dendrochronology and lichenometry dating methods were applied to various moraine features on Mount Baker and the maximum extent was dated to the late 19th century (Osborn and others, 2012). Photographs from the early 20th century show that the glaciers are typically in contact with their LIA moraines (Basagic & Fountain, 2011), the North Cascades are no exception (Figure 9) therefore I assume that the LIA moraines in my study region outline the glacier extent in 1900.

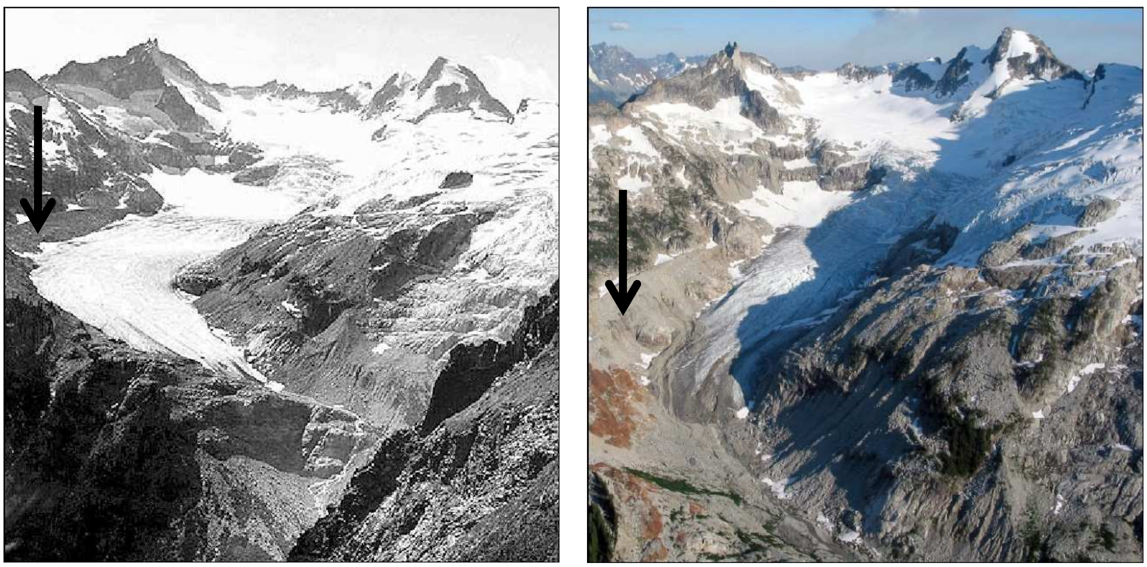


Figure 9 - Comparison of Chickamin Glacier from 1939 (left) and 2004 (right). The glacier is in contact with a lateral moraine in the 1939 photograph. Source: 1939 photographer-Dwight Watson from the University of Washington Special Collections; 2004 photograph taken by John Scurlock. Arrows are pointing to the same location on the LIA moraine in each photograph.

As a second check on the accuracy of glacier outlines, I compared area change for individual glaciers between inventories. For the largest area change I re-examined the outlines. If the change was due to a different interpretation or mis-interpretation of the largest outline, it was adjusted. After starting with the outliers, I progressively checked the glaciers with smaller and smaller changes until few or no corrections were needed. At this point I felt confident that further checking would result in little or no adjustments. In some cases seasonal snow cover or shadows obscured the glacier boundary and the glacier extent is classified as 'No Data' (Table 5). If a feature was originally mis-identified as a glacier it was eliminated from the inventory.

The total uncertainty (km^2) is the root sum of squares of position, digitizing, and interpretation uncertainties, as expressed in equation (1) in Chapter 2. The positional uncertainty is defined as the accuracy of the aerial photography, which is the root mean square error calculated during the orthorectifying process. As mentioned previously, I assume positional uncertainty to be zero because any positional error will only shift the polygon and will not change the area (DeBeer & Sharp, 2009). The digitizing uncertainty for the aerial photography was determined by digitizing glacier outlines at 1:2000 scale and again at 1:500. Interpretation uncertainty is estimated from the 2006 imagery from a sample of glaciers that were digitized independently by another person. The root mean square (RMS) difference between outlines is the interpretation uncertainty.

To calculate a normalized area change, I calculated a fractional area change (FAC) by subtracting the glacier area, A, (typically the most recent) from the initial glacier area , A_i, and dividing by the initial area.

$$FAC = \frac{A - A_i}{A_i} \quad (6)$$

The uncertainty of area change (U_Δ) is the root sum of squares (RSS) of the uncertainty total from each year,

$$U_\Delta = \frac{1}{2}\sqrt{U^2 + U_i^2} \quad (7)$$

where the uncertainty from the initial year is (U_i), and the uncertainty from the most recent is (U). The relative uncertainty (U_R) is the RSS divided by original area, A_i.

$$U_R = \frac{U_\Delta}{A_i} \quad (8)$$

Results

The aerial imagery was of varying quality and spatial extent. The black and white imagery from 1989 - 1998 made it difficult to distinguish seasonal snow from firn and ice, and the extent of seasonal snow varied not only between years but also across the region. The color imagery from 2006 and 2009 (NAIP) made interpretation more clear (Figure 10). The number of glaciers identified in each inventory including the 24K and LIA is listed in Table 5, and details by glacier in Appendix A.

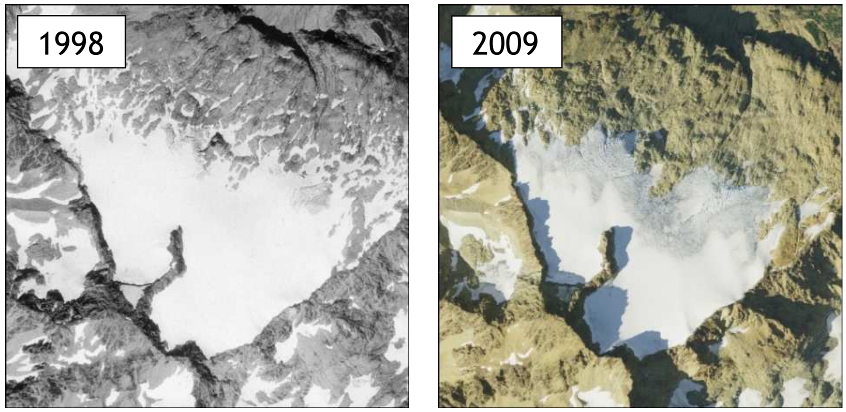


Figure 10 – The ability to define a glacier outline is enhanced when color photography (right) is available compared to black and white (left). Basin ID is 213202.

Table 5 – Results of the temporal glacier inventories. Potential is the number of glaciers within the spatial extent of the imagery. NoData are glaciers not included in the temporal analysis due to snow cover, shadows or misclassification. Final is the number of glaciers used in the analysis. Grouped Final is the year used in analysis and the final number of glaciers used in the analysis. The shaded area defines the mutually exclusive years in the 24K.

Year	Potential	NoData	Final	Grouped	Final
LIA	314	7	307	1900	307
1957	17	3	14	1958	288
1958	301	31	271	1958	
1959	6	3	3	1958	
1963	15	5	10	1968	51
1968	41	0	41	1968	
1974	96	1	95	1974	124
1975	30	1	29	1974	
1979	1	0	1	1974	
1983	85	5	80	1983	178
1984	84	6	78	1983	
1985	21	1	20	1983	
1989	55	3	52	1990	293
1990	198	16	180	1990	
1992	75	63	12	1990	
1993	51	1	49	1990	
1998	654	116	534	1998	534
2006	697	140	558	2009	683
2009	697	323	375	2009	

The positional uncertainty for the DOQs is 7m (USGS, 1996), for the NAIP imagery, both 2006 and 2009 it is 6m (USDA, 2008). Comparison of digitizing at 1:2000 versus a control effort at 1:500 for 40 glaciers reveals a digitizing uncertainty of 3 m. The interpretation uncertainty examined 42 glaciers and the difference between outlines, compared to the average area, is normally distributed showing upwards of 50% variability (Figure 11). The greatest uncertainty is common to the smallest glaciers where it is often difficult to separate seasonal from perennial snow. The imagery used in this test had significant seasonal snow cover, and the independent digitizer was inexperienced with the region and did not have the advantage of knowing the historic glacier boundaries. The dataset was subdivided into two groups, one that has relatively little seasonal snow, and the other where snow was extensive. The interpretation uncertainty (root mean square of differences in area) of the snow-free group was 0.02 km^2 and for the snowy group was 0.07 km^2. I used the smaller 0.02 km^2 uncertainty for the digitizing uncertainty of the outlines because I digitized all new inventories and examined cases of extensive variation between inventories as previously explained.

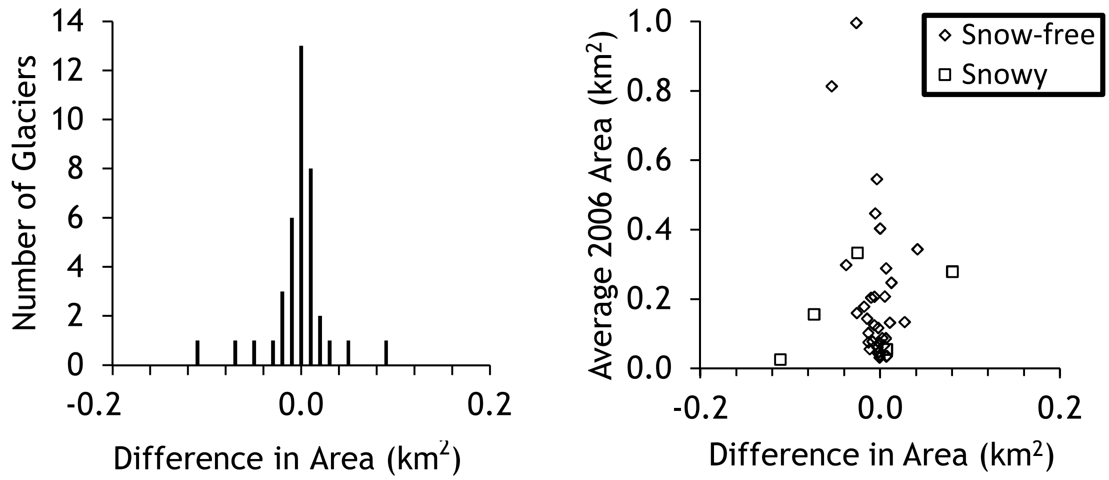


Figure 11 – Results of the two independent digitizing efforts. Histogram on left shows the distribution of area difference between two independent digitizing efforts. The graph on the right shows the difference with average area of the two independent digitizing efforts.

Analysis

Glacier change across the region

For analysis purposes, I grouped a number of different inventories together because those inventories were close together in time and mutually exclusive spatially. The 24K glaciers which span 28 years were divided into four groups using the year that had the most features, 1958 includes 1957-1959, 1968 includes 1964-1968, 1974 include 1973-1975, and 1983 includes 1982-1985 (Table 5). For the 2006 and 2009 glacier outlines, they were combined as 2009. However, unlike the 24K and DOQs, these two inventories are not mutually exclusive, but due to snow cover much of the landscape in 2009 was obscured and together these two inventories provide a complete coverage of the region. Also, only 3 years apart much of the change is observed in the uncertainty precluding estimating a meaningful difference over that 3 year period. The imagery in 2009 was better than 2006 where the glaciers were not completely snow covered. A 2009 glacier outline was only digitized if the imagery in 2009 was better than 2006. If there was no suitable 2009 outline, I used the 2006 glacier area value. If there were outlines for both 2006 and 2009 (247), I used the 2009 outline. For all but 44 of the 247 outlines change between 2006 and 2009 was less than uncertainty. The combined 2009 group has a total of 683 glaciers (216.59 km^2) of which 313 glaciers (46% or 68 km^2) were from 2006 and 370 glaciers (54% or 148.59 km^2) were from 2009.

Due to variables of snow cover, shadows, and image quality not all glacier were outlined in all inventories. Table 6 shows the number of glaciers that each inventory has in common.

Table 6- The results of the temporal glacier inventory displaying the number of glaciers in common for each combination of inventories, (A) refers to the glacier time series that has a 1900 glacier outline in common with each other inventories (B) is the inventories that have 24K outlines in common and (C) is the inventories that have an aerial imagery year in common. The inventories represent the combined inventories of Table 5.

	1900 (A)				24K (B)				Aerial Imagery (C)		
	1900	1990	1998	2009	1958	1968	1974	1983	1990	1998	2009
1900	**307**	**153**	**283**	**303**	128	15	67	76	153	283	303
1958	128	54	121	126	**288**				100	243	278
1968	15	11	13	15		**51**			32	25	42
1974	67	30	59	67			**124**		44	85	122
1983	76	47	72	76				**178**	87	124	173
1990	153	153	140	151	100	32	44	87	**293**	189	280
1998	283	140	283	280	243	25	85	124	189	**534**	517
2009	303	151	280	303	278	42	122	173	280	517	**683**

Table 7 – Sample size of identical glaciers present in each inventory. Group 1 has the 1900 inventory in common, and group 2 has the 24K and the 1990 in common. Insufficient numbers of glaciers are present in the 1990 and 1990 inventories precluding comparison.

	Temporal Sequence	Number of Glaciers
Group 1	1900-1958- -1998-2009	116
	1900-1968- -1998-2009	7
	1900-1974- -1998-2009	41
	1900-1983- -1998-2009	56
Group 2	1958-1990-1998-2009	65
	1968-1990-1998-2009	14
	1974-1990-1998-2009	16
	1983-1998-1990-2009	42

To track glacier change in the region I used two methods. First, I compared the same glaciers across the various inventories and, second, compared the partially sampled populations of glaciers that may be composed of partially overlapping sets of glaciers (Table 6). The advantage of tracking identical glaciers across inventories is certainty of knowing the change applies to the same group of glaciers and is a precise measure. The disadvantage is that the set of glaciers is small and how representative that set is of the entire population may be questionable. The second method has the advantage of large datasets, which better approximate changes in the population, however, because the sets do not use all the same glaciers some change may be due to differences in glaciers sampled.

To track the identical glaciers over time, several subsets were identified (Table 7). These subsets are divided into two groups. Group 1 is limited to the

North Cascades Park Complex where the LIA outlines (1900) were confined.

Group 2 is more geographically dispersed across the region (Table 8).

Table 8 - Total area and uncertainty (km^2) for the two different groups of glaciers within each group the same glaciers are tracked across the inventories. The first column is the inventory year, 24K in column 1 representing different years, as indicated by the 24K column heading. For example for the 3rd column, 1968, the year for the 24K in column 1 is 1968 so the sequence of area in the 3rd column is 1900, 1968, 1998, and 2009, for the same 7 (n) glaciers.

	24K	1958	1968	1974	1983
Group 1	n	116	7	41	65
	1900	95.58 ± 2.35	5.74 ± 0.21	46.20 ± 1.14	51.18 ± 1.42
	24K	50.41 ± 1.99	3.01 ± 0.21	23.38 ± 0.78	27.70 ± 1.13
	1998	47.90 ± 1.47	2.61 ± 0.15	21.85 ± 0.71	25.29 ± 0.92
	2009	43.66 ± 1.44	2.30 ± 0.15	17.69 ± 0.69	20.99 ± 0.90
Group 2	n	65	14	16	43
	24K	35.25 ± 1.32	5.21 ± 0.21	4.13 ± 0.25	23.45 ± 0.96
	1990	35.13 ± 0.75	4.83 ± 0.21	3.99 ± 0.28	22.65 ± 0.72
	1998	33.68 ± 0.74	4.49 ± 0.21	3.48 ± 0.28	21.61 ± 0.72
	2009	31.04 ± 0.73	4.05 ± 0.21	2.42 ± 0.27	18.47 ± 0.70

For group 1, the relative change between 1900 and the four 24K years are similar, with a reduction of glacier are by about half of the original area (Table 9). The change between the 24K years and 1998 varies between -5% to -13%; between 1998 and 2009 ranges from -9% to -19%. The change for all periods is similar within each period given the uncertainty (Figure 12).

Table 9 – Fractional area change of total area of the same glaciers over the period 1900-2009 from group 1 and from 24K to 2009 from group 2 (Table 8). The columns represent different datasets of glaciers that correspond to the individual years in the 24K inventory. The change is relative to the first year in the specific time periods over time starting with 1900 (group 1) and the 24K years the four 24K years are 1958, 1968, 1974, and 1983 (group 2).

	Time Period		24K = 1958	24K = 1968	24K = 1974	24K = 1983
Group 1			(n=116)	(n=7)	(n=41)	(n=65)
	1900	24K	-47% ± 3%	-48% ± 5%	-49% ± 3%	-46% ± 4%
	24K	1998	-5% ± 5%	-13% ± 8%	-7% ± 5%	-9% ± 5%
	1998	2009	-9% ± 4%	-12% ± 8%	-19% ± 5%	-17% ± 5%
	24K	2009	-13% ± 5%	-24% ± 8%	-24% ± 4%	-24% ± 5%
	1900	2009	-54% ± 3%	-60% ± 4%	-62% ± 3%	-59% ± 3%
Group 2			(n=65)	(n=14)	(n=16)	(n=42)
	24K	1990	0% ± 4%	-7% ± 6%	-3% ± 9%	-3% ± 5%
	1990	1998	-4% ± 3%	-7% ± 6%	-13% ± 10%	-5% ± 5%
	1998	2009	-8% ± 3%	-10% ± 7%	-30% ± 11%	-15% ± 5%
	24K	2009	-13% ± 5%	-16% ± 6%	-39% ± 10%	-18% ± 4%

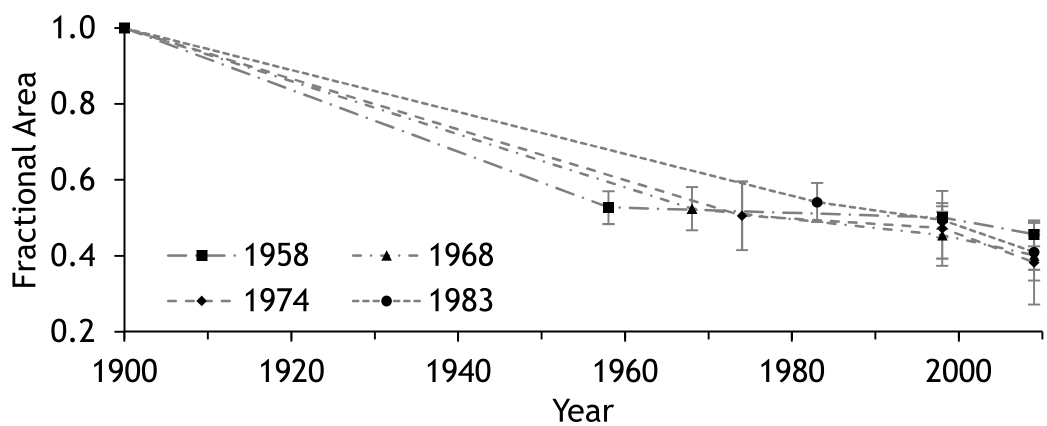


Figure 12 - Area change of the same glaciers for each temporal sequence grouped by 24K year from 1900-2009.

For group 2 no significant area change occurs between four 24K years and 1990 (Table 9); between 1990 and 1998 a small decrease occurs of about 1% given uncertainty; for 1998 and 2009 significant shrinkage occurs but variable. The first two sets (n=65, n=14) are similar and the latter two show much more change (Figure 13).

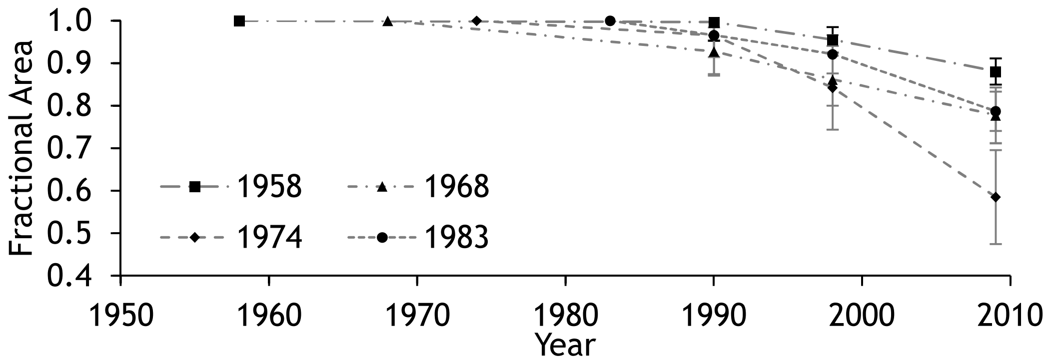


Figure 13 - Area change of identical glaciers for each temporal sequence grouped by 24K year to 2009.

For the larger and partially overlapping datasets, nine different time periods were used (Table 10) to best quantify the glacier change in the region. To test whether the sets are from the same or different populations the topographic characteristics are examined, derived from the 24K data.

Table 10 – A comparison of the topographic characteristics of each set of glaciers. The topographic data are derived from the 24K data, n is the number of glaciers, Z is the mean glacier elevation, σZ is standard deviation of elevation, A is the mean glacier area, and σA is the standard deviation of the area. Aspect is the fraction facing each direction. The italics indicate a statistical difference from the other data sets.

		Z	σZ	A	σA	Aspect (%)			
	n	(m)	(m)	(km^2)	(km^2)	N	E	S	W
All 24K	**642**	**2013**	**236**	**0.373**	**0.740**	**52**	**28**	**9**	**11**
1900-1958	100	2063	193	0.444	0.959	56	20	12	13
1958-1990	189	2053	233	0.422	0.929	59	22	6	13
1990-1998	517	2007	214	0.387	0.754	57	26	6	10
1998-2009	278	1996	223	0.365	0.665	52	27	9	12
1900-2009	128	1985	219	0.449	0.883	50	27	10	13
1958-2009	303	2038	213	0.330	0.745	51	25	11	13
1968-2009	42	2082	220	0.209	0.332	69	24	5	2
1974-2009	*122*	*1861*	*199*	*0.589*	*1.065*	*53*	*28*	*8*	*11*
1983-2009	173	2031	246	0.428	0.601	47	34	7	12

The results of a one-way ANOVA test show that the means of elevation and area are not statistically different at the 95% level between sets, except for 1974-2009. Aspect is not different between sets. Therefore, with the exception of 1974-2009 all sets are considered equivalent populations and their changes can be compared. The 1974-2009 dataset is excluded from further comparison. Total and fractional area change for the nine time periods were then sub-divided into five groups, one for the entire set, two based on glacier size (<> 0.1 km^2) and two based on statistical significance of area change (significant/insignificant). The motivation for the grouping rests on the observation that small glaciers are much more variable due relatively high interpretation uncertainty.

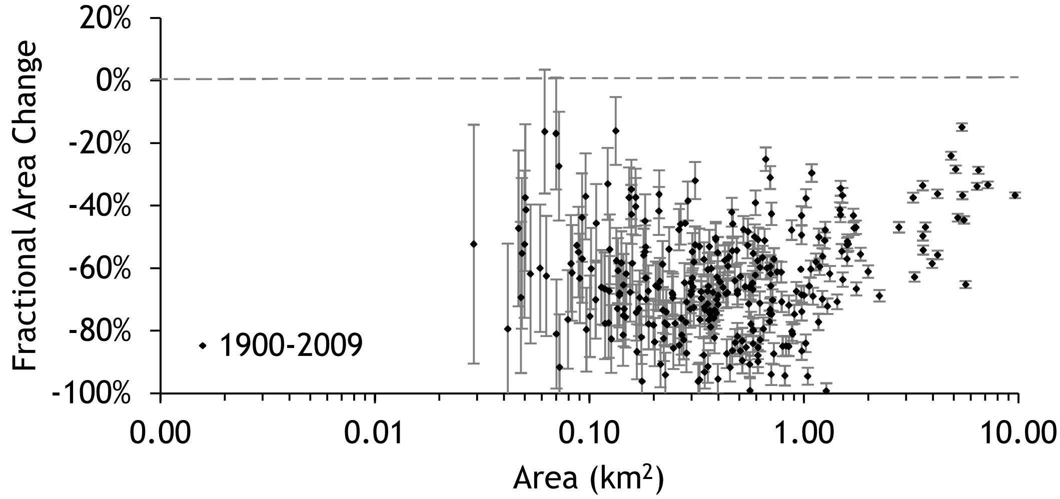
Table 11a - Area change over different time periods separated by areas greater/less than 0.1 km^2 based on their initial area and by significant and insignificant changes, n is the number of glaciers, FAC is fractional area change.

	n	Area (km^2)		Total Area Change	FAC
1900-2009		1900	2009		
All	303	246.22 ± 5.97	113.34 ± 3.67	-132.87 ± 7.01	-54% ± 3%
A > 0.1 km^2	277	244.44 ± 5.79	112.56 ± 3.41	-131.89 ± 6.72	-54% ± 3%
A < 0.1 km^2	26	1.77 ± 0.17	0.79 ± 0.27	-0.98 ± 0.32	-56% ± 18%
Sig. Δ	295	245.70 ± 5.92	112.97 ± 3.59	-132.73 ± 6.92	-54% ± 3%
Insig. Δ	8	0.51 ± 0.05	0.37 ± 0.08	-0.14 ± 0.10	-27% ± 19%
1900-1958		1900	1958		
All	128	105.99 ± 2.54	56.85 ± 2.13	-49.15 ± 3.31	-46% ± 3%
A > 0.1 km^2	118	105.31 ± 2.47	56.39 ± 2.03	-48.92 ± 3.20	-46% ± 3%
A < 0.1 km^2	10	0.68 ± 0.07	0.46 ± 0.10	-0.22 ± 0.12	-33% ± 18%
Sig. Δ	123	105.17 ± 2.49	56.39 ± 1.80	-48.78 ± 3.07	-46% ± 3%
Insig. Δ	5	0.82 ± 0.05	0.45 ± 0.33	-0.37 ± 0.33	-45% ± 40%
1958-1990		1958	1990		
All	100	42.18 ± 1.72	41.32 ± 1.23	-0.87 ± 2.11	-2% ± 5%
A > 0.1 km^2	55	39.53 ± 1.32	38.92 ± 0.76	-0.61 ± 1.53	-2% ± 4%
A < 0.1 km^2	45	2.65 ± 0.39	2.40 ± 0.47	-0.25 ± 0.61	-10% ± 23%
Sig. Δ	18	11.75 ± 0.31	11.15 ± 0.24	-0.60 ± 0.39	-5% ± 3%
Insig. Δ	82	30.43 ± 1.40	30.17 ± 0.99	-0.26 ± 1.72	-1% ± 6%
1990-1998		1990	1998		
All	189	72.56 ± 2.33	68.89 ± 2.30	-3.67 ± 3.27	-5% ± 5%
A > 0.1 km^2	122	68.67 ± 1.63	65.29 ± 1.61	-3.38 ± 2.28	-5% ± 3%
A < 0.1 km^2	67	3.89 ± 0.70	3.60 ± 0.70	-0.29 ± 0.99	-8% ± 25%
Sig. Δ	43	37.29 ± 0.63	34.48 ± 0.62	-2.81 ± 0.88	-8% ± 2%
Insig. Δ	146	35.27 ± 1.69	34.41 ± 1.69	-0.86 ± 2.39	-2% ± 7%
1998-2009		1998	2009		
All	517	171.16 ± 6.22	150.82 ± 6.11	-20.34 ± 8.72	-12% ± 5%
A > 0.1 km^2	288	158.51 ± 3.83	140.43 ± 3.73	-18.08 ± 5.35	-11% ± 3%
A < 0.1 km^2	229	12.65 ± 2.39	10.38 ± 2.37	-2.26 ± 3.37	-18% ± 27%
Sig. Δ	171	118.43 ± 2.39	101.29 ± 2.30	-17.14 ± 3.32	-14% ± 3%
Insig. Δ	346	52.73 ± 3.83	49.52 ± 3.81	-3.21 ± 5.40	-6% ± 10%

Table 11b - Area change over different time periods separated by areas greater/less than 0.1 km^2 based on their initial area and by significant and insignificant changes, n is the number of glaciers, FAC is fractional area change.

	n	Area (km^2)		Total Area Change	FAC
1958-2009		1958	2009		
All	278	91.67 ± 3.92	78.07 ± 3.25	-13.60 ± 5.09	-15% ± 6%
A > 0.1 km^2	152	84.76 ± 2.88	72.53 ± 1.94	-12.23 ± 3.47	-14% ± 4%
A < 0.1 km^2	126	6.91 ± 1.04	5.54 ± 1.30	-1.37 ± 1.67	-20% ± 24%
Sig. Δ	88	66.15 ± 1.62	54.73 ± 1.18	-11.42 ± 2.01	-17% ± 3%
Insig. Δ	190	25.52 ± 2.30	23.34 ± 2.07	-2.18 ± 3.09	-9% ± 12%
1968-2009		1968	2009		
All	42	8.77 ± 0.47	6.91 ± 0.47	-1.86 ± 0.66	-21% ± 8%
A > 0.1 km^2	20	7.75 ± 0.29	6.11 ± 0.24	-1.64 ± 0.38	-21% ± 5%
A < 0.1 km^2	22	1.02 ± 0.18	0.80 ± 0.23	-0.22 ± 0.29	-22% ± 28%
Sig. Δ	15	6.96 ± 0.24	5.38 ± 0.19	-1.58 ± 0.30	-23% ± 4%
Insig. Δ	27	1.81 ± 0.23	1.53 ± 0.28	-0.28 ± 0.36	-16% ± 20%
1983-2009		1983	2009		
All	173	71.24 ± 2.58	55.78 ± 2.09	-15.46 ± 3.32	-22% ± 5%
A > 0.1 km^2	132	68.78 ± 2.29	54.08 ± 1.66	-14.70 ± 2.83	-21% ± 4%
A < 0.1 km^2	41	2.46 ± 0.29	1.70 ± 0.42	-0.76 ± 0.51	-31% ± 21%
Sig. Δ	125	63.18 ± 2.01	48.23 ± 1.55	-14.95 ± 2.54	-24% ± 4%
Insig. Δ	48	8.06 ± 0.57	7.55 ± 0.53	-0.51 ± 0.78	-6% ± 10%

Table 11 (a,b) shows the overall change from 1900-2009 (-54% ± 3%) has the most variability in the smaller glaciers, but most glaciers (97%) significantly changed. Most of the change in glacier area occurred from 1900-1958 (-46% ± 3%) with 96% shrinking significantly, whereas from 1958-2009 (-15% ± 6%) 32% glaciers changing significantly. As suspected the uncertainty for the smaller glaciers is relatively greater than that for the larger glaciers and over shorter time periods the small change observed is often smaller than the uncertainty, these results can be seen graphically.



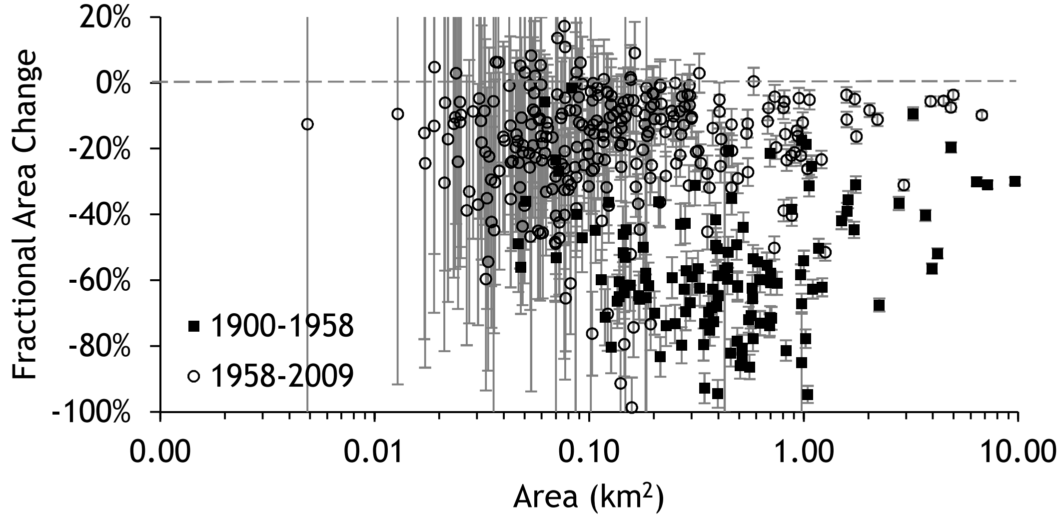


Figure 14 – Fractional area change for different temporal area change groups. The upper graph shows the overall fractional area change from 1900-2009. The lower graph breaks up the change into two nearly equal periods, 1900-1958 and 1958-2009.

For each period the glaciers with insignificant change were examined to detect any similarities among them or differences from the glaciers with significant change. There are two main characteristics associated with glaciers showing insignificant change, time between inventories and glacier size (Table 12).

Table 12 - Analysis of glaciers with insignificant change. The variables used in the comparison are number of years, percent of glaciers that have insignificant change out of the total number analyzed, average and standard deviation (σ) of fractional area change, average relative uncertainty FAC, original area of the glaciers, average and standard deviation (σ) of initial area.

Years	Number of Years	Percent of Group	Average FAC	σ_{FAC}	Average Relative Uncertainty	Average Original Area	σ_{Area}
1900-2009	109	3%	-32%	14%	0.012	0.064	0.029
1900-1958	58	4%	-29%	24%	0.067	0.165	0.138
1958-1990	32	86%	-4%	11%	0.022	0.371	0.895
1990-1998	8	78%	-5%	13%	0.016	0.242	0.402
1998-2009	11	68%	-11%	16%	0.016	0.152	0.257
1958-2009	51	68%	-13%	12%	0.017	0.134	0.184
1968-2009	41	64%	-22%	18%	0.014	0.067	0.050
1983-2009	26	27%	-13%	16%	0.017	0.168	0.245

The time interval between glacier inventories influences the fraction of glaciers with insignificant change. For example, over the entire time period from 1900-2009 only 3% of the glaciers did not experience significant change, whereas for the eight year period between 1990 and 1998, 78% did not exhibit significant change. Certainly slowly changing glaciers will not show significant change over short time periods so climate plays a role here as well. Larger glaciers, with an overall larger total uncertainty exhibit a smaller fractional uncertainty whereas small glaciers, particularly those less than 0.1 km^2 have much larger relative uncertainty (Figure 15b).

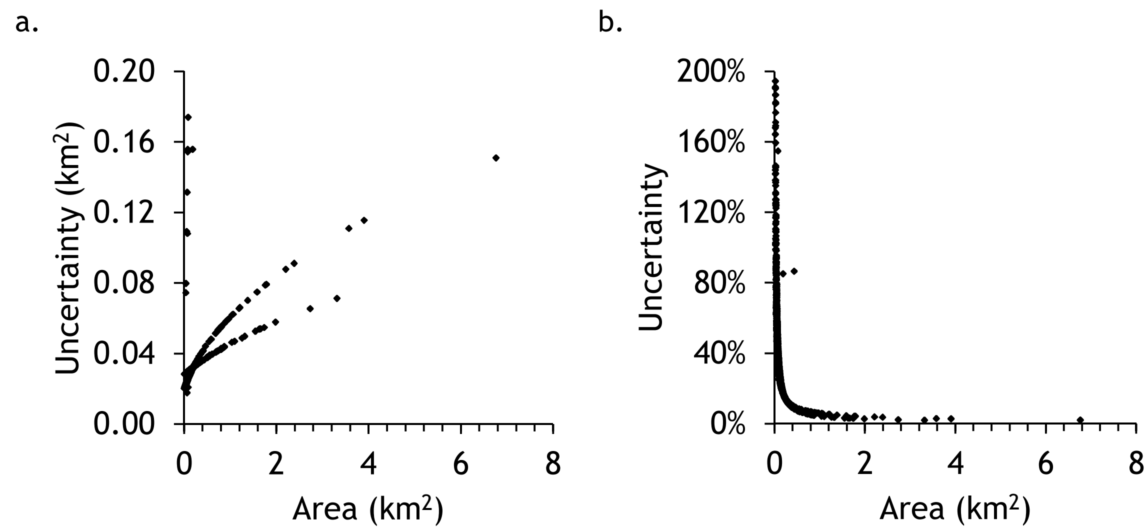


Figure 15 - Uncertainty of all area change years compared to original area of the glacier. (a) Uncertainty of area change as a fraction of initial area, (b) uncertainty of area change as a percent of initial area. The two arms in (a) represent the uncertainty associated with the 24K and aerial photography since the digitizing uncertainty is different for inventories with those data sources.

Estimating Glacier Change for the Region

To estimate total glacier area over time for the entire North Cascades, I used the total fractional change for each time intervals from Table 11. To estimate the total glacier total area at any time (6) can be rewritten as,

$$A = A_i \, (FAC + 1) \tag{6}$$

where, A is the area at the time of interest and A_i is the initial total area. Using the 24K as the initial area the remaining areas can be bootstrapped. For example, the total area for 1990 is estimated from the change since 24K year 1958, then the area in 1998 can be estimated from the change since 1990, and so on. This approach was applied to the time intervals in the following sequence, 1900←1958, 1958→1990, 1990→1998, 1998→2009 then 1968←2009 and 1983←2009. The FAC used to estimate glacier area were the 'All' column found in Table 11. The fraction of area was rescaled so that 1900 was 1.0. Uncertainty was calculated for each year using the uncertainty associated with the FAC calculation from the partially overlapping datasets and the total area from each year (10).

$$U = \frac{1}{2}\left(U_i(FAC + 1) + A_i U_f\right) \tag{7}$$

where the uncertainty from the initial area, U_i, and is the initial area, A_i, times the uncertainty of the final area, U_f. Results were tabulated in Table 13 and Figure 16.

Table 13 - Overall area change from 1900-2009 summarized using fractional area change values for individual years.

Year	Estimated Area (km^2)	Fractional Area
1900	533.89 ± 22.77	1.00 ± 0.04
1958	288.30 ± 12.50	0.54 ± 0.04
1968	298.99 ± 17.25	0.56 ± 0.06
1983	302.82 ± 17.34	0.57 ± 0.06
1990	282.53 ± 13.33	0.53 ± 0.05
1998	268.41 ± 13.40	0.50 ± 0.05
2009	236.20 ± 12.60	0.44 ± 0.05

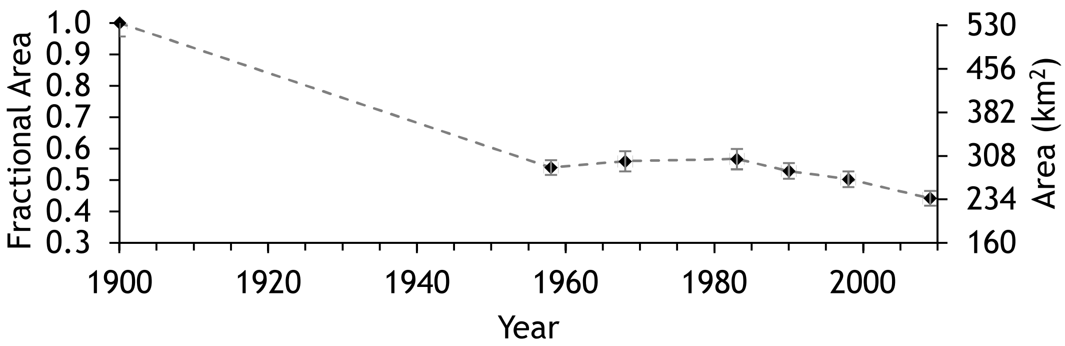


Figure 16 - Overall fractional area change from 1900-2009 from Table 11.

To compare the results for glacier change between the sets of identical glaciers to the datasets of similar glaciers both are plotted in Figure 17.

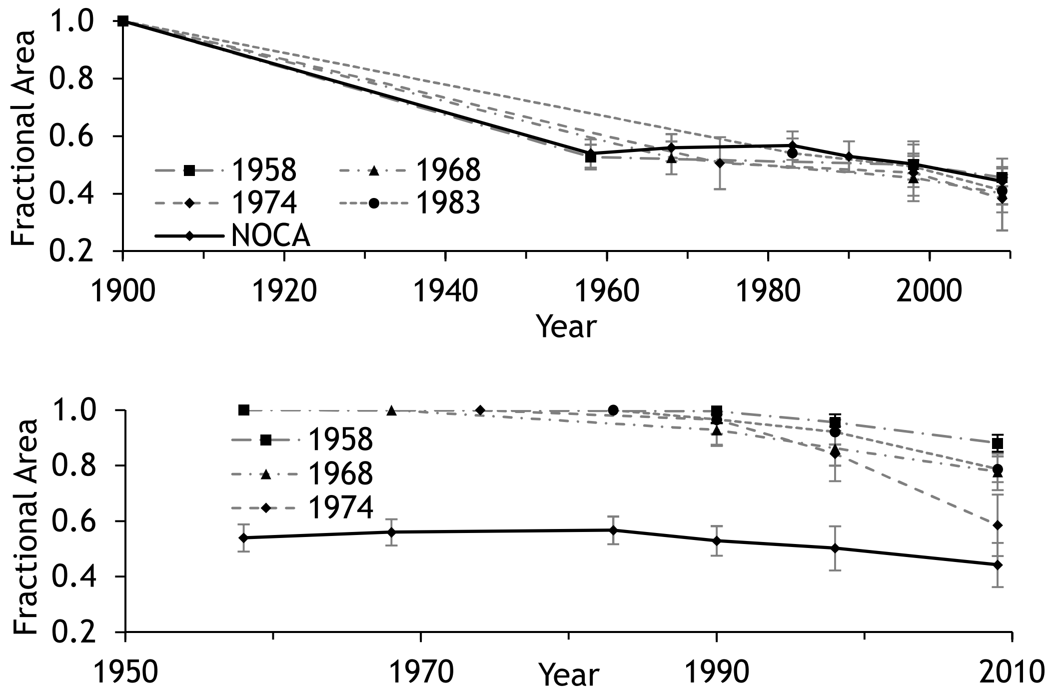


Figure 17 - Fractional area change of the North Cascades using identical glaciers (by different 24K year) compared to the partially overlapping estimate of glacier area change for the entire region (NOCA) from Figure 12. Top graph shows the comparison from 1900 using the group 1 data. The bottom graph shows the estimate relative to 1958 using group 2 data from Table 9.

For the overall trends from 1900-2009, the overlapping datasets underestimate fractional area change from 1998-2009, -6% compared to the identical glaciers (-9% to –19%) but still within uncertainty estimates. They also show less variability in the time period between 1958 and 1990 but is well within the uncertainty boundaries of the overall estimate. For group 2 of the same glaciers (24K year through 2009) the overlapping dataset is within uncertainty calculations.

While the glacier inventories of the North Cascades provides an estimate for glacier change across the region, the temporal density is lacking. To provide more detail over time, glacier data from Mount Baker and South Cascade Glacier (Krimmel, 1989, Bidlake and others, 2012) were used. I updated the record of glacier area on Baker by including the 2009 outline from the NAIP imagery (Table 14a, b, Table 15) and on South Cascade Glacier by digitizing the LIA outline as seen from the moraines visible on the 2009 imagery (http://ak.water.usgs.gov/glaciology/south_cascade/images/SCG_LIA_Topo.jpg) (Table 16).

Table 14 (a) - Mount Baker temporal glacier area change data. Source, S, is as follows: 1 =(Fountain and others, 2007a); 2 = (O'Neal, 2005); 3 = (Harper, 1993); 4 = this thesis.

	Boulder		Coleman		Deming		
Year	Area (km^2)	Fractional Area	Area (km^2)	Fractional Area	Area (km^2)	Fractional Area	S
1900	5.48 ± 0.15	0.15 ± 1.00	5.45 ± 0.15	0.15 ± 1.00	6.51 ± 0.16	1.00 ± 0.02	1
1931	3.95 ± 0.13	0.13 ± 0.72			4.89 ± 0.75	0.75 ± 0.03	2
1940	3.61 ± 0.12	0.12 ± 0.66	4.80 ± 0.14	0.14 ± 0.88	4.94 ± 0.76	0.76 ± 0.03	3
1947	3.40 ± 0.12	0.12 ± 0.62	4.64 ± 0.14	0.14 ± 0.85	4.75 ± 0.73	0.73 ± 0.03	3
1956	3.46 ± 0.12	0.12 ± 0.63			5.00 ± 0.77	0.77 ± 0.03	3
1963	3.58 ± 0.12	0.12 ± 0.65	4.89 ± 0.14	0.14 ± 0.90	5.06 ± 0.78	0.78 ± 0.03	3
1964							3
1965			4.91 ± 0.14	0.14 ± 0.90	5.04 ± 0.77	0.77 ± 0.03	3
1967	3.63 ± 0.12	0.12 ± 0.66	4.94 ± 0.14	0.14 ± 0.91	5.05 ± 0.78	0.78 ± 0.03	3
1970	3.64 ± 0.12	0.12 ± 0.66	4.97 ± 0.14	0.14 ± 0.91	5.05 ± 0.78	0.78 ± 0.03	3
1972			4.97 ± 0.14	0.14 ± 0.91			3
1974	3.75 ± 0.12	0.12 ± 0.68	4.98 ± 0.14	0.14 ± 0.91	5.13 ± 0.79	0.79 ± 0.03	3
1977	3.78 ± 0.12	0.12 ± 0.69	5.04 ± 0.14	0.14 ± 0.93	5.23 ± 0.80	0.80 ± 0.03	3
1979	4.06 ± 0.13	0.13 ± 0.74	5.11 ± 0.14	0.14 ± 0.94	5.24 ± 0.80	0.80 ± 0.03	3
1985			5.01 ± 0.14	0.14 ± 0.92	5.09 ± 0.78	0.78 ± 0.00	3
1986	4.06 ± 0.13	0.13 ± 0.74					3
1987			5.01 ± 0.14	0.14 ± 0.92	5.09 ± 0.78	0.78 ± 0.03	3
1990			4.96 ± 0.14	0.14 ± 0.91	5.06 ± 0.78	0.78 ± 0.03	3
1993	3.64 ± 0.12	0.12 ± 0.66	4.89 ± 0.14	0.14 ± 0.90			1
1994							1
2005	3.56 ± 0.12	0.12 ± 0.00					1
2006	3.52 ± 0.12	0.12 ± 0.64	4.83 ± 0.14	0.14 ± 0.89	4.93 ± 0.76	0.76 ± 0.03	1
2009	3.47 ± 0.12	0.12 ± 0.63	4.62 ± 0.14	0.14 ± 0.85	4.76 ± 0.73	0.73 ± 0.03	4

Table 14 (b) - Mount Baker temporal glacier area change data. Source, S, is as follows: 1 =(Fountain and others, 2007a); 2 = (O'Neal, 2005); 3 = (Harper, 1993); 4 = this thesis.

	Easton		Rainbow		Roosevelt		
Year	Area (km^2)	Fractional Area	Area (km^2)	Fractional Area	Area (km^2)	Fractional Area	S
1900	4.19 ± 0.13	1.00 ± 0.03	3.02 ± 0.11	1.00 ± 0.04	5.10 ± 0.14	1.00 ± 0.03	1
1931	3.21 ± 0.11	0.77 ± 0.04	2.62 ± 0.10	0.87 ± 0.04			2
1940	2.75 ± 0.11	0.66 ± 0.04	1.67 ± 0.08	0.55 ± 0.05	3.86 ± 0.12	0.76 ± 0.03	3
1947	2.65 ± 0.10	0.63 ± 0.04	1.70 ± 0.08	0.56 ± 0.05	3.74 ± 0.12	0.73 ± 0.03	3
1956	2.59 ± 0.10	0.62 ± 0.04					3
1963			1.75 ± 0.08	0.58 ± 0.05	3.96 ± 0.13	0.78 ± 0.03	3
1964	2.68 ± 0.10	0.64 ± 0.04					3
1965					3.91 ± 0.13	0.77 ± 0.03	3
1967	2.72 ± 0.11	0.65 ± 0.04	1.78 ± 0.08	0.59 ± 0.05	3.93 ± 0.13	0.77 ± 0.03	3
1970	2.76 ± 0.11	0.66 ± 0.04	1.78 ± 0.08	0.59 ± 0.05	3.95 ± 0.13	0.78 ± 0.03	3
1972					3.99 ± 0.13	0.78 ± 0.03	3
1974	2.80 ± 0.11	0.67 ± 0.04	1.83 ± 0.09	0.61 ± 0.05	4.05 ± 0.13	0.79 ± 0.03	3
1977	2.83 ± 0.11	0.68 ± 0.04	1.83 ± 0.09	0.61 ± 0.05	4.13 ± 0.13	0.81 ± 0.03	3
1979	2.88 ± 0.11	0.69 ± 0.04	1.94 ± 0.09	0.64 ± 0.05	4.14 ± 0.13	0.81 ± 0.03	3
1985	2.85 ± 0.11	0.68 ± 0.04			4.02 ± 0.13	0.79 ± 0.03	3
1986	2.85 ± 0.11	0.68 ± 0.04	1.83 ± 0.09	0.61 ± 0.05			3
1987	2.85 ± 0.11	0.68 ± 0.04	1.82 ± 0.09	0.60 ± 0.05	4.03 ± 0.13	0.79 ± 0.03	3
1990	2.85 ± 0.11	0.68 ± 0.04	1.81 ± 0.09	0.60 ± 0.05	3.95 ± 0.13	0.77 ± 0.03	3
1993			1.80 ± 0.09	0.60 ± 0.05	3.92 ± 0.13	0.77 ± 0.03	1
1994	2.82 ± 0.11	0.67 ± 0.04					1
2005			1.73 ± 0.08				1
2006	2.74 ± 0.11	0.65 ± 0.04	1.70 ± 0.08	0.56 ± 0.05	3.90 ± 0.13	0.77 ± 0.03	1
2009	2.68 ± 0.10	0.64 ± 0.04	1.68 ± 0.08	0.56 ± 0.05	3.65 ± 0.12	0.72 ± 0.03	4

Table 15 - Total and fractional area of all glaciers on Mount Baker. If there were missing values from Table 14 (a,b) for any given year, the values were interpolated per glacier/per year.

Year	Area (km^2)	Fractional Area	Year	Area (km^2)	Fractional Area
1900	29.76 ± 2.254	1.00 ± 0.08	1977	22.85 ± 0.736	0.77 ± 0.03
1931	23.75 ± 0.779	0.80 ± 0.03	1979	23.37 ± 0.740	0.79 ± 0.03
1940	21.63 ± 0.718	0.73 ± 0.03	1985	22.87 ± 0.739	0.77 ± 0.03
1947	20.88 ± 0.703	0.70 ± 0.03	1986	22.87 ± 0.735	0.77 ± 0.03
1956	21.52 ± 0.711	0.72 ± 0.03	1987	22.80 ± 0.737	0.77 ± 0.03
1963	21.91 ± 0.720	0.74 ± 0.03	1990	22.46 ± 0.734	0.75 ± 0.03
1964	21.92 ± 0.720	0.74 ± 0.03	1993	22.12 ± 0.400	0.74 ± 0.02
1965	21.93 ± 0.718	0.74 ± 0.03	1994	22.08 ± 0.338	0.74 ± 0.02
1967	22.05 ± 0.722	0.74 ± 0.03	2005	21.71 ± 0.242	0.73 ± 0.01
1970	22.15 ± 0.724	0.74 ± 0.03	2006	21.63 ± 0.077	0.73 ± 0.00
1972	22.33 ± 0.726	0.75 ± 0.03	2009	20.86 ± 0.076	0.70 ± 0.00
1974	22.54 ± 0.733	0.76 ± 0.03			

Table 16 - South Cascade Glacier area change from 1900-2009. Source number is as follows: 1=2009 NAIP imagery and interpretation; 2= Unpublished data (Krimmel); 3= (Elsberg and others, 2001); 4= (Krimmel 1989, 1993, 1994, 1995, 1997, 1996, 1998, 1999, 2000, 2001a, 2002b, Elsberg and others, 2001, Bidlake and others 2004, 2005, 2007, 2010, 2012), 5=2009 NAIP imagery and 7 = oblique aerial photograph (USGS).

Year	Area (km^2)	Fractional Area	S	Year	Area (km^2)	Fractional Area	S
1900	3.23 ± 0.065	1.00 ± 0.0201	1	1986	2.18 ± 0.001	0.68 ± 0.0005	3
1928	2.85 ± 0.057	0.88 ± 0.0201	7	1987	2.17 ± 0.001	0.67 ± 0.0005	3
1958	2.51 ± 0.001	0.78 ± 0.0004	2	1988	2.15 ± 0.001	0.67 ± 0.0005	3
1961	2.43 ± 0.001	0.75 ± 0.0004	2	1989	2.13 ± 0.001	0.66 ± 0.0005	3
1964	2.40 ± 0.001	0.74 ± 0.0004	2	1990	2.12 ± 0.001	0.66 ± 0.0005	3
1967	2.35 ± 0.001	0.73 ± 0.0004	2	1991	2.10 ± 0.001	0.65 ± 0.0005	3
1968	2.34 ± 0.001	0.72 ± 0.0004	2	1992	2.09 ± 0.001	0.65 ± 0.0005	4
1969	2.33 ± 0.001	0.72 ± 0.0004	2	1993	2.08 ± 0.001	0.64 ± 0.0005	4
1970	2.32 ± 0.001	0.72 ± 0.0004	3	1994	2.05 ± 0.001	0.64 ± 0.0005	4
1971	2.32 ± 0.001	0.72 ± 0.0004	3	1995	2.03 ± 0.001	0.63 ± 0.0005	4
1972	2.32 ± 0.001	0.72 ± 0.0004	3	1996	2.02 ± 0.001	0.62 ± 0.0005	4
1973	2.32 ± 0.001	0.72 ± 0.0004	3	1997	2.00 ± 0.001	0.62 ± 0.0005	4
1974	2.31 ± 0.001	0.72 ± 0.0004	3	1998	1.97 ± 0.001	0.61 ± 0.0005	4
1975	2.30 ± 0.001	0.71 ± 0.0004	3	1999	1.96 ± 0.001	0.61 ± 0.0005	4
1976	2.30 ± 0.001	0.71 ± 0.0004	3	2000	1.95 ± 0.001	0.61 ± 0.0005	4
1977	2.30 ± 0.001	0.71 ± 0.0004	3	2001	1.92 ± 0.001	0.60 ± 0.0005	4
1978	2.28 ± 0.001	0.71 ± 0.0004	3	2002	1.92 ± 0.001	0.60 ± 0.0005	4
1979	2.27 ± 0.001	0.70 ± 0.0004	3	2003	1.89 ± 0.001	0.59 ± 0.0005	4
1980	2.26 ± 0.001	0.70 ± 0.0004	3	2004	1.82 ± 0.001	0.56 ± 0.0005	4
1981	2.25 ± 0.001	0.70 ± 0.0004	3	2005	1.75 ± 0.001	0.54 ± 0.0006	4
1982	2.24 ± 0.001	0.69 ± 0.0004	3	2006	1.74 ± 0.001	0.54 ± 0.0006	4
1983	2.22 ± 0.001	0.69 ± 0.0005	3	2007	1.73 ± 0.001	0.54 ± 0.0006	4
1984	2.20 ± 0.001	0.68 ± 0.0005	3	2009	1.72 ± 0.010	0.53 ± 0.0058	6
1985	2.19 ± 0.001	0.68 ± 0.0005	3				

Over the past century, the glaciers on Mount Baker have gone through one advance/retreat cycle (Figure 18). Between 1900 and 2009 the six glaciers on Mount Baker fluctuated in the following three phases 1) Rapid retreat from 1900 through the 1950s; 2) Approximately 30 years of advance ending around 1980; 3) Retreat through 2009. The individual glaciers are highly correlated with each other but the magnitude of change particularly from 1900 to about 1950 differ greatly. In contrast, South Cascade Glacier has more or less retreated throughout the entire period, except for a brief period of stability and perhaps slight advance in the early 1970s (Figure 18).

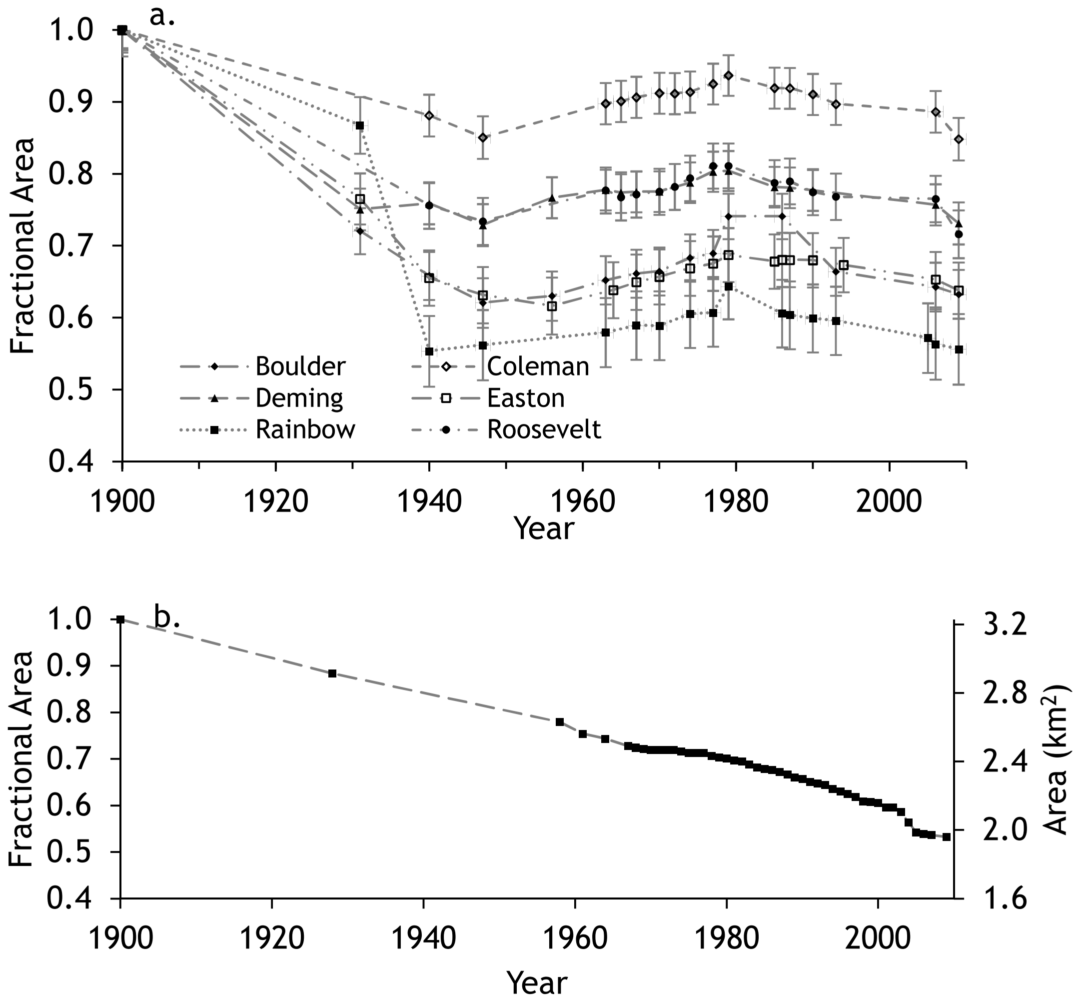
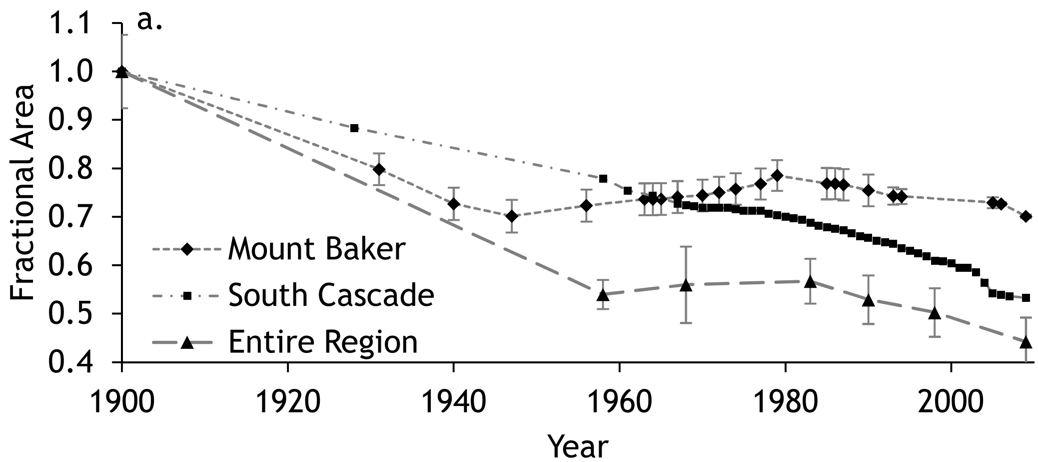


Figure 18 – Area change for glaciers on Mount Baker (a) and South Cascade Glacier (b).



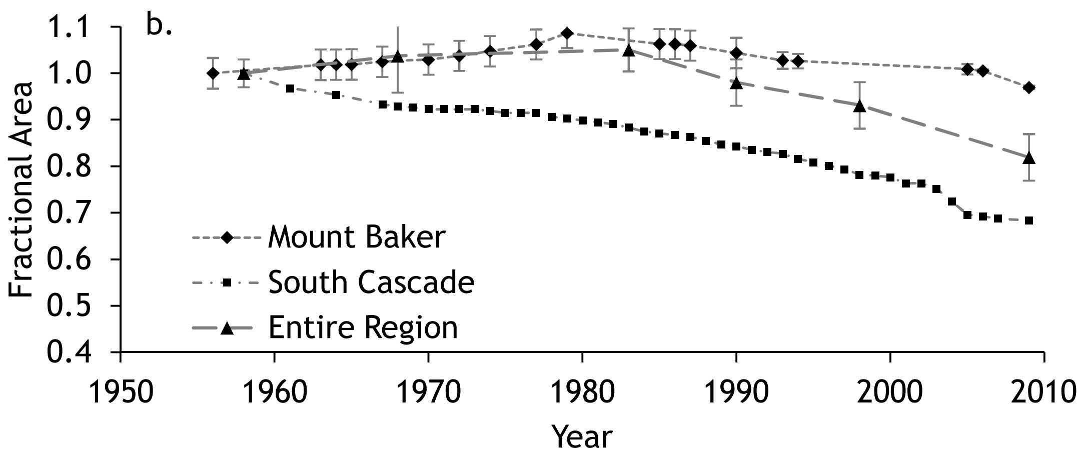


Figure 19 – Fractional area over the past century (a) for the total of all glaciers on Mount Baker, South Cascade and the total estimate of the North Cascades including Mount Baker. (b) is similar to (a) but only for the last 60 years, with the same vertical scale.

The glaciers from the entire region using three different temporal datasets show that the entire region is responding in similar ways, but with different magnitudes. Overall, the entire North Cascades and Mount Baker show similar trends over the past century following that described earlier for Mount Baker (Figure 19). South Cascade Glacier generally follows the other glaciers but it retreated less from 1900-1958 and retreated more from 1958 to 2009. During the 1960s-1970s the glacier slowed retreat but never stabilized or advanced. Since the 1970s its retreat was much faster than the other glaciers.

Three monitoring programs have been measuring mass balance at 15 glaciers in the North Cascades. The longest running mass balance program is at South Cascade Glacier from 1958 – present. The monitored glaciers are distributed spatially throughout the region and have different areas (Figure 20).

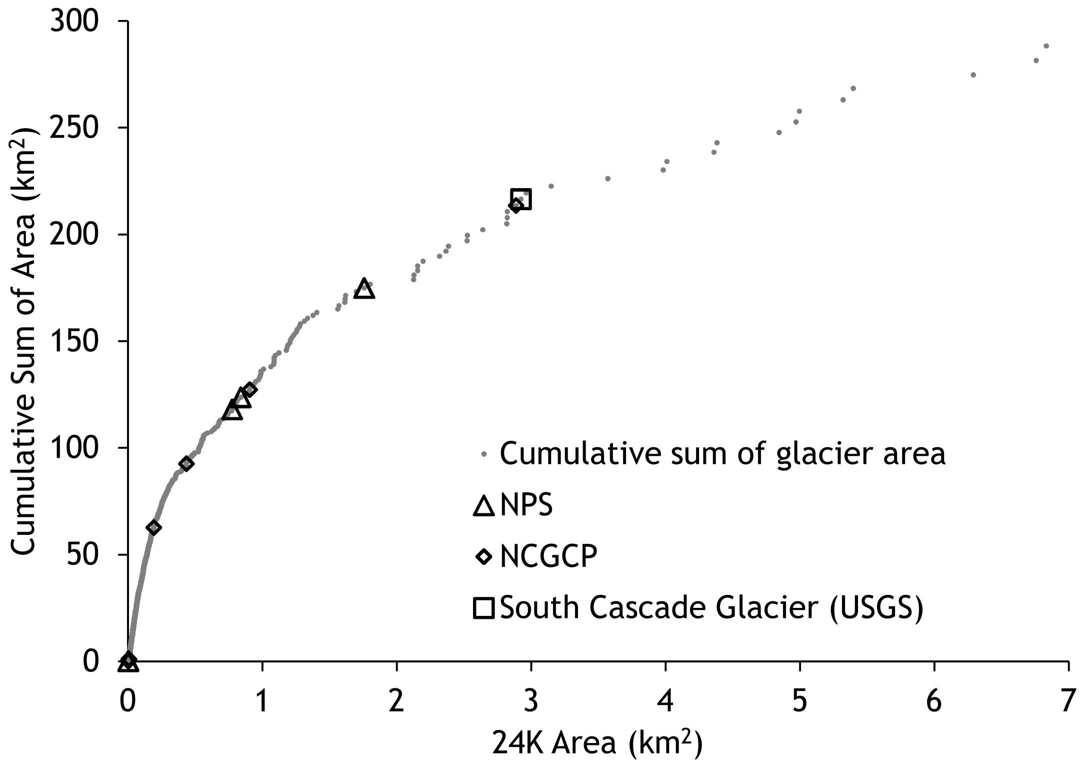


Figure 20 - Cumulative area sum for the North Cascades 24K (Chapter 2) with monitored glaciers indicated by points.

Mass balance on South Cascade Glacier has an overall negative mass balance trend since 1958 consistent with area change (Figure 21). There was a brief period of positive mass balance in the 1970s, but since 1977 the mass balance has been very negative (Bidlake and others, 2012). A mass balance study in the North Cascades from 1984-2006 shows that the cumulative mass balance was negative through most of the 1980s, followed by a period of stability/growth during the mid-1990s and since the late 1990s, the cumulative mass balance has been very negative (Pelto, 2008) (Figure 22). Other monitored glaciers in the North Cascades National Park also show a similar trend of stability in the 1990s followed by decline in the late 1990s to 2009 (Riedel & Larrabee, 2011) (Figure 23). The comparison between the area change and the mass balance shows that there is an overall negative mass loss of glacial ice that can be seen both in the direct glacier measurements and in large negative area change in the glacier inventories. The mass balance trends in the NPS and NCGCP monitored glaciers are less when compared to South Cascade Glacier and are more reflective of regional glacier change, and South Cascade Glacier is an outlier.

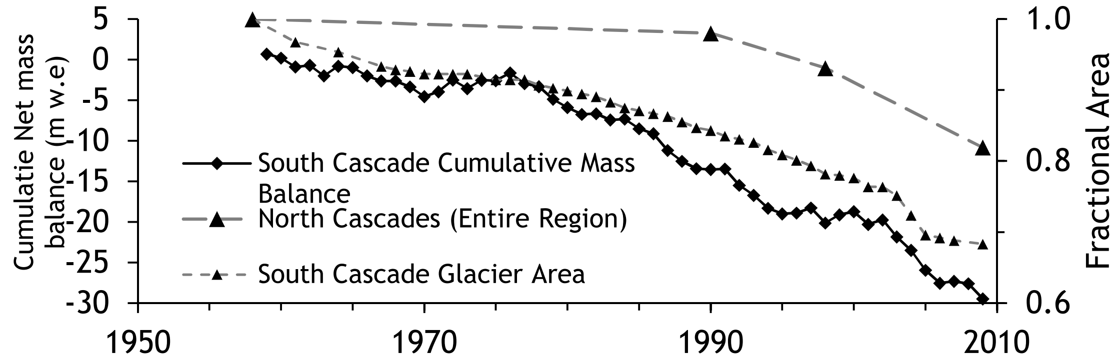


Figure 21 -Cumulative nest mass balance at South Cascade Glacier from 1958 – 2009. Fractional area of South Cascade Glacier and the entire North Cascades (from 1958) are also included for comparison.

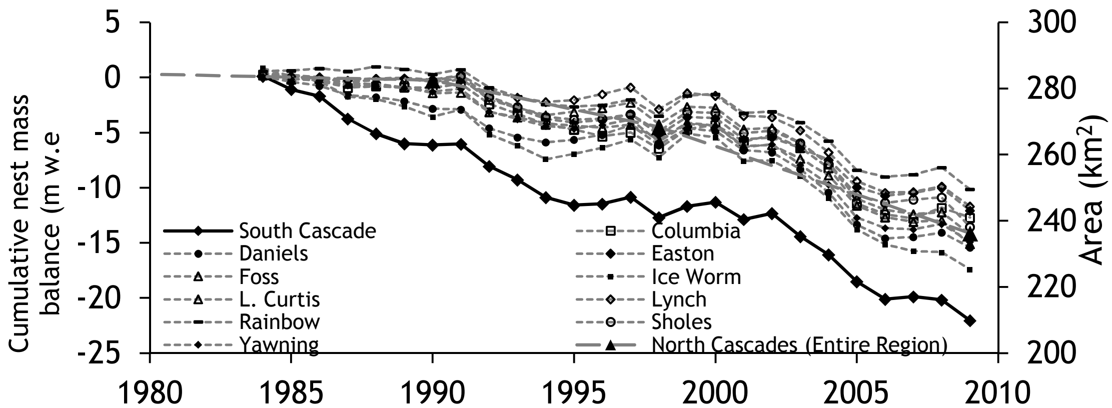


Figure 22 - Cumulative net mass balance of the North Cascades Glacier Climate Project monitored glaciers since 1984. The total glacier coverage in the North Cascades is included for comparison.

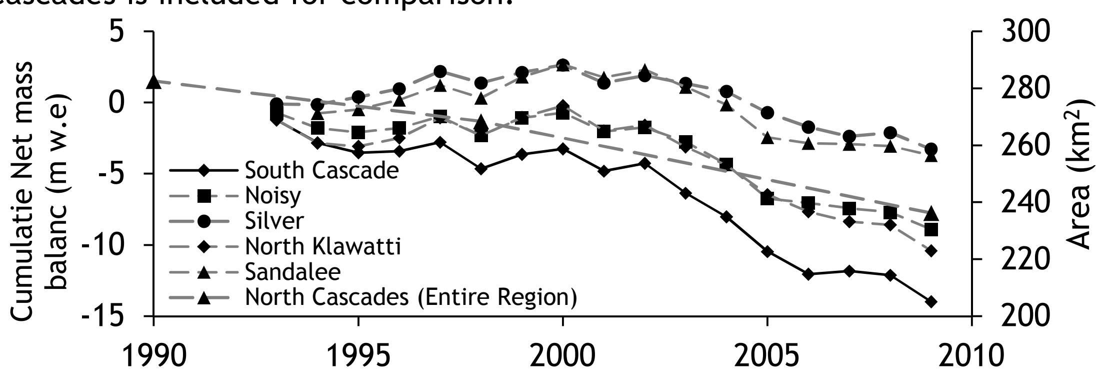


Figure 23 - Cumulative net mass balance of the North Cascades National Park monitored glaciers since 1993. The total glacier coverage in the North Cascades is included for comparison.

Discussion & Conclusions

In the North Cascades glacier area lost more than half (-56% ± 3%) since the LIA (~1900) to 2009. All estimates of fractional glacier area loss in percent are relative to 1900, except when otherwise stated. Most of that loss occurred in the first half of the century (1900-1958) when almost half of the area was lost (-46% ± 3%). In the latter half century 1958-2009 an additional 10% was lost. These results are consistent with Granshaw and Fountain (2006) who found glacier area loss of 7% (1958-1998) within the North Cascades Park Complex. The period from 1958 to 1990 was relatively stable with area change less than overall uncertainty. Generally, smaller glaciers lost more fractional area than larger and smaller glaciers also exhibit more variability in change. Most of the variability could be explained by the area change values being within overall area change uncertainty.

The differences in area change between South Cascade, Mount Baker and the entire region from 1900 to 1958 shows that Mount Baker lost about 30% while the region as a whole lost more than half and South Cascade glacier only lost about 20% (Figure 19). Between 1958 and 1980s, the glaciers on Mount Baker and the entire region were stable, while South Cascade has only a brief period of stability in the early 1970s. Since that time the glacier has been rapidly retreating.

The long term mass balance monitoring programs in the North Cascades (South Cascade, NPS, and NCGCP) all show similar trends of negative mass balance, with the exception of South Cascade which is more negative than the other monitored glaciers. These generally negative mass balances are consistent with the negative area change values.

My results in the North Cascades (-56%, 1900-2009) are consistent with other studies of glacier area change over the past century across the western United States. On Mount Rainier on the southern end of the North Cascades, the glaciers changed by -22% between 1913 and 1994 (Nylen, 2004); and a little further south (70 km) Mount Adams changed by 49% from 1904 to 2006 (Sitts and others, 2010); in Oregon, glaciers on Mount Hood have changed by -34% since 1907-2004 (Jackson & Fountain, 2007). The Sierra Nevada shows that glacier area has a 55% area loss between 1903 and 2004 (Basagic & Fountain, 2011), the Front Range of Colorado, in Rocky Mountain National Park - 40% change 1909-2004 (Hoffman and others, 2007). The decadal changes are similar as well.

These more detailed studies from the western United States have a similar trend to the studies from around the world, however the magnitude of the trends is different. From 1919 to 2006, glaciers in the Canadian Rocky Mountains decreased by 40% ± 5% (Tennant and others, 2012). In Switzerland, glacier area change was slightly negative (-2%) from 1850-1973. In the Canadian Cordillera from 1951-2001, the glaciers shrunk by -15% (North Cascades -18% from 1958-2009), while the glaciers in the Columbia Mountains and Coast Mountains decreased by 5% during 1951-2001 and 1964-2001, respectively

(DeBeer & Sharp, 2007). In Switzerland from 1973-1998 there was -6% glacier change and overlapping that period from 1985-1998, -14% glacier area change (Paul, 2004). The magnitude of recent glacier area change is similar to the North Cascades. On a global scale, a mass balance synthesis, 1961-2004, shows that until 1970 glacier mass balance was about zero, but since then the balance has been negative (Kaser and others, 2006). Like my results small glaciers exhibit a wider range of area change values, than larger glaciers. Also, in Switzerland, smaller glaciers showed more variability in area change than the larger glaciers.

In conclusion, glacier area in the North Cascades has decreased by more than half (-56% ± 3%) from 1900-2009. Most of the area loss occurred in the first half of the century from 1900 to 1958 with 46% of glacier area loss. The period from 1958 to 1990 the glacier area was stable (only 1% glacier shrinkage), and since 1990 the glaciers have lost an additional 9% of glacier area. Smaller glaciers have more variability in fractional area change and most of the change is within uncertainty estimates. The overall regional trends are similar to the long term temporal data from Mount Baker and South Cascade Glacier.

Chapter 4 – Climate and Topographic Analysis

Introduction

The purpose of this chapter is to examine the response of glaciers over the past century to climate variations (precipitation and air temperature) and to local topography. Comparison with seasonal air temperature and precipitation trends may indicate which season affects glacier area change more than others. For example, in the Sierra Nevada and Rocky Mountains, glacier area retreat was significantly correlated with warmer spring and summer temperatures (Basagic & Fountain, 2011, Hoffman and others, 2007). Local topography plays an important role in glacier change by enhancing or diminishing the effects of climate (Graf, 1976). Previous studies in the North Cascades found no significant correlation between area change and topographic variables including aspect, slope and elevation (Granshaw & Fountain, 2006). However, in the Sierra Nevada, less area shrinkage was correlated with greater headwall height as glaciers retreating into areas with less annual solar insolation (Basagic & Fountain, 2011). In British Columbia, glaciers with little to no change were found at higher elevations, with steeper slopes, and less solar radiation while shrinking glaciers were found at lower elevations, with lower slopes, and higher solar radiation (DeBeer & Sharp, 2009).

A large-scale climate variation such as the PDO influences temperature and precipitation patterns in the North Cascades. PDO (Pacific Decadal Oscillation), is an index of the North Pacific sea surface temperature (SST) variability, pole ward of 30N, (Mantua and others, 1997) (http://jisao.washington.edu/pdo/) (Figure 24). A warm phase PDO causes to below-average snowpack and streamflow in the West, and a cool phase PDO causes an above average effect on snowpack and streamflow (Munn, 2002, Bitz & Battisti, 1999, Mote, 2005). McCabe and Dettinger (2002) showed that PDO explains year to year variation in snowpack better than ENSO.

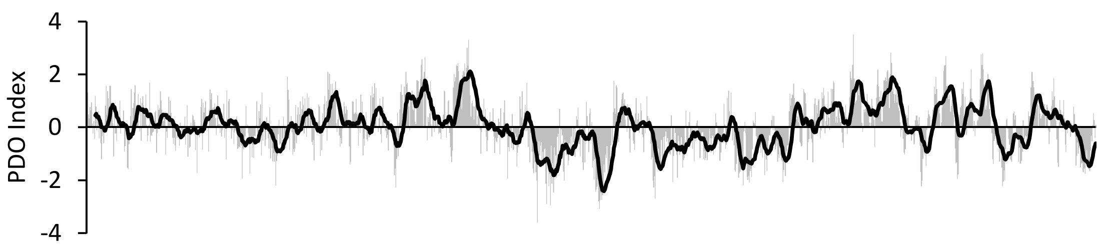


Figure 24 – Monthly PDO index values from 1900-2009 with a one year moving average (dark line).

Methods

The fractional area change data is from Chapter 3 - Table 11 and air temperature and precipitation data were acquired from the Parameter-elevation Regression on Independent Slopes Model (PRISM) (http://www.prism.oregonstate.edu). The data uses climate stations to calculate a continuous, gridded dataset which consists of monthly maximum and minimum air temperatures and precipitation (Di Luzio and others, 2008). PRISM data are available from 1900 to 2006 at a 2 km grid and 2007-2009 at a 4 km grid. The centroid of each glacier was used to extract PRISM data values for each individual glacier. Because of the large grid size compared to the often smaller glaciers, identical climates are identified since many glaciers intersect the same grid cell.

Seasonal climates were calculated from the mean-monthly climate data. How to divide the year into seasons (natural, cultural) is open to question. Harper (1993) in his study on Mount Baker and Granshaw (2002) divided the year into two seasons, accumulation (Oct – April), and ablation (May – Sept) in an attempt to match the glacial cycle of mass gain/loss. Basagic and Fountain (2011) and Hoffman and others (2007) used a four season approach, a core winter and summer with two transition seasons of spring and autumn. These latter two studies found spring warming to be highly correlated with glacier shrinkage. To provide a similarly nuanced perspective on the seasonal effects of climate variation, I too divide the year into four seasons.

For a regional climate trend analysis, I used the Mann-Kendall non-parametric test to determine if a trend (increasing or decreasing) exist. The Mann-Kendall detects trends over time and has been used in both streamflow and climate data analysis (Chang and others, 2012, Pellicciotti and others, 2010, Yue and others, 2002) and is useful in detecting monotonic trends over time. The null hypothesis is that there is no trend for a given time series. Significant trends are reported at the 95% confidence level. In addition to the Mann-Kendall test, a regression analysis was included to determine the rate and significance of a linear trend at the 95% confidence level. Based on the intervals between glacier inventories (Chapter 3), the intervals for regional climate analysis are 1900-2009, 1900-1958, 1958-2009, 1958-1990 and 1990-2009.

For the topographic analysis, I examined the slope, elevation, aspect and insolation for each glacier and derived the mean value for each factor in ArcGIS using zonal statistics. Aspect was recalculated as northness and eastness to avoid the issue of a circular compass. Northness was calculated by taking the cosine of mean aspect, with the result being a value between 1 and -1 with “1” being true north and “-1” being true south. Eastness was calculated by taking the sine of mean aspect, with the result being “1” as true east. The mean annual insolation value for each glacier outline was derived from the solar radiation grid which represents the direct incoming solar radiation per grid cell in units of watts/m^2. The topographic analysis was divided into three separate groups, all glaciers, area greater than 0.1 km^2 and area less than 0.1 km^2 because the smaller glaciers have a lot of variability in fractional area change that could influence any trends.

A Pearson product-moment correlation and a non-parametric Spearman rank correlation were calculated to determine the correlation between the topographic and climate variables and fractional area change for individual glaciers. The two different correlation coefficients were used because of their different properties. The Pearson test assumes a normal distribution and equal variances, and it is sensitive to outliers because the correlation is based on how close the correlation follows a linear distribution. The Spearman test has relatively few assumptions and is not as sensitive to outliers in the data because the test statistic is derived by creating a ranked pair of values. It is also used for small sample sizes and non-normal data. The significance is reported at the 95% confidence level.

Since it is likely that multiple climate and topographic variables are correlated with fractional area change, a multiple regression analysis is calculated. The slope of the maximum air temperature for each glacier for each time period was used instead of average temperature in the multiple regression analysis to account for the rate of temperature change over time. The multiple regression analysis will be done on three different groups of area change data, 1900-2009, 1900-1958 and 1958-2009 to capture the temporal range of area change for the entire region.

Results

Regional climate

The extracted PRISM minimum temperature data showed some odd temperature anomalies that are most likely artifacts from different climate stations being used over certain time periods. A comparison with mean maximum and minimum temperature from the Snoquamie Falls climate station at 143 m elevation (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wasnoq) showed that variations in the minimum temperature data from PRISM was not reflected in the Snoqualmie data suggesting an errors in the PRISM minimum temperature data. The maximum temperature data do not show the same anomalies and reflect similar variations in the Snoqualmie data therefore it will be used for the trend and correlation analysis. Although Tmin values is recognized to have some errors over the period of record, I justify the use in Table 17 that the errors are small compared to the long term average used to classify the seasons. The Tmin data will not be used in the analysis and air temperature changes will be based on Tmax.

The divisions between seasons are based on mean monthly air temperatures and precipitation averaged over the entire period of the PRISM record, 1900-2009 (Table 17). Core summer is defined as both minimum and maximum air temperature above 0°C, average degree days above 400, and precipitation less than 100 mm (June – Sept). These criteria infer warm sunny days. Core winter is defined as mean temperatures below 0°C, degree days less than -75, and precipitation greater than 250 mm (Dec- March). These criteria infer cold, snowy days. The exception to this rule is March where maximum temperatures are slightly above freezing. The remaining months are transitional, spring (April – May) and autumn (October-November).

Table 17 - Mean monthly values of minimum and maximum air temperature (Tmin, Tmax), ˚C, Precipitation (Precip), mm, over the time period 1900-2009 derived from PRISM data. The numbers of degree days (DD) are calculated based on a 30-day month and assignment into seasonal category.

Month	Mean Tmin	Mean Tmax	Mean of Tmin and Tmax	Precip	Degree Days	Season
October	0.7	7.9	4.3	240.3	259.2	Autumn
November	-4.1	1.0	-1.6	368.2	-94.0	Autumn
December	-6.2	-2.2	-4.2	393.8	-253.3	Winter
January	-6.8	-2.4	-4.6	370.0	-275.7	Winter
February	-7.0	-0.3	-3.6	274.8	-217.5	Winter
March	-5.6	2.8	-1.4	234.1	-83.1	Winter
April	-2.7	7.3	2.3	147.6	138.1	Spring
May	0.7	11.4	6.1	108.7	363.5	Spring
June	2.5	14.0	8.3	86.9	495.8	Summer
July	5.3	18.5	11.9	51.7	713.8	Summer
August	6.6	18.9	12.7	56.0	764.6	Summer
September	4.4	15.1	9.8	116.5	587.6	Summer

Air temperatures significantly warmed from 1900 to 2009 (Table 18 and Figure 25) with seasonal air temperature warming in winter and summer, the first half of the century (1900-1958) has significantly warming in annual and summer air temperatures. In the later half (1958-2009) temperature warmed in all seasons except autumn. From 1958-1990 spring air temperature warmed significantly. From 1990-2009, temperatures have not significantly increased. The regression results were similar for both the annual values seasonal values.

Table 18 - Mann-Kendall (MK) and regression (r^2) results for seasonal and annual temperature and precipitation trends for the time periods listed in the left hand column. Bold numbers indicate significance at the 95% confidence level.

	Period		Annual	Autumn	Winter	Spring	Summer
Temperature	1900-2009	MK	**4.16**	1.06	**3.93**	1.41	**4.15**
	1900-1958		**2.33**	1.24	0.88	0.86	**3.40**
	1958-2009		**3.95**	1.52	**3.31**	**3.21**	**2.99**
	1958-1990		0.36	0.26	-1.16	**2.59**	0.64
	1990-2009		0.81	1.07	1.59	-1.40	0.10
	1900-2009	r^2	**0.17**	0.01	**0.13**	0.02	**0.18**
	1900-1958		**0.09**	0.01	0.02	0.01	**0.19**
	1958-2009		**0.28**	0.05	**0.24**	**0.18**	**0.15**
	1958-1990		0.00	0.00	0.05	**0.14**	0.00
	1990-2009		0.03	0.09	**0.21**	0.08	0.00
Precipitation	1900-2009	MK	-0.42	0.73	-1.16	1.47	0.20
	1900-1958		0.64	0.41	0.52	0.50	0.81
	1958-2009		**-2.11**	-0.04	-1.44	**-2.01**	**-2.00**
	1958-1990		-0.64	-0.02	-0.67	-0.02	0.00
	1990-2009		-1.65	-0.23	-1.01	**-1.78**	**-1.98**
	1900-2009	r^2	0.00	0.00	0.01	0.03	0.00
	1900-1958		0.01	0.00	0.01	0.01	0.01
	1958-2009		0.07	**0.29**	**0.65**	0.01	0.07
	1958-1990		0.01	0.00	0.02	0.00	0.00
	1990-2009		0.16	0.02	0.06	0.11	0.13

Precipitation exhibited no trend over the past century (Table 18 and Figure 25). A decrease in precipitation was found in summer and spring from 1958 to 2009 and then again from 1990 to 2009. The regression correlations indicate that the linear trends for all periods are weak.

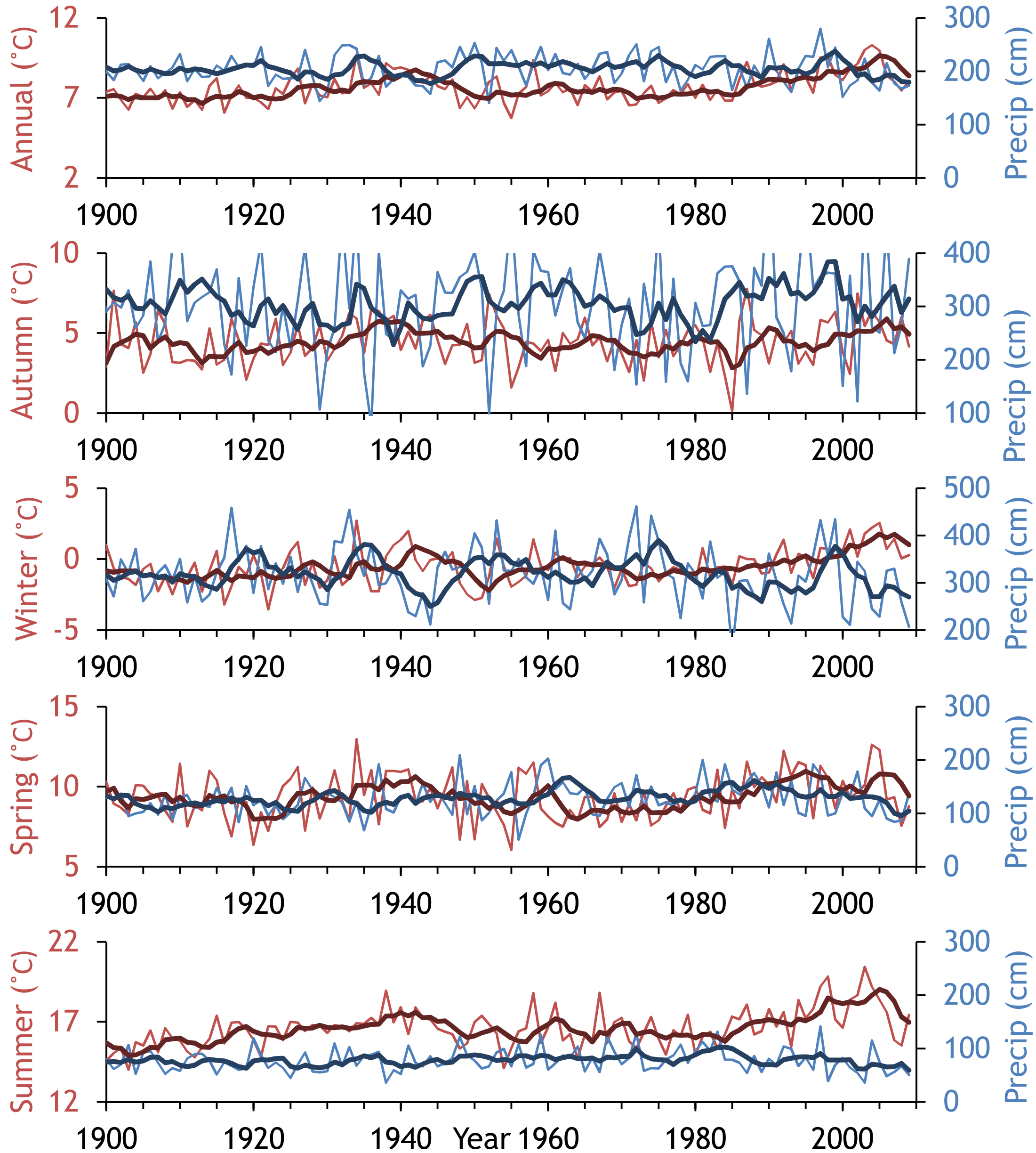


Figure 25 – Annual and seasonal maximum temperatures and precipitation for the North Cascades. The darker line is a 5-year running mean.

Correlation of glacier area change and topographic/climate variables

To interpret both correlation tests, a positive correlation indicates that more area shrinkage (more negative) is associated with an increasing value of the variable in question. Conversely a negative correlation indicates that less area loss (less negative) is associated with a decreasing value of the correlative variable.

Over the century, 1900-2009, warmer temperature is significantly correlated with more fractional area loss in all seasons (Table 19); no significant correlation exists between precipitation and area change. Greater precipitation is significantly correlated to less fractional area loss from 1900-1958, 1958-1990, and 1968-2009 (Table 19). The opposite correlation between 1998 and 2009 shows that lower summer precipitation is associated with higher fractional area loss. Higher temperature is significantly correlated to higher fractional area loss in all seasons from 1983-2009 and 1998-2009. From 1958-2009 higher winter and summer temperatures were correlated with higher fractional area loss and from 1968-2009 only higher winter temperatures were significantly correlated (Table 19).

Table 19 - Results of the correlation analysis between glacier area change and climate variables. The first group refers to the Pearson correlation coefficient (r), and the second group is the Spearman rank correlation coefficient (r_s). Bold numbers indicate significance at 95% confidence level. The seasonal values are as follows A = autumn, Sp = spring, Su=summer, W = winter. Red indicates significant positive trends, and blue is significant negative trends.

All Features			Precipitation				Temperature			
		n	A	Sp	Su	W	A	Sp	Su	W
Pearson	1900-2009	303	0.05	0.08	0.08	0.05	**-0.12**	**-0.17**	**-0.20**	**-0.15**
	1900-1958	128	**0.23**	**0.20**	**0.21**	**0.26**	-0.14	-0.07	-0.14	-0.06
	1958-1990	100	**0.34**	**0.35**	**0.37**	**0.37**	**-0.25**	-0.19	-0.16	-0.06
	1990-1998	189	0.11	0.00	-0.02	0.07	0.06	0.02	0.08	-0.01
	1998-2009	517	-0.05	-0.07	**-0.21**	-0.03	**-0.26**	**-0.23**	**-0.18**	**-0.24**
	1958-2009	278	0.07	0.05	0.01	0.06	-0.03	0.08	**-0.09**	**-0.38**
	1968-2009	42	**0.50**	**0.51**	**0.51**	**0.52**	-0.01	0.01	-0.11	**-0.13**
	1983-2009	173	0.03	-0.11	**-0.15**	0.06	**-0.24**	**-0.36**	**-0.34**	**-0.23**
Spearman	1900-2009	303	**0.15**	0.07	0.04	**0.17**	-0.11	**-0.17**	**-0.18**	**-0.13**
	1900-1958	128	0.14	0.14	0.15	0.17	-0.10	-0.14	-0.12	-0.06
	1958-1990	100	**0.34**	**0.36**	**0.35**	**0.37**	-0.13	-0.11	-0.11	-0.04
	1990-1998	189	0.13	-0.00	-0.01	0.05	0.12	0.12	0.12	0.06
	1998-2009	517	**-0.16**	**-0.14**	**-0.25**	-0.09	**-0.26**	**-0.21**	**-0.20**	**-0.24**
	1958-2009	278	0.12	0.10	0.05	0.10	**-0.10**	0.00	**-0.10**	**-0.37**
	1968-2009	42	**0.42**	**0.53**	**0.48**	**0.47**	-0.01	0.02	-0.09	-0.05
	1983-2009	173	0.02	-0.09	-0.15	0.04	**-0.18**	**-0.24**	**-0.26**	**-0.21**

The above results of Table 19 were divided into two groups to see how glacier size affects the various climate correlations (Table 20). The results of the temperature correlation for the large glaciers are very similar to that of all the glaciers in Table 19, whereas the small glaciers are not. This suggests that temperature changes have a more effective influence on larger glaciers. Conversely, while changes in precipitation continue to have some effect on larger glaciers, perhaps at a somewhat less significance, on the smaller glaciers its correlation is greater suggesting that smaller glaciers are more responsive to changes in precipitation.

Table 20 - Results of correlation analysis for the climate analysis divided into two groups for glaciers greater than and less than 0.1km^2. All other factors are the same as Table 19.

		Precipitation				Temperature			
area > 0.1 km^2		A	Sp	Su	W	A	Sp	Su	W
Pearson	1900-2009	0.01	0.10	0.10	0.04	**-0.12**	**-0.19**	**-0.20**	**-0.14**
	1900-1958	**0.20**	**0.18**	**0.18**	**0.23**	-0.13	-0.08	-0.14	-0.11
	1958-1990	0.23	**0.29**	**0.27**	**0.31**	-0.22	-0.21	-0.17	-0.11
	1990-1998	0.10	-0.02	-0.09	0.09	-0.08	-0.11	-0.04	-0.10
	1998-2009	-0.08	-0.06	**-0.18**	-0.05	-0.11	-0.01	**-0.15**	**-0.38**
	1958-2009	0.04	-0.01	-0.04	0.06	-0.13	-0.09	**-0.24**	**-0.26**
	1968-2009	**0.47**	0.38	0.41	**0.45**	0.01	-0.05	-0.04	-0.01
	1983-2009	0.03	-0.07	-0.08	0.08	**-0.24**	**-0.21**	**-0.21**	**-0.22**
Spearman	1900-2009	**0.15**	0.09	0.06	**0.16**	**-0.12**	**-0.18**	**-0.18**	**-0.13**
	1900-1958	0.15	0.16	0.16	0.18	-0.11	-0.15	-0.13	-0.10
	1958-1990	0.11	0.17	0.14	0.20	-0.19	-0.11	-0.12	-0.08
	1990-1998	0.13	-0.09	-0.13	0.02	-0.07	-0.06	-0.04	-0.10
	1998-2009	**-0.16**	-0.08	**-0.20**	-0.09	**-0.16**	-0.09	**-0.17**	**-0.39**
	1958-2009	0.04	0.08	0.02	0.06	-0.11	-0.07	**-0.23**	-0.14
	1968-2009	0.20	0.21	0.23	0.29	0.08	0.12	-0.06	0.05
	1983-2009	0.01	-0.02	-0.05	0.05	**-0.22**	-0.16	**-0.21**	**-0.21**
		Precipitation				Temperature			
area < 0.1 km^2		A	Sp	Su	W	A	Sp	Su	W
Pearson	1900-2009	0.24	-0.01	-0.12	0.25	-0.12	-0.06	-0.19	-0.30
	1900-1958	**0.75**	**0.73**	**0.75**	**0.74**	-0.04	-0.35	0.07	**0.66**
	1958-1990	**0.36**	**0.34**	**0.40**	**0.36**	-0.23	-0.11	-0.09	0.03
	1990-1998	0.20	0.05	0.06	0.11	0.17	0.14	0.20	0.08
	1998-2009	-0.04	-0.11	**-0.26**	-0.02	0.05	**0.17**	-0.02	**-0.40**
	1958-2009	0.12	0.09	0.05	0.10	0.15	0.16	0.07	0.05
	1968-2009	**0.62**	**0.68**	**0.66**	**0.64**	**0.51**	**0.46**	0.41	**0.45**
	1983-2009	0.04	**-0.33**	**-0.35**	0.03	-0.27	-0.25	-0.05	-0.24
Spearman	1900-2009	0.33	0.03	-0.13	0.34	-0.00	-0.12	-0.16	-0.17
	1900-1958	0.59	0.46	0.44	0.59	0.33	-0.29	0.12	0.61
	1958-1990	**0.42**	**0.44**	**0.44**	**0.41**	-0.06	0.01	-0.02	0.09
	1990-1998	**0.28**	0.14	0.16	0.15	**0.32**	**0.31**	**0.32**	**0.28**
	1998-2009	**-0.20**	**-0.21**	**-0.32**	-0.11	-0.02	0.12	-0.00	**-0.36**
	1958-2009	0.13	0.06	0.03	0.10	0.11	0.15	0.07	0.07
	1968-2009	**0.45**	**0.67**	**0.53**	**0.48**	0.40	0.37	0.32	0.27
	1983-2009	0.06	-0.31	**-0.42**	0.01	-0.30	-0.28	-0.07	-0.28

The effect of topographic setting is examined in Table 21. Smaller glaciers were significantly correlated with more fractional area loss from 1900-2009, 1900-1958, 1998-2009 and 1983-2009. Glaciers at lower elevations had significant fractional area loss from 1900-2009, 1998-2009, 1990-1998 and 1983-

2009. Steeper slopes were significantly correlated with more area loss from 1900-2009 and 1958-2009. There were no significant correlations with northness and eastness. Glaciers located more to the east (longitude) lost more area than western glaciers although southern glaciers lost more than northern glaciers in 1983-2009, and 1998-2009, and while northern-most glaciers lost more from 1958-1990. Glaciers with more solar insolation were significantly correlated with higher area change from 1900-1958.

Table 21 - Results of correlation analysis for glacier area change and topographic variables. Bold numbers indicate significance at 95% confidence level. Blue indicates a significant negative trend and red is a significant positive trend. The first group refers to the Pearson correlation coefficient (r), and the second group is the Spearman rank correlation coefficient (r_s). N is the sample size. The topographic variables are (initial area (A_1), mean elevation (Z_{MEAN}), slope, northness, eastness, longitude, latitude, and insolation (Ins.).

All Features		n	A_i	Z_{MEAN}	Mean Slope	N-ness	E-ness	Long.	Lat.	Ins.
Pearson	1900-2009	303	**0.36**	**0.25**	**-0.16**	0.02	-0.06	-0.02	-0.02	0.05
	1900-1958	128	**0.30**	0.07	**-0.26**	-0.03	0.06	-0.12	**0.22**	**-0.26**
	1958-1990	100	0.14	-0.09	-0.01	-0.01	0.06	-0.19	**0.34**	**0.23**
	1990-1998	189	0.08	0.00	-0.10	0.10	0.00	-0.09	-0.08	-0.06
	1998-2009	517	**0.11**	**0.26**	0.09	-0.07	-0.04	**0.44**	**-0.35**	**0.09**
	1958-2009	278	0.10	**0.14**	0.10	0.03	0.03	0.00	-0.01	**0.12**
	1968-2009	42	0.11	-0.05	0.04	-0.07	**0.32**	**-0.45**	-0.28	-0.03
	1983-2009	173	**0.23**	**0.34**	**0.16**	0.04	-0.06	**0.24**	**-0.18**	0.10
Spearman	1900-2009	303	**0.13**	**0.25**	**-0.17**	0.02	-0.08	0.02	0.00	0.04
	1900-1958	128	0.08	0.14	**-0.25**	-0.03	0.04	-0.01	0.14	**-0.23**
	1958-1990	100	0.18	-0.08	-0.05	0.01	-0.02	-0.12	0.12	0.13
	1990-1998	189	0.09	-0.06	-0.11	0.11	0.01	-0.09	-0.05	-0.09
	1998-2009	517	0.06	**0.26**	0.06	**-0.09**	-0.06	**0.44**	**-0.39**	**0.10**
	1958-2009	278	0.10	0.11	0.09	0.05	-0.01	-0.04	-0.03	0.12
	1968-2009	42	0.20	-0.06	0.08	-0.15	0.30	**-0.41**	-0.27	-0.07
	1983-2009	173	**0.25**	**0.31**	0.05	0.02	-0.04	**0.25**	**-0.15**	0.08

The above results were divided into two groups to see how glacier size affects the influence of topographic variables (Table 22). For large glaciers (>

0.1 km^2), a smaller initial area and higher slope are significantly correlated with more fractional area loss from 1900-2009, 1900-1958, 1998-2009, 1958-2009, and 1983-2009. Higher elevations were correlated with less area loss. Northness and eastness do not have any significant trends. Longitude and latitude and insolation have a combination of positive and negative significant trends over a few time periods. For the small glaciers (< 0.1 km^2) initial area, mean slope, northness and insolation did not have many significant trends. Elevation was significantly correlated (higher elevation, less loss) for the entire century (1900-2009) and the last 10 years (1998-2009). Glaciers that were most east-facing for 1900-1958 lost less fractional area. Longitude and latitude have mixed correlations.

Table 22 - Results of correlation analysis for the topographic analysis divided into two groups for glaciers greater than and less than 0.1 km^2. All other factors are the same as Table 21.

Area > 0.1km^2		n	A_i	Z_{MEAN}	Slope	N-ness	E-ness	Long.	Lat.	Ins.
Pearson	1900-2009	276	**0.42**	**0.24**	**-0.18**	0.01	-0.06	-0.04	-0.03	0.07
	1900-1958	118	**0.40**	0.10	**-0.36**	0.01	0.03	-0.04	0.15	**-0.27**
	1958-1990	55	0.14	0.01	-0.14	0.23	0.05	-0.06	0.10	**0.46**
	1990-1998	122	0.17	0.08	-0.11	0.16	-0.04	0.04	-0.14	**-0.20**
	1998-2009	291	**0.16**	**0.34**	0.07	-0.07	-0.01	**0.42**	**-0.25**	0.09
	1958-2009	152	0.12	**0.18**	0.13	0.06	0.07	0.15	0.00	**0.22**
	1968-2009	20	0.14	0.24	0.32	-0.30	0.12	-0.41	-0.03	-0.03
	1983-2009	134	**0.25**	**0.36**	0.11	0.04	-0.02	0.14	-0.12	0.10
Spearman	1900-2009	276	**0.24**	**0.24**	**-0.19**	0.00	-0.08	0.02	0.00	0.06
	1900-1958	118	**0.26**	0.15	**-0.30**	-0.01	0.03	0.02	0.15	**-0.25**
	1958-1990	55	0.04	0.02	-0.02	0.20	0.02	0.08	-0.07	0.26
	1990-1998	122	**0.23**	-0.01	-0.11	0.14	-0.04	0.09	-0.14	-0.17
	1998-2009	291	**0.16**	**0.33**	0.00	-0.08	-0.07	**0.46**	**-0.36**	**0.13**
	1958-2009	152	0.01	**0.18**	0.14	0.10	0.00	0.08	-0.04	**0.22**
	1968-2009	20	0.12	0.14	0.23	-0.31	0.15	-0.23	0.05	-0.09
	1983-2009	134	**0.30**	**0.31**	-0.04	0.03	-0.02	0.13	-0.05	0.03
Area < 0.1km^2		**n**	**A_i**	**Z_{MEAN}**	**Slope**	**N-ness**	**E-ness**	**Long.**	**Lat.**	**Ins.**
Pearson	1900-2009	26	**-0.47**	**0.39**	-0.10	0.08	-0.03	0.15	-0.15	-0.17
	1900-1958	10	0.25	0.15	-0.07	-0.29	**0.72**	**-0.87**	**0.80**	-0.38
	1958-1990	45	0.12	-0.14	0.18	-0.18	0.06	-0.24	**0.50**	0.07
	1990-1998	70	0.08	-0.09	-0.11	0.06	0.04	-0.20	-0.03	0.05
	1998-2009	229	-0.10	**0.17**	0.12	-0.07	-0.07	**0.47**	**-0.46**	0.11
	1958-2009	126	-0.05	0.10	0.08	0.00	-0.01	-0.15	-0.02	0.04
	1968-2009	22	0.41	-0.25	-0.06	0.08	**0.43**	**-0.53**	**-0.46**	-0.03
	1983-2009	41	0.16	0.26	0.30	-0.01	-0.16	**0.40**	**-0.31**	0.15
Spearman	1900-2009	26	-0.07	**0.44**	-0.07	0.15	-0.10	0.14	-0.14	-0.08
	1900-1958	10	0.31	0.21	-0.10	-0.36	**0.69**	**-0.71**	0.48	-0.36
	1958-1990	45	0.13	-0.14	-0.02	-0.17	-0.03	-0.26	0.25	0.04
	1990-1998	70	0.11	-0.13	-0.11	0.05	0.07	**-0.29**	0.04	0.01
	1998-2009	229	-0.12	**0.19**	0.13	-0.09	-0.06	**0.44**	**-0.42**	0.09
	1958-2009	126	-0.06	0.06	0.08	0.00	-0.02	-0.11	-0.03	0.04
	1968-2009	22	0.36	-0.15	-0.07	0.01	0.40	**-0.43**	**-0.53**	0.00
	1983-2009	41	0.12	0.24	**0.33**	-0.02	-0.15	**0.48**	**-0.42**	0.23

To explore the factors that may combine to influence glacier area change I employed a multiple regression model. The relative importance of each independent variable is represented by the standardized beta value (Table 23). I used a stepwise model which only includes significant factors in the final regression model. The multiple regression model for 1900-2009 with all topographic predictors, summer temperature and winter precipitation produced an $R^2 = 0.162$, $p < .001$. From 1900-2009, initial area and elevation explain about 16% of glacier area change. None of the other topographic or climate variables were significant. For the model from 1900-1958 resulted in an $R^2 = 0.230$, $p < .001$. Mean elevation, mean slope, spring and winter temperature changes significantly explain about 23% of the variability in glacier area change. The model from 1958 to 2009 produced an $R^2 = 0.164$, $p < .001$. The variables that produced the significant results include mean elevation, latitude, spring and summer precipitation and spring and summer temperature changes explain about 16% of glacier area change with the topographic and climate variables.

When the regression models are divided into large (> 0.1 km^2) and small glaciers (< 0.1 km^2), the regression models for larger glaciers have a higher R^2 value. These models also include winter temperature as a significant factor. The regression models for the smaller glaciers show that location, both aspect and latitude/longitude were significant factors for glacier area change.

Table 23 - Results of the multiple regression analysis. Only the significant standardized beta coefficients are reported below to show their relative weights of importance to the overall model. The seasonal values of precipitation and temperature change that were significant in each multiple regression model are as follows A = autumn, Sp = spring, Su=summer, W = winter. The topographic variables are (initial area (A_1), mean elevation (Z_{MEAN}), slope, northness (N-ness), eastness (E-ness), longitude, latitude, and insolation (Ins.).

	All Glaciers			Area > 0.1 km^2			Area < 0.1 km^2	
	1900-2009	1900-1958	1958-2009	1900-2009	1900-1958	1958-2009	1900-2009	1900-1958
R^2	0.16	0.23	0.16	0.20	0.25	0.26	0.37	0.92
A_i	0.32	0.26		0.38	0.30			
Z_{MEAN}	0.20		0.20	0.17		0.31		
Slope		-0.18			-0.26			
N-ness								-0.40
E-ness								
Long.							-1.06	-0.92
Lat.			-0.17					
Ins.						0.15		
Precip			1.64 Sp; -0.30 S			1.52 Sp; -1.22 S		
Temp		0.22 Sp; -0.23 W	-0.52 Sp; 0.23 S		-0.18 W	-0.70 Sp; 0.38 W	-1.35 S	

Because there were not enough time intervals to generate a significant correlation between regional climate and the area change from (chapter 3: Table 13, Figure 16), they are qualitatively explored. The mean temperature and precipitation were calculated for 1900-1958; 1958-1968; 1968-1974; 1974-1983; 1983-1990; 1998-1998 and 1998-2009 (Table 24). Consistent with the regional trend analysis, the mean precipitation values are more or less consistent with some variability in mean autumn values. The temperature variations in all seasons show that the temperatures are getting warmer, and the warmer temperatures are associated with periods of glacier area decline (Figure 26).

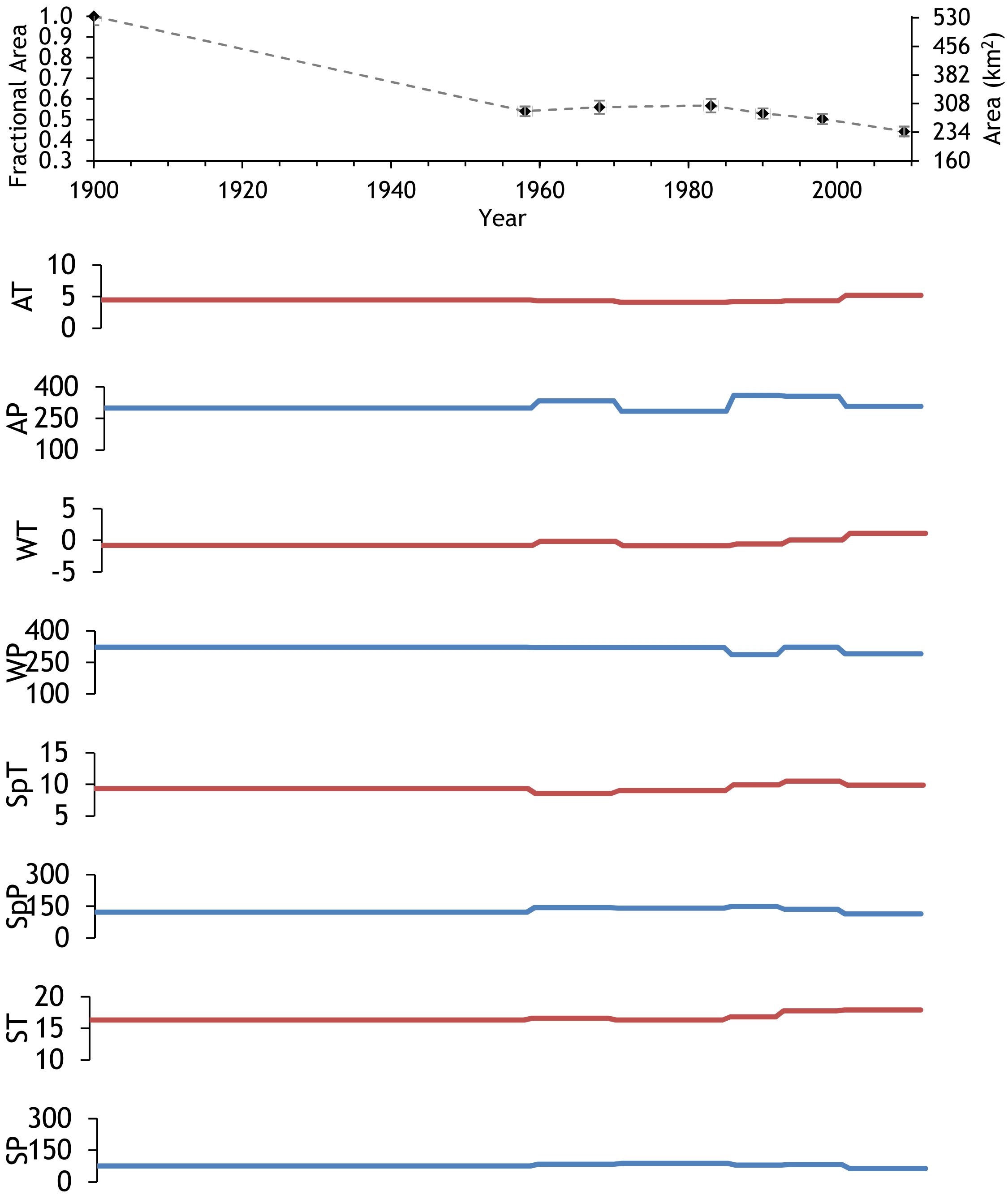


Figure 26- Annual and seasonal temperature averages over the same periods of glacier area change in the entire North Cascades region. Temperature is in degrees Celsius and precipitation is in centimeters.

Table 24 – Precipitation (P) and Temperature (T) for seasonal and annual averages corresponding with periods of glacier area change for the entire North Cascades. The seasonal values are as follows A = autumn, Sp = spring, Su=summer, W = winter.

	AT	AP	SuT	SuP	Sp T	SpP	WT	WP	FT	F P
1900-1958	7.5	203.1	16.3	75.9	9.3	121.4	-0.8	322.7	4.5	300.0
1958-1968	7.6	214.2	16.6	83.7	8.6	143.1	-0.2	320.4	4.3	334.1
1968-1983	7.4	206.8	16.3	87.3	9.0	141.4	-0.8	320.3	4.1	284.2
1983-1990	7.8	207.1	16.8	79.9	9.9	149.2	-0.6	287.0	4.2	359.4
1990-1998	8.4	216.7	17.8	82.7	10.5	136.0	0.0	322.1	4.3	354.9
1998-2009	8.9	188.5	17.9	63.1	9.9	114.4	1.1	291.2	5.2	308.3

In addition to the temperature and precipitation comparisons, fractional area change for the entire region, Mount Baker, and South Cascade Glacier and the net mass balance measurements for South Cascade Glacier are compared to the PDO index (Figure 27). From 1900-1958 the PDO index is more positive, which is comparable to the negative fractional glacier area. From 1958-1983 the period of glacier area stability/slight advance have a negative average PDO. From 1983 to 1990 and 1990 to 1998 show a generally positive PDO associated with area loss. The South Cascade Glacier mass balance measurements have an inverse relationship with PDO, with the generally negative mass balance values associated with positive PDO values.

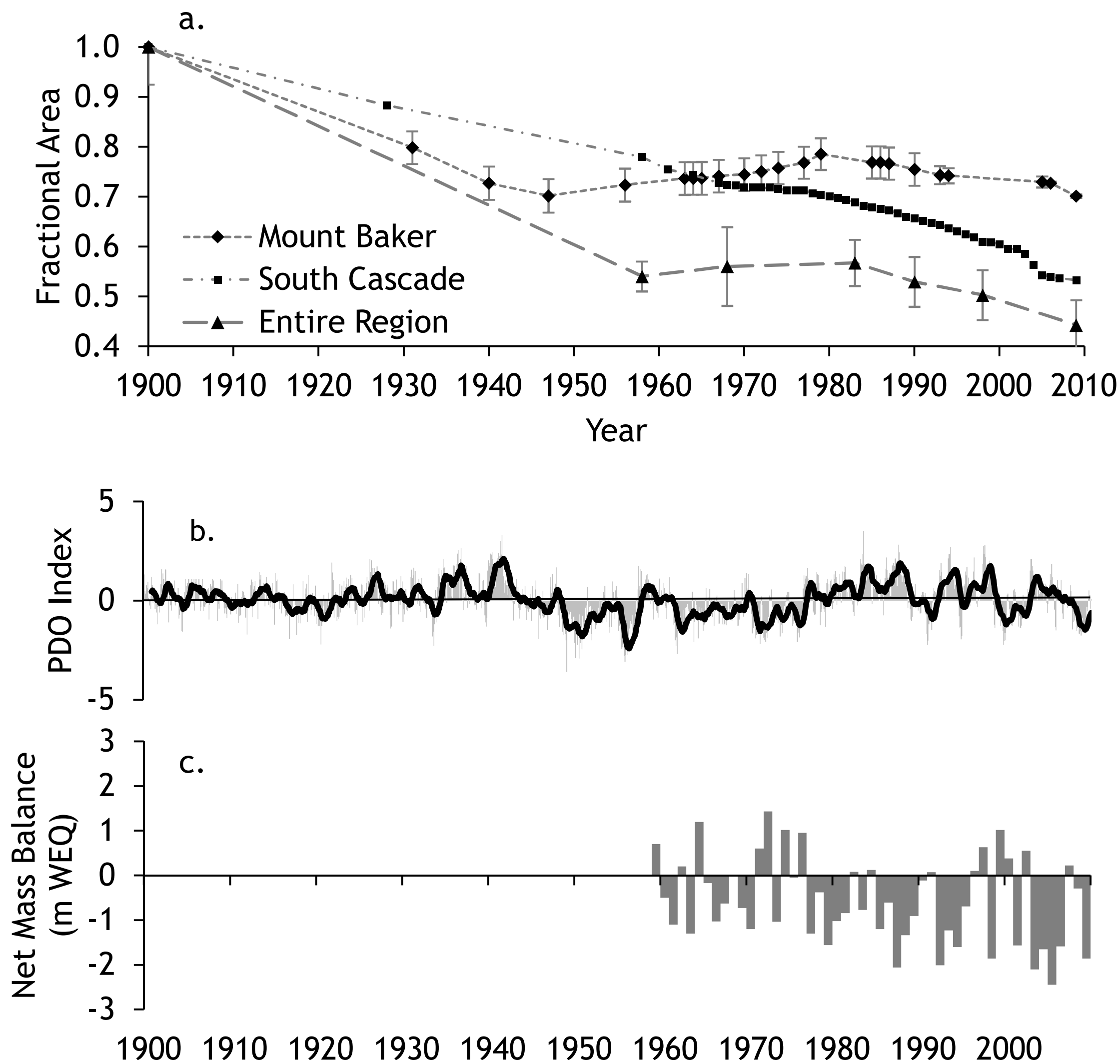


Figure 27 - North Cascades fractional area change (a), monthly PDO index values with a one year running mean (dark black line) (b), and South Cascade annual net mass balance (c) to show potential relationships over the past century.

Discussion & Conclusions

Regional climate trends indicate that from 1900-2009 maximum air temperature has significantly increased in all seasons (except spring) and annually. No significant change in precipitation over the past century was detected. When the temperature trends are related to the time period of glacier area change, significant warming occurred from 1900-1958, with most of that coming in summer (ablation season) and there was a large decrease in glacier area. From 1958-1985, no temperature trend was apparent, which corresponds with the general stagnation of glaciers. From 1985-2005, there was a dramatic increase in annual temperatures and precipitation decreased, which corresponds to a retreat of glacier area. From 2005-2009 there was a small decrease in air temperature.

The correlation of warmer air temperature to more area loss is consistent over long and short time periods (1900-2009, 1983-2009 and 1998-2009), while correlations between precipitation and fractional area loss over shorter time periods show that precipitation can be a more important factor over short time periods (1900-1958, 1958-1990, 1968-2009). My results are consistent with a study on Mount Baker that showed accumulation season precipitation and ablation season temperatures explained variations in terminus response (Harper, 1993). My results are consistent with these results as the strongest correlations between area change and the seasonal temperature/precipitation means are in winter (precipitation) and summer (temperature). Elsewhere in the western United States, spring and summer temperature were shown to be important to glacier area change in Colorado and the Sierra Nevada (Hoffman and others, 2007, Basagic & Fountain, 2011). In the North Cascades, summer and winter temperature warming was more significantly correlated to glacier area loss than spring temperature warming, which was only significant since 1958.

The results of the topographic analysis indicate that smaller glaciers at lower elevations with steeper slopes lost more area than larger, higher, less steep glaciers. When the correlations were divided into two groups based on area (> 0.1 km^2 or < 0.1 km^2), some differences in the correlations occurred. Initial area, elevation, slope and insolation were more significant indicators of area change of larger glaciers. For the smaller glaciers, eastness, latitude, and longitude had significant correlations to area change suggesting that the geographic location of the small glaciers is more important than local topographic characteristics. No strong correlations exist between fractional area change and the various topographic variables, confirming the previous findings of Granshaw and Fountain (2006). My results are similar to other studies in the Rocky Mountains of British Columbia (BC) showing that smaller glaciers, with low slope at lower elevation had a higher absolute area change (Tennant and others, 2012). For smaller glaciers in the interior of BC, local topography of lower elevation, less steep slopes and higher insolation contributed to the glacier area change (DeBeer & Sharp, 2009).

The multiple regression model for the North Cascades showed that the combination of topographic and climate variables only explained up to 23% of fractional area change. The significant variables for the three time periods analyzed include initial area, elevation, slope, latitude, spring and summer precipitation, spring, summer, and winter temperatures. The small percentage of area change that is explained by all topographic variables is consistent with the weak correlation trends above and suggests that initial area, elevation, and insolation are the main contributing factors to fractional area change.

Chapter 5 – Discussion and Conclusions

A comparison of two glacier inventories (Post and others, 1971, Fountain and others, 2007b), one compiled by glaciologists and the other by cartographers (24K) can show overall agreement. They are most different in the number of small glaciers (less than 0.1 km^2) with the cartographic results including all the small features. However, filtering glaciers less than 0.1 km^2 from the 24K inventory resulted in an underestimate of total Post and others (1971) inventory by almost half the number of glaciers, and 90% of the area. My area filtering results for the entire North Cascades are consistent with results from within the North Cascades Park Complex found by Granshaw & Fountain (2006). Reducing the shear stress threshold to estimate the number of 'true' glaciers in the 24K inventory resulted in a match of the Post and others (1971) inventory by ~100% in number and ~100% area. These results are similar to the Sierra Nevada (Basagic & Fountain, 2011).

I reconciled the methods and assumptions of the Post and others (1971) inventory to the 24K inventory and found better agreement the two inventories are comparable, 24K identified 93% of the number of glaciers in Post and 94% of the total area. Both are within uncertainty.

Total glacier area decreased by -56% ± 3% from 1900-2009. Most of the area loss occurred in the first half of the century from 1900-1958 (-46% ± 5%); from 1958-1990 glacier area was largely unchanged with -1% ± 5%, relative to 1900 area, and from 1990 to 2009 glaciers lost -9% ± 5%. Small glaciers exhibited more variability and have also lost the most relative area. This general trend of glacier change for the region is reflected in the more detailed time series on Mount Baker and at South Cascade Glacier. The magnitude of change at South Cascade Glacier was less than Mount Baker and the entire region during the first half of the century (1900-1958). Except for a brief period of stability in the early 1970s, South Cascade Glacier has continued to decline. On Mount Baker, there was a period of growth/stability that lasted from the 1950s through the 1980s, and has been rapidly declining since then. Long term mass balance measurements for three different monitoring programs (South Cascade Glacier, NPS and NCGCP) show similar trends during their periods of record. South Cascade shows more negative mass balance than the other monitored glaciers, which suggest that it is somewhat representative of the entire region. There is overall consistency between the mass balance trends for the monitored glaciers when compared with the glacier area change for the entire North Cascades.

The results of glacier area change are similar to other glacier studies. Elsewhere in Washington State, glaciers on Mount Rainier changed by -22% between 1913 and 1994; glaciers on Mount Adams shrank by 49%, 1904-2006 (Sitts and others, 2010). In the Canadian Rocky Mountains glaciers shrank by 40% between 1919 and 2009 (Tennant and others, 2012). In Oregon, the glaciers on Mount Hood shrank by 34% between 1907 and 2004 (Jackson & Fountain, 2007). Since the beginning of the 20th century, the Sierra Nevada lost 55% of glacier area 1903 and 2004 (Basagic & Fountain, 2011). The glaciers in Rocky Mountain National Park also lost 40% of glacier area since the turn of the century 1909-2004 (Hoffman and others, 2007). Only glaciers in Glacier National Park have lost more fractional area (65%) than the North Cascades since the end of the LIA (Hall & Fagre, 2003). Similar results were found in the European Alps with -36% area change between 1850 and 2006, and in the New Zealand Alps with a -49% glacier area loss (Hoelzle and others, 2007).

Decadal variations over the past century are similar within the North Cascades and compared to glaciers elsewhere, although variability does exist (Dyurgerov & Meier, 2000). Within the North Cascades, there was a period of rapid retreat from 1900 through the 1940s. Between the 1950s and 1980s, glacier area was stable or advancing and since the 1980s, glaciers resumed shrinking. General trends elsewhere indicate that beginning in the 1920s glaciers were shrinking (Matthes, 1940) and that continued until the 1940s/1950s when some glaciers stabilized (Nylen, 2004, Hoffman and others, 2007, Jackson & Fountain, 2007, Harper, 1993) and even began advancing in the 1960s (Hubley, 1956, Harper, 1993). This period of stability/advance ended in the 1980s, and glaciers started retreating again until the present time.

Climate trends in the North Cascades show that air temperature since 1900 has increased in all seasons (except spring), while precipitation does not show significant trends, consistent with Mote (2003). Warming seasonal air temperatures are correlated with glacier area shrinkage between 1900 and

2009, with winter and summer temperatures being more highly correlated. Over decadal periods air temperature and precipitation were correlated with glacier area change, consistent with (McCabe & Fountain, 2013). These results are also consistent with other glacier studies that show temperature warming is better correlated with glacier area change than precipitation (Basagic, 2008, Hoffman and others, 2007).

Local topography influences glacier area change by enhancing or diminishing the effects of climate variation. More area loss was correlated with smaller glaciers on lower elevations with steeper slopes and higher mean annual insolation. For small glaciers (< 0.1 km^2), the topographic factor of facing east, and their geographic location of latitude and longitude were correlated to area loss. For small glaciers, geographic location in the region was more important that local topographic variables. These results are consistent with other glacial studies in British Columbia where glaciers at lower elevations had more glacier area loss (DeBeer & Sharp, 2009, Tennant and others, 2012).

In conclusion, glaciers in the North Cascades have lost more than half their area since 1900 (-56%). There was an initial period of glacier area decline until the 1950s, followed by a period of stability/growth until the 1980s, and glaciers have been rapidly declining since then. Over the past century, regional temperatures have increased, while precipitation shows no trend. The warming temperature in winter and summer caused the observed glacier area loss. On the decadal time scale variations in both precipitation and temperature are important. More fractional area loss was associated with smaller glaciers on lower elevations with steeper slopes and higher means annual insolation. Geographic location (facing east, latitude and longitude) was more important to fractional area loss for the smallest glaciers than their local topographic setting.

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Appendix A – 24K Subset

Each glacier from the 24K subset is listed below with the following attributes, BasinID is the unique identifier, RECNO(s) are the values from the original 24K dataset, year is the source year of the 24K map, S_{mean} is the mean slope (°), Z_{mean} is the mean elevation (m), A_{mean} is the mean aspect (°), I_{mean} is the mean insolation (watts/m^2), and the location of the glacier by latitude and longitude.

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
211102	2306		0.035 ± 0.005	1983	27	2066	85	11858	48.969124	-121.702481
211103	2307		0.015 ± 0.003	1983	29	1822	37	13437	48.971481	-121.692680
211104	2309		0.530 ± 0.019	1983	25	2056	4	6896	48.977019	-121.704764
211201	2327		0.048 ± 0.006	1974	22	1488	49	16850	48.927915	-121.616525
211202	2329		0.012 ± 0.003	1974	36	1752	45	14517	48.924726	-121.618972
211203	2328		0.081 ± 0.007	1974	31	1758	73	20991	48.929039	-121.622595
211204	2326		0.036 ± 0.005	1974	21	1667	154	25398	48.933710	-121.621374
211205	2313		0.015 ± 0.003	1983	20	1934	178	11922	48.974072	-121.644948
211206	2314		0.081 ± 0.007	1983	33	2074	119	12214	48.978506	-121.642054
211207	2317		0.021 ± 0.004	1983	41	2142	335	7125	48.982509	-121.630687
211208	2316		0.034 ± 0.005	1983	36	1719	323	10304	48.986495	-121.631863
211209	2315		0.173 ± 0.011	1983	33	1867	9	7929	48.984429	-121.635590
211210	2311		0.839 ± 0.024	1983	27	1847	30	9535	48.985707	-121.649261
211211	2310		0.232 ± 0.012	1983	31	1685	56	11173	48.995487	-121.655873
211301	(Granshaw and Fountain 2006)		0.016 ± 0.003	1958	24	1932	26	10852	48.960484	-121.512451
211302	2337		0.057 ± 0.006	1974	22	1514	31	14908	48.911699	-121.553396
211305	2330		0.114 ± 0.009	1974	18	1437	35	16047	48.935020	-121.564672
211306	2331		0.025 ± 0.004	1974	28	1648	45	15665	48.932596	-121.570114
211401	2198; 2199; 2200		0.105 ± 0.008	1974	35	1895	11	8196	48.932000	-121.452208
211402	2206; 2208		0.120 ± 0.009	1974	26	1864	64	17739	48.935954	-121.460178
211403	2213		0.040 ± 0.005	1974	33	1899	58	15735	48.943454	-121.465148
211404	2214		0.020 ± 0.004	1974	26	1911	92	22132	48.945371	-121.466627
211405	2220		0.062 ± 0.006	1974	30	1844	40	12706	48.950408	-121.467807
211406	2221		0.047 ± 0.006	1974	26	1925	45	13155	48.952090	-121.472169
211407	2251		0.034 ± 0.005	1974	35	1916	22	5507	48.991406	-121.462004
211408	2260		0.143 ± 0.010	1974	30	1953	51	10423	48.993757	-121.468696
211409	2263		0.078 ± 0.007	1974	28	2123	56	10114	48.996467	-121.473909
211410	2263		0.036 ± 0.005	1974	39	2113	333	5578	48.996693	-121.477899
211411	2254		0.011 ± 0.003	1974	24	2076	209	10119	48.992899	-121.474932
211412	2256		0.086 ± 0.008	1974	24	1979	334	9045	48.992575	-121.484452
211413	2257		0.060 ± 0.006	1974	24	1928	50	17269	48.994310	-121.489627
211414	2227		0.028 ± 0.004	1974	16	1793	94	25567	48.968517	-121.493495
211415	2056		0.060 ± 0.006	1974	38	1740	8	11036	48.973299	-121.502334
211416	2324		0.048 ± 0.006	1974	27	2001	330	5742	48.976390	-121.522212

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
211501	2249		0.109 ± 0.009	1983	22	2381	250	8227	48.985727	-121.254821
211502	(Granshaw and Fountain 2006)		0.072 ± 0.007	1958	35	2182	309	9717	48.978032	-121.259590
211503	2237		0.048 ± 0.006	1983	20	2351	94	15637	48.975544	-121.253967
211504	2231		0.113 ± 0.009	1968	30	2291	273	6984	48.967058	-121.247490
211505	2226; 2478		0.120 ± 0.009	1983	31	2108	283	3843	48.962352	-121.253541
211506	2478	Redoubt Glacier	2.041 ± 0.037	1983	19	2163	11	4459	48.955581	-121.272405
211507	2228		1.177 ± 0.028	1983	26	2044	18	10192	48.961769	-121.290158
211508	2233		0.430 ± 0.017	1983	32	2078	52	17356	48.964947	-121.302623
211509	2232		0.181 ± 0.011	1983	32	2106	2	8227	48.966308	-121.314221
211510	2236		0.176 ± 0.011	1983	29	1910	32	15254	48.970283	-121.323064
211601	2278		0.038 ± 0.005	1983	28	2335	282	14847	48.953797	-121.305983
211602	(Granshaw and Fountain 2006)		0.058 ± 0.006	1958	27	2282	221	15643	48.951905	-121.299575
211603	2279		0.196 ± 0.011	1983	32	1829	345	10819	48.930428	-121.323664
211604	2203		0.034 ± 0.005	1983	35	1821	36	15228	48.932148	-121.337592
211701	2177		0.046 ± 0.006	1983	29	1946	39	15181	48.890007	-121.362126
211702	2178		0.040 ± 0.005	1983	33	1905	4	9067	48.891914	-121.365115
211801	2149		0.260 ± 0.013	1974	34	1862	339	11365	48.859968	-121.379156
211802	2144		0.179 ± 0.011	1974	29	1717	349	9000	48.859821	-121.388140
211803	2135; 2151		0.082 ± 0.007	1974	29	1683	7	10668	48.860202	-121.396019
211804	2151		0.509 ± 0.018	1974	26	1681	12	11378	48.861065	-121.410411
211901	2145		0.159 ± 0.010	1974	27	1922	69	13842	48.858121	-121.459298
211902	2145		0.097 ± 0.008	1974	33	1805	50	14617	48.861531	-121.458592
211905	2437		0.314 ± 0.015	1974	26	1818	29	8579	48.864575	-121.522379
212101	2319		0.172 ± 0.011	1983	24	1795	13	9247	48.928884	-121.634077
212102	2304		0.016 ± 0.003	1983	21	1995	282	15804	48.926352	-121.639984
212201	2437		0.538 ± 0.019	1974	27	1950	348	5258	48.863889	-121.535816
212202	2422		0.049 ± 0.006	1974	18	1602	50	14605	48.870145	-121.545319
212203	2418		0.043 ± 0.005	1974	28	1906	44	10369	48.871886	-121.554295
212204	2346		0.037 ± 0.005	1974	29	1930	54	14877	48.876617	-121.564129
212205	2344		0.093 ± 0.008	1974	17	1592	19	15072	48.880020	-121.570921
212206	2343		0.062 ± 0.006	1974	32	1759	5	11107	48.886610	-121.576098
212207	2342		0.076 ± 0.007	1974	28	1850	13	10562	48.886140	-121.581746
212208	2341		0.099 ± 0.008	1974	29	1977	40	11724	48.886002	-121.586531
212209	2341		0.136 ± 0.010	1974	27	1799	59	18189	48.890510	-121.586317
212210	2338		0.039 ± 0.005	1974	30	1778	39	14498	48.894020	-121.588811
212211	2339		0.041 ± 0.005	1974	38	1781	45	16156	48.897143	-121.592780
212212	2340		0.233 ± 0.012	1974	27	1832	324	12763	48.895374	-121.598697
212301	2429		0.034 ± 0.005	1974	24	2021	252	7639	48.857978	-121.535863
212302	2444		0.574 ± 0.020	1974	25	1861	301	3641	48.839667	-121.533916
212303	10478	East Nooksack Glacier	0.577 ± 0.020	1974	30	1731	298	5457	48.828457	-121.540771
212304	10478	East Nooksack Glacier	2.244 ± 0.039	1974	28	1822	48	15624	48.828656	-121.571158
212305	2408	West Nooksack Glacier	0.166 ± 0.011	1974	36	1806	73	16356	48.842016	-121.574920
212306	2485	Price Glacier	1.615 ± 0.033	1974	31	1750	353	11114	48.843764	-121.590289

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
212307	2419		0.106 ± 0.008	1974	42	1985	7	8214	48.842360	-121.599836
212401	2421; 2488	Hanging Glacier	0.582 ± 0.020	1974	33	2132	306	10611	48.837795	-121.606434
212402	1860; 2421		0.807 ± 0.023	1974	28	1689	344	6742	48.837576	-121.620309
212403	1861		0.158 ± 0.010	1974	31	1717	16	10219	48.836595	-121.634531
212404	2405		0.082 ± 0.007	1974	27	1598	1	6292	48.838679	-121.642369
212501	2383	Table Mountain Glacier	0.159 ± 0.010	1974	21	1655	23	4528	48.849800	-121.707247
212601	1856		0.157 ± 0.010	1974	25	1674	335	3698	48.826746	-121.732883
212602	1840		0.560 ± 0.019	1974	23	1799	16	5902	48.823701	-121.745752
212603	10477	Sholes Glacier	1.189 ± 0.028	1975	19	1844	8	4574	48.813830	-121.768156
212604	10476	Mazama Glacier	5.397 ± 0.060	1975	22	2025	15	5542	48.801385	-121.802008
212605	10523		0.309 ± 0.014	1975	23	2083	92	9454	48.808799	-121.818827
212606	1829		0.328 ± 0.015	1975	17	2032	97	4313	48.814734	-121.813421
212607	1838		0.097 ± 0.008	1975	25	1943	48	9282	48.820868	-121.808640
212608	1835	Hadley Glacier	0.727 ± 0.022	1975	26	2008	354	5234	48.818759	-121.820527
212609	1835	Hadley Glacier	0.232 ± 0.012	1975	30	1981	38	10628	48.820985	-121.834561
212610	1835	Hadley Glacier	0.128 ± 0.009	1975	20	2037	24	5856	48.826396	-121.843429
212701	10523		0.228 ± 0.012	1975	25	2178	323	8694	48.807257	-121.826374
212702	2496	Roosevelt Glacier	3.571 ± 0.049	1975	22	2247	313	10502	48.792256	-121.830675
212703	2497	Coleman Glacier	5.088 ± 0.058	1975	23	2046	321	8874	48.784478	-121.844653
212704	2497		3.817 ± 0.051	1975	23	2269	341	6616	48.783468	-121.866946
213101	2498	Thunder Glacier	0.939 ± 0.025	1975	27	2142	290	10175	48.773466	-121.862761
213102	1806		0.221 ± 0.012	1975	21	1952	296	14816	48.758314	-121.870307
213103	1809		0.056 ± 0.006	1975	38	2171	262	18005	48.764816	-121.865111
213104	1807		0.124 ± 0.009	1975	38	2242	261	16304	48.759685	-121.862567
213105	2499	Deming Glacier	4.996 ± 0.058	1975	22	2271	218	17417	48.760892	-121.841482
213201	1610		0.709 ± 0.022	1974	27	1687	20	10540	48.696866	-121.973908
213202	1614		0.970 ± 0.025	1974	20	1813	30	7283	48.708820	-121.982706
221101	2500	Easton Glacier	2.888 ± 0.044	1975	19	2174	200	28079	48.749559	-121.829955
221102	2503	Talum Glaciers	2.155 ± 0.038	1975	26	2254	131	21429	48.756712	-121.803199
221103	2502	Boulder Glacier	3.851 ± 0.051	1975	25	2262	97	13710	48.767183	-121.793943
221104	2495	Park Glacier	3.149 ± 0.046	1975	22	2081	97	10535	48.784854	-121.787668
221105	1802		0.196 ± 0.011	1975	25	1567	59	16980	48.784339	-121.750665
221106	1850		0.205 ± 0.012	1975	30	1774	47	13108	48.787216	-121.758090
221107	1824		0.304 ± 0.014	1975	23	1529	39	14993	48.792648	-121.762625
221108	2494	Rainbow Glacier	1.784 ± 0.035	1975	21	1816	65	10151	48.796699	-121.779496
221109	2494	Rainbow Glacier	0.449 ± 0.017	1975	23	1778	142	2851	48.803991	-121.774117
221110	2494	Rainbow Glacier	0.133 ± 0.009	1975	24	1876	143	7425	48.807251	-121.771959
221201	1851		0.077 ± 0.007	1974	12	1665	280	3012	48.808421	-121.733469
221202	1874		0.234 ± 0.013	1974	19	1637	31	4427	48.814763	-121.734507
221203	1862; 1863; 1864		0.188 ± 0.011	1974	23	1641	335	3395	48.817605	-121.663308
221204	1866; 2489	Lower Curtis Glacier	0.873 ± 0.024	1974	24	1883	274	10780	48.827313	-121.618996
221205	2487	Sulphide Glacier	0.277 ± 0.014	1974	33	1999	273	11987	48.817935	-121.620280
221206	2487	Sulphide Glacier	0.119 ± 0.009	1974	34	2231	253	19624	48.814446	-121.616120

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
221301	1901; 2487	Sulphide Glacier	3.667 ± 0.050	1974	21	2108	136	15331	48.814109	-121.604566
221302	2486	Crystal Glacier	2.385 ± 0.040	1974	24	2233	166	20627	48.823502	-121.589532
221303	1882; 1912; 1913; 1914		0.257 ± 0.013	1974	30	1793	129	7488	48.813882	-121.570859
221304	1885		0.284 ± 0.014	1974	33	2010	174	19517	48.818713	-121.556972
221401	10479		0.276 ± 0.014	1974	31	1696	96	24769	48.820456	-121.541366
221402	1897		0.113 ± 0.009	1974	32	1976	214	10706	48.833593	-121.527805
221403	2439; 2444; 2445		0.272 ± 0.014	1974	28	1784	32	13112	48.841642	-121.526211
221404	2434; 2435		0.020 ± 0.004	1974	20	1763	87	1113	48.848791	-121.533099
221405	2437		0.230 ± 0.012	1974	26	1992	85	11740	48.860259	-121.528364
221406	2423		0.044 ± 0.005	1974	18	1761	81	877	48.859262	-121.509663
221501	2109; 2145		0.423 ± 0.017	1974	30	1541	78	21840	48.845963	-121.455179
221502	2145		0.083 ± 0.007	1974	36	1835	106	13793	48.854989	-121.457676
221503	2095		0.178 ± 0.011	1983	40	1759	294	13981	48.836938	-121.368287
221504	2090		0.116 ± 0.009	1974	25	1365	306	17534	48.837112	-121.377206
221601	10471		0.088 ± 0.008	1983	28	2201	218	20074	48.834874	-121.359844
221602	10471		0.113 ± 0.009	1983	25	2246	224	20082	48.834441	-121.355967
221603	2089		0.798 ± 0.023	1983	26	2144	233	11748	48.831234	-121.348519
221604	1742		0.160 ± 0.010	1983	34	2001	265	10154	48.820539	-121.346301
221605	1714		0.200 ± 0.012	1983	33	1682	328	14211	48.802031	-121.353753
221606	1707		0.697 ± 0.022	1983	27	1862	45	13368	48.791765	-121.381235
221701	1706		0.259 ± 0.013	1974	29	1993	323	5259	48.793127	-121.395109
221702	1765		0.096 ± 0.008	1974	25	1644	352	5522	48.750295	-121.387911
221703	1635		0.114 ± 0.009	1974	16	1507	19	8977	48.752239	-121.397030
221704	1603		0.438 ± 0.017	1985	30	1708	348	8850	48.748414	-121.418651
221705	2001		0.103 ± 0.008	1985	30	1824	348	7915	48.738462	-121.432372
221706	1988		0.153 ± 0.010	1985	23	1566	319	10308	48.742418	-121.435292
221707	2000		0.085 ± 0.008	1985	15	1388	333	10606	48.733354	-121.446935
221708	1998		0.100 ± 0.008	1985	36	1766	59	17154	48.736094	-121.463850
221709	1997		0.140 ± 0.010	1985	27	1594	14	13106	48.738846	-121.469023
221710	1994		0.071 ± 0.007	1985	30	1992	39	10968	48.738523	-121.480942
221711	1996		0.131 ± 0.009	1985	21	1438	64	20006	48.743406	-121.470331
221712	1999		0.041 ± 0.005	1985	34	1940	82	16541	48.745599	-121.478697
221713	1767		0.066 ± 0.007	1985	25	1742	132	1401	48.749647	-121.472587
221714	1646		0.473 ± 0.018	1974	25	1957	96	11183	48.756990	-121.473514
221801	1665		0.250 ± 0.013	1974	21	1833	347	4202	48.769948	-121.456870
221802	1763		0.083 ± 0.007	1974	33	1922	352	7880	48.762999	-121.469610
221803	1647; 1648		0.094 ± 0.008	1974	35	1784	318	10379	48.762439	-121.475787
221804	1646		0.276 ± 0.014	1974	33	1905	352	9963	48.759151	-121.480716
221805	1646		0.241 ± 0.013	1974	33	1899	359	9214	48.758974	-121.488733
221806	(Granshaw and Fountain 2006)		0.140 ± 0.010	1958	25	1789	345	9491	48.744321	-121.487520
221807	1995		0.045 ± 0.005	1985	28	2013	339	5801	48.741383	-121.484536
221808	1993		0.128 ± 0.009	1985	16	1950	315	5988	48.737087	-121.486837
221809	1986		1.123 ± 0.027	1985	21	1893	323	5186	48.727396	-121.497908

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221901	1969		0.779 ± 0.023	1974	16	1857	350	3485	48.672131	-121.527652
221902	1981		0.111 ± 0.009	1974	23	2076	283	14759	48.665233	-121.520572
221903	1970; 1978		0.144 ± 0.010	1974	23	1598	31	14187	48.654581	-121.562254
221904	1979		0.269 ± 0.013	1974	24	1735	20	7042	48.657771	-121.575390
222101	1981		1.294 ± 0.029	1974	16	1935	122	9087	48.662733	-121.509164
222102	1985		0.236 ± 0.013	1985	13	1633	235	3794	48.659262	-121.497011
222103	2014		0.094 ± 0.008	1985	17	1691	305	5238	48.647053	-121.490931
222201	2013		0.043 ± 0.005	1985	34	1794	77	21276	48.646897	-121.481466
222202	2012		0.185 ± 0.011	1985	33	1771	52	14648	48.651727	-121.485291
222203	1981		0.103 ± 0.008	1958	28	1717	89	10262	48.660723	-121.490619
222204	2015		0.071 ± 0.007	1985	21	1820	61	6049	48.664768	-121.491510
222205	1969		0.890 ± 0.024	1974	15	1822	0	1671	48.673399	-121.496716
222206	1969		1.149 ± 0.028	1974	21	1877	17	6023	48.671249	-121.510516
222207	1968		0.112 ± 0.009	1974	23	1864	19	3792	48.677441	-121.518532
222208	1992		0.352 ± 0.015	1985	26	1868	73	15413	48.732275	-121.482850
222209	2003		0.039 ± 0.005	1985	22	1875	129	7141	48.741737	-121.425237
222210	(Granshaw and Fountain 2006)		0.082 ± 0.007	1958	37	1665	278	3294	48.740799	-121.384011
222301	2030; 2031		0.536 ± 0.019	1983	27	1686	82	20787	48.703446	-121.348349
222302	2021; 2022		0.210 ± 0.012	1983	28	1522	0	11499	48.712177	-121.355895
222303	2024		0.125 ± 0.009	1983	27	1572	6	13807	48.711984	-121.367695
222304	2029		0.027 ± 0.004	1983	39	1376	53	17262	48.737327	-121.361870
222305	2006		0.205 ± 0.012	1983	33	1872	95	24124	48.739575	-121.373021
222306	2006; 2028		0.211 ± 0.012	1983	33	1800	37	14001	48.745523	-121.373690
222307	2026; 2027		0.084 ± 0.007	1983	32	1469	34	14587	48.746620	-121.365353
222308	1766		0.159 ± 0.010	1974	24	1549	18	12515	48.750345	-121.380711
222309	1707		0.287 ± 0.014	1974	26	1907	45	13481	48.784916	-121.374463
222310	1704		0.054 ± 0.006	1983	34	1658	199	347	48.793128	-121.357438
222311	1709		0.150 ± 0.010	1983	36	1708	84	23106	48.797208	-121.346015
222312	1723		0.103 ± 0.008	1983	39	1829	183	4942	48.805808	-121.322835
222313	1670		0.235 ± 0.013	1983	36	2121	227	16973	48.771949	-121.302288
222314	1664	Terror Glacier	0.728 ± 0.022	1983	28	2064	146	9822	48.766843	-121.289335
222315	1669		0.190 ± 0.011	1983	29	2077	165	13353	48.770712	-121.275235
222316	1661		0.215 ± 0.012	1983	21	1751	243	2677	48.764765	-121.275282
222401	1630		0.355 ± 0.015	1958	31	1357	40	14894	48.733232	-121.196974
222402	1629		0.186 ± 0.011	1958	29	1875	355	9722	48.732663	-121.208726
222403	1759; 2032; 2490		0.167 ± 0.011	1958	32	1578	59	18409	48.733240	-121.253341
222404	1771		0.169 ± 0.011	1983	30	1955	128	4598	48.752438	-121.251903
222405	1649		0.126 ± 0.009	1968	32	1490	30	13387	48.759205	-121.248909
222406	1640; 1651		0.097 ± 0.008	1983	33	1587	53	17411	48.760354	-121.253880
222407	1644		0.037 ± 0.005	1983	40	1937	7	12071	48.758679	-121.260788
222408	1675		0.286 ± 0.014	1983	34	1798	117	18121	48.772042	-121.267093
222501	2491	Neve Glacier	0.462 ± 0.018	1958	25	1901	316	8067	48.654405	-121.152469
222502	1619		0.181 ± 0.011	1958	29	1989	346	8281	48.646473	-121.167458

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222601	3131		0.077 ± 0.007	1958	23	2028	305	7079	48.578134	-121.187771
222602	3130		0.091 ± 0.008	1958	28	1691	13	11405	48.568213	-121.222812
222603	3343		0.355 ± 0.015	1983	33	1952	84	12053	48.583765	-121.268427
222701	3355		0.166 ± 0.011	1983	27	1936	314	9629	48.576613	-121.273562
223101	1678; 1682		0.533 ± 0.019	1983	38	1752	355	11569	48.776887	-121.282375
223102	1690; 1692; 1969; 1770		0.945 ± 0.025	1983	35	1776	29	15967	48.781100	-121.304836
223103	1710		0.142 ± 0.010	1983	34	2146	131	7663	48.800503	-121.303600
223104	1715		0.105 ± 0.008	1983	43	1821	72	21065	48.802989	-121.297904
223105	2481		0.629 ± 0.021	1983	31	2197	112	17343	48.808097	-121.304919
223201	2085; 2088; 2094		0.122 ± 0.009	1983	40	1883	333	13032	48.834756	-121.274462
223202	1740; 1743		0.358 ± 0.015	1983	30	1845	323	12419	48.819133	-121.289689
223203	2480		0.393 ± 0.016	1983	30	1930	2	12092	48.816896	-121.301706
223204	2479; 2480		0.375 ± 0.016	1983	42	2070	355	11204	48.814956	-121.311906
223205	1744; 1748; 10470		1.775 ± 0.034	1983	29	1732	55	17682	48.824534	-121.327642
223206	10470		0.307 ± 0.014	1983	30	2157	118	5779	48.839440	-121.333669
223207	(Granshaw and Fountain 2006)	Challenger Glacier	0.986 ± 0.026	1983	16	2016	81	3418	48.844927	-121.352685
223301	2146		1.008 ± 0.026	1983	23	2042	356	5551	48.857812	-121.320734
223302	10469	Challenger Glacier	3.397 ± 0.048	1975	23	2023	354	5310	48.844927	-121.352685
223303	(Granshaw and Fountain 2006)		0.350 ± 0.015	1975	26	2105	129	6442	48.844927	-121.352685
223304	2156	Whatcom Glacier	0.371 ± 0.016	1983	32	1766	56	17978	48.861821	-121.367480
223305	2287		0.050 ± 0.006	1983	22	2011	189	4988	48.923203	-121.302137
223401	2283		0.124 ± 0.009	1983	35	1984	30	13727	48.914737	-121.279530
223402	2285		0.057 ± 0.006	1983	32	2018	30	14324	48.916620	-121.283824
223403	2284		0.056 ± 0.006	1983	30	1913	34	13781	48.919548	-121.286050
223404	2196		0.064 ± 0.007	1983	32	1993	70	19346	48.922710	-121.292058
223405	2286		0.145 ± 0.010	1983	28	1973	59	17387	48.926720	-121.295501
223406	2280; 2281		0.138 ± 0.010	1983	31	2037	50	15309	48.930865	-121.301021
223407	2478	Redoubt Glacier	0.550 ± 0.019	1983	18	2303	126	12395	48.952508	-121.291710
223408	2218		0.100 ± 0.008	1983	29	2254	266	10864	48.945269	-121.263801
223501	2215		0.052 ± 0.006	1968	23	1653	30	13819	48.941177	-121.239455
223502	2216		0.523 ± 0.019	1983	29	2085	55	15538	48.942106	-121.252580
223503	2223		0.226 ± 0.012	1983	32	2068	69	19037	48.950805	-121.254945
223504	2229; 2296		0.351 ± 0.015	1968	29	2375	148	15243	48.964260	-121.241209
223601	2295		0.065 ± 0.007	1968	30	1676	16	11734	48.963873	-121.217577
223602	2230		0.110 ± 0.009	1968	35	1863	52	17019	48.964400	-121.226398
223603	2235		0.296 ± 0.014	1968	39	2223	72	11772	48.968509	-121.232344
223604	2241		0.149 ± 0.010	1968	35	2114	109	17537	48.974990	-121.229724
223605	2242		0.068 ± 0.007	1968	34	2361	318	4593	48.980172	-121.232363
223606	2292; 2294		0.833 ± 0.024	1968	26	2277	334	6986	48.976303	-121.242294
223607	2291		0.197 ± 0.011	1968	28	2342	120	7739	48.988969	-121.244266
223608	2270		0.409 ± 0.017	1958	30	1907	32	8592	48.999798	-121.216893
223609	2269		0.122 ± 0.009	1958	37	2371	11	4457	49.001916	-121.227646
223610	2268		0.805 ± 0.023	1958	26	2211	355	5658	48.999843	-121.239561

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223611	2265		0.309 ± 0.014	1983	30	2251	336	9201	48.993071	-121.250026
223612	2264		0.200 ± 0.012	1983	32	2143	352	11020	48.991760	-121.259765
223701	2134		0.148 ± 0.010	1968	23	1604	6	13231	48.850619	-121.138428
223702	2131		0.543 ± 0.019	1968	30	1989	24	10019	48.850840	-121.156187
223703	2136		0.109 ± 0.009	1968	28	1711	348	12176	48.854903	-121.165511
224201	2381		0.036 ± 0.005	1968	30	2062	16	9806	48.985448	-120.862428
224202	2372		0.034 ± 0.005	1968	42	2204	21	7414	48.984583	-120.865472
224203	2379		0.063 ± 0.006	1968	30	2079	3	7797	48.986770	-120.869627
224401	2045	Jerry Glacier	0.161 ± 0.010	1959	20	1991	9	13470	48.740817	-120.903567
224402	2045	Jerry Glacier	0.363 ± 0.016	1959	25	2128	31	9774	48.742676	-120.916008
224403	2047		0.008 ± 0.002	1959	35	2071	56	17800	48.746788	-120.921236
224404	1937		0.436 ± 0.017	1968	33	2036	33	12173	48.775965	-120.944852
224405	1929	Nohokomeen Glacier	1.801 ± 0.035	1968	23	2217	322	6543	48.779218	-120.968515
224501	1925		0.018 ± 0.003	1968	37	2275	145	16059	48.768615	-120.956469
224502	1926		0.212 ± 0.012	1968	25	2147	108	6822	48.770600	-120.945268
224601	3262		0.057 ± 0.006	1958	36	2034	21	12289	48.509098	-120.788119
224602	3245	Lewis Glacier	0.172 ± 0.011	1958	27	2079	17	13261	48.511804	-120.797087
224603	3240		0.081 ± 0.007	1958	31	2380	118	12111	48.525013	-120.810372
224604	3235		0.064 ± 0.007	1958	39	1994	68	20304	48.528217	-120.803854
224605	3248		0.056 ± 0.006	1958	34	2158	70	19803	48.531453	-120.808377
224606	3249		0.077 ± 0.007	1958	41	2065	32	15858	48.534364	-120.811945
224607	3254		0.044 ± 0.005	1958	33	2058	78	21340	48.546303	-120.820017
224608	3226		0.076 ± 0.007	1958	29	1983	28	13495	48.578450	-120.846385
224609	3228		0.060 ± 0.006	1958	34	2144	50	14963	48.579885	-120.852690
224610	2042		0.027 ± 0.004	1959	23	1950	22	11832	48.665562	-120.923577
224701	3210; 3230	Mesahchie Glacier	0.540 ± 0.019	1958	29	2127	348	9592	48.582611	-120.869574
224702	3185		0.214 ± 0.012	1958	31	2127	332	12472	48.582925	-120.882891
224703	3178	Katsuk Glacier	0.810 ± 0.023	1958	24	2207	31	10199	48.582620	-120.896804
224704	3180; 3181; 3214		0.141 ± 0.010	1958	30	2079	45	15905	48.587207	-120.900423
224705	3182; 3184	Kimtah Glacier	0.094 ± 0.008	1958	26	2101	348	8780	48.590913	-120.905385
224706	3182	Kimtah Glacier	0.831 ± 0.024	1958	31	2240	21	10839	48.589665	-120.918149
224707	3186		0.059 ± 0.006	1958	28	1910	358	13280	48.591579	-120.938133
224708	3197; 3213		0.123 ± 0.009	1958	29	2113	55	16645	48.596275	-120.978988
224709	3203		0.034 ± 0.005	1958	31	2154	46	14652	48.599659	-120.983709
224710	3201		0.055 ± 0.006	1958	28	2109	48	14998	48.604187	-120.987565
224711	3206; 3207		0.060 ± 0.006	1958	28	2119	60	17531	48.607098	-120.990236
224712	3083; 3208; 3209		0.109 ± 0.009	1958	31	2081	24	11506	48.613581	-120.996616
224713	2037; 2038		0.048 ± 0.006	1959	36	1976	357	10305	48.652688	-120.962473
224714	2036		0.107 ± 0.008	1959	30	2070	42	16481	48.649261	-120.953659
224801	1623		0.077 ± 0.007	1958	27	2085	10	10465	48.692262	-121.036817
225101	3255		0.070 ± 0.007	1958	35	2139	348	11582	48.547767	-120.825658
225102	3256		0.046 ± 0.006	1958	16	1874	327	16490	48.551629	-120.829642
225103	3257		0.025 ± 0.004	1958	34	1842	25	12540	48.553561	-120.837008

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
225104	3218		0.025 ± 0.004	1958	42	2146	20	12528	48.551456	-120.841299
225105	3220		0.169 ± 0.011	1958	31	2167	349	12462	48.550918	-120.849115
225106	3215; 3216		0.104 ± 0.008	1958	32	2003	20	12552	48.533865	-120.869472
225107	3150		0.184 ± 0.011	1958	31	2198	1	9138	48.525586	-120.910967
225108	3211	Banded-Douglas Glacier	0.459 ± 0.018	1958	25	2100	14	8224	48.528089	-120.925304
225109	3211	Banded-Douglas Glacier	0.968 ± 0.025	1958	29	2247	85	14441	48.534635	-120.941030
225110	3174; 3175		0.194 ± 0.011	1958	38	2179	86	21320	48.544419	-120.938668
225111	3173		0.189 ± 0.011	1958	26	1982	347	12474	48.550728	-120.941892
225112	3176		0.067 ± 0.007	1958	38	2204	15	10580	48.548490	-120.946716
225113	3177		0.200 ± 0.012	1958	33	2178	25	11585	48.551825	-120.956332
225114	3211	Banded-Douglas Glacier	0.728 ± 0.022	1958	21	2288	322	6992	48.543298	-120.952727
225115	3212	Fremont Glacier	0.948 ± 0.025	1958	19	2436	281	9186	48.531048	-120.957590
225201	3157; 3158; 3159		0.086 ± 0.008	1958	19	2283	205	1666	48.516378	-120.954022
225202	3152		0.059 ± 0.006	1958	26	2011	311	12140	48.503581	-120.955005
225203	3168; 3170	Thunder Glacier	0.227 ± 0.012	1958	35	1876	35	14430	48.502709	-120.984755
225204	3171	Thunder Glacier	0.166 ± 0.011	1958	33	2071	38	14367	48.505921	-120.995344
225205	3088	Boston Glacier	6.758 ± 0.067	1958	24	2132	23	7946	48.505570	-121.026977
225301	3044		0.069 ± 0.007	1958	34	2244	334	9881	48.527005	-121.043915
225302	(Granshaw and Fountain 2006)		0.138 ± 0.010	1958	34	2214	337	8308	48.525218	-121.050193
225303	3040; 3042; 3087		1.726 ± 0.034	1958	31	2083	325	10190	48.517605	-121.066167
225304	3039		0.154 ± 0.010	1958	31	1976	4	8601	48.517785	-121.089808
225305	3041		0.100 ± 0.008	1958	33	1935	25	12303	48.520307	-121.097657
225306	3361	Inspiration Glacier	4.479 ± 0.055	1958	23	2194	102	7648	48.538386	-121.116036
225307	3359		0.547 ± 0.019	1958	26	2271	208	7852	48.548536	-121.101156
225308	3053		0.118 ± 0.009	1958	31	2131	137	1883	48.545014	-121.093188
225309	3059; 3060	Klawatti Glacier	2.203 ± 0.038	1958	27	2226	85	11318	48.557677	-121.095602
225310	3070	North Klawatti Glacier	1.758 ± 0.034	1958	17	2127	113	13671	48.572618	-121.093802
225401	3062; 3063		0.226 ± 0.012	1958	23	2050	36	12085	48.566918	-121.060204
225402	3069		0.295 ± 0.014	1958	26	2164	74	12850	48.573036	-121.069203
225403	3073		0.152 ± 0.010	1958	31	2063	77	21700	48.581495	-121.072125
225501	3077	Borealis Glacier	1.208 ± 0.028	1958	24	2054	33	12717	48.587587	-121.085112
225502	3078		0.067 ± 0.007	1958	29	1938	0	10788	48.593840	-121.090704
225503	3076		0.054 ± 0.006	1958	21	2256	268	12063	48.589544	-121.098453
225504	3074		0.404 ± 0.016	1958	27	2210	306	9761	48.583738	-121.099418
225505	3072		0.195 ± 0.011	1958	36	2034	358	10164	48.581026	-121.114813
225506	3084; 3085		0.178 ± 0.011	1958	26	1714	16	13837	48.582837	-121.127080
225507	3066		0.053 ± 0.006	1958	28	2207	196	2313	48.577635	-121.120434
225508	3065		0.098 ± 0.008	1958	28	2228	221	5655	48.576366	-121.115711
225509	3358	McAllister Glacier	4.971 ± 0.058	1958	24	2064	338	9429	48.560562	-121.124638
225510	3148		0.299 ± 0.014	1958	32	1887	17	12078	48.565357	-121.150217
225511	3091		0.099 ± 0.008	1958	32	1802	33	13273	48.567455	-121.154392
225512	3091		0.874 ± 0.024	1958	30	1905	31	12902	48.570187	-121.165285
225513	3091		0.124 ± 0.009	1958	26	1806	28	13044	48.574991	-121.173807

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225514	3132		0.216 ± 0.012	1958	32	1871	46	15833	48.576760	-121.179256
225601	1617		0.184 ± 0.011	1958	32	1855	346	13381	48.638336	-121.108008
225602	2491	Neve Glacier	3.898 ± 0.051	1958	19	2096	52	9191	48.643996	-121.140128
225701	1621; 1762	Colonial Glacier	1.039 ± 0.026	1958	19	1969	16	5712	48.661668	-121.138663
225702	1760		0.199 ± 0.012	1958	25	2066	100	9841	48.669183	-121.147267
226101	3098		0.056 ± 0.006	1958	25	2148	204	19697	48.564814	-121.165326
226102	3098		0.071 ± 0.007	1958	31	2136	216	22257	48.562938	-121.160894
226103	3144; 3146		0.731 ± 0.022	1958	25	2231	256	18614	48.557125	-121.147551
226104	3099		0.122 ± 0.009	1958	29	2241	196	14435	48.548726	-121.143009
226105	3101		0.411 ± 0.017	1958	33	2231	272	14372	48.543323	-121.136869
226106	3111; 3112; 3114		0.201 ± 0.012	1958	35	1925	289	10600	48.529220	-121.146312
226107	3108; 3109; 3110		0.105 ± 0.008	1958	30	1854	263	10457	48.536513	-121.145280
226108	3122		0.300 ± 0.014	1958	35	1870	333	10302	48.522809	-121.156461
226109	3104; 3106		0.267 ± 0.013	1958	29	1949	331	7130	48.518806	-121.176797
226110	3356		0.405 ± 0.016	1983	17	1924	132	5618	48.570843	-121.271181
226201	3117; 3119; 3121		0.086 ± 0.008	1958	27	2106	183	13427	48.517383	-121.161559
226202	3116; 3120		0.082 ± 0.007	1958	32	2016	132	6536	48.519257	-121.152965
226203	3360; 3361	Eldorado Glacier	2.025 ± 0.037	1958	20	2237	158	14224	48.528070	-121.132792
226205	(Granshaw and Fountain 2006)		0.061 ± 0.006	1958	31	2049	243	12932	48.512953	-121.085204
226206	(Granshaw and Fountain 2006)		0.070 ± 0.007	1958	29	2135	237	19765	48.510248	-121.081115
226207	3036; 3038		0.322 ± 0.015	1958	24	2166	191	11168	48.508788	-121.071596
226208	3037		0.147 ± 0.010	1958	28	2282	210	14864	48.508469	-121.061326
226209	3089	Quien Sabe Glacier	0.677 ± 0.021	1958	26	2326	276	15094	48.494894	-121.043239
226210	2620		0.055 ± 0.006	1958	36	1758	15	11913	48.463063	-121.068693
226211	2618		0.060 ± 0.006	1958	39	1829	22	12080	48.464386	-121.075692
226212	2614; 2617		0.126 ± 0.009	1958	42	1654	19	13644	48.467428	-121.084176
226213	2608		0.270 ± 0.013	1958	38	2137	15	12609	48.469136	-121.094519
226301	2612		0.042 ± 0.005	1958	38	1941	221	11868	48.460392	-121.094620
226302	2590		0.077 ± 0.007	1958	26	2070	302	8110	48.432252	-121.042258
226303	2561	Middle Cascade Glacier	0.988 ± 0.026	1958	27	1960	337	11018	48.417349	-121.051927
226304	2561	Middle Cascade Glacier	0.287 ± 0.014	1958	36	2037	35	14968	48.419138	-121.062560
226305	2562		0.074 ± 0.007	1958	28	2110	319	8394	48.421707	-121.068579
226306	2563		0.059 ± 0.006	1958	40	2218	312	7453	48.417399	-121.070583
226307	2564		0.074 ± 0.007	1958	36	2191	315	10359	48.415263	-121.073908
226308	2565		0.070 ± 0.007	1958	37	2023	319	10835	48.414584	-121.081159
226401	2554		0.054 ± 0.006	1958	29	2174	212	16501	48.411340	-121.061238
226402	2557		0.048 ± 0.006	1958	35	2267	243	22373	48.411107	-121.058830
226403	2632		0.031 ± 0.005	1958	35	2152	341	8448	48.380712	-121.065207
226404	2775	LeConte Glacier	0.214 ± 0.012	1958	28	2181	280	12907	48.359298	-121.044779
226405	2819		0.063 ± 0.007	1958	28	2228	262	17220	48.354080	-121.044751
226406	10480	South Cascade Glacier	2.924 ± 0.044	1958	13	1916	352	3623	48.356983	-121.057349
226407	10481		0.492 ± 0.018	1958	31	2025	2	8385	48.359718	-121.077324
226408	2725		0.549 ± 0.019	1958	23	1876	25	10590	48.363612	-121.139971

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226410	2510		0.035 ± 0.005	1958	29	1709	358	15902	48.387256	-121.142181
226411	2508; 2509; 2511; 2512		0.089 ± 0.008	1958	27	1873	45	14654	48.389027	-121.153381
226412	2513		0.062 ± 0.006	1958	32	1910	15	11181	48.391994	-121.159421
226413	2514		0.047 ± 0.006	1958	31	1853	16	11203	48.393369	-121.164261
226501	2754		0.193 ± 0.011	1958	30	1667	313	8436	48.362287	-121.170537
226502	2721		0.819 ± 0.023	1958	30	1854	4	10298	48.356868	-121.206487
226503	2762		0.072 ± 0.007	1958	24	1646	30	13235	48.361461	-121.216616
226504	2770		0.053 ± 0.006	1958	30	1737	14	11874	48.367609	-121.227237
226505	2723		0.116 ± 0.009	1958	27	1690	26	13118	48.369245	-121.231834
226601	2515		0.047 ± 0.006	1958	34	1906	8	8837	48.396196	-121.235333
226602	2532		1.088 ± 0.027	1963	25	1953	2	4737	48.393801	-121.251639
226603	2545		0.117 ± 0.009	1963	26	1932	66	19575	48.400027	-121.270456
226604	2546		0.036 ± 0.005	1963	34	2099	95	12274	48.405690	-121.275369
226701	2549		0.254 ± 0.013	1963	23	2061	31	6061	48.410320	-121.273835
226702	2549		0.735 ± 0.022	1963	25	2008	9	7528	48.409979	-121.285279
226803	2548		0.090 ± 0.008	1963	26	2056	315	11684	48.407315	-121.295965
226804	2547		0.069 ± 0.007	1963	32	2008	333	8693	48.405517	-121.301746
226904	2541; 2542; 2543		0.066 ± 0.007	1963	36	1763	358	10390	48.377815	-121.316498
226905	2544		0.006 ± 0.002	1963	41	1756	0	10758	48.378736	-121.325194
227103	2738		0.086 ± 0.008	1958	26	1971	289	16716	48.354531	-121.221108
227104	2739		0.117 ± 0.009	1958	22	2076	192	18671	48.352050	-121.212978
227105	2741		0.105 ± 0.008	1958	18	2069	257	19240	48.348516	-121.204362
227106	2724		0.033 ± 0.005	1958	28	2046	310	11809	48.334494	-121.199006
227107	2737		0.029 ± 0.004	1958	27	1876	347	10231	48.315056	-121.219400
227201	2733		0.028 ± 0.004	1958	21	1678	146	25416	48.309554	-121.224439
227202	2745		0.080 ± 0.007	1958	32	1985	111	7011	48.329543	-121.197888
227203	2750		0.254 ± 0.013	1958	32	2000	112	8647	48.339218	-121.192633
227204	2752		0.743 ± 0.022	1958	33	1857	67	19453	48.347468	-121.195236
227205	2507		0.080 ± 0.007	1958	25	1732	63	21030	48.358900	-121.130276
227206	2793		0.025 ± 0.004	1958	17	1724	268	4684	48.346420	-121.069817
227207	2849		0.077 ± 0.007	1958	29	1982	342	6397	48.337258	-121.073825
227208	2783		0.040 ± 0.005	1958	27	2155	302	14283	48.334115	-121.072118
227209	2847		0.087 ± 0.008	1958	32	2106	286	7128	48.327182	-121.069088
227210	2781	Spire Glacier	0.928 ± 0.025	1958	29	2048	337	7854	48.321165	-121.080139
227211	2853		0.105 ± 0.008	1958	31	1791	15	12187	48.323847	-121.096116
227212	2824		0.031 ± 0.005	1958	14	1959	12	586	48.318719	-121.096815
227301	2856		0.156 ± 0.010	1958	25	2179	195	18108	48.315350	-121.081085
227302	2859		0.103 ± 0.008	1958	28	2234	180	14020	48.314202	-121.073104
227303	2846		0.040 ± 0.005	1958	24	2316	225	24369	48.314571	-121.069650
227304	2868		0.115 ± 0.009	1958	31	2133	183	11513	48.312586	-121.060171
227305	2869		0.033 ± 0.005	1958	37	2216	212	17979	48.311677	-121.054077
227306	2834	Dome Glacier	1.062 ± 0.027	1958	22	2367	254	18892	48.305784	-121.038771
227307	2835		0.121 ± 0.009	1958	29	2387	194	21853	48.299853	-121.036973

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227308	10468		0.181 ± 0.011	1958	33	2135	169	6576	48.298655	-121.024943
227309	2845		0.110 ± 0.009	1958	34	2275	219	14140	48.299487	-121.015969
227310	2838		0.325 ± 0.015	1958	20	2268	161	9312	48.296129	-121.006985
227311	2911		0.095 ± 0.008	1958	28	2121	270	6675	48.256382	-120.996705
227312	2963		0.324 ± 0.015	1984	23	2001	3	9501	48.246500	-121.021494
227313	3362		0.218 ± 0.012	1984	25	2093	34	12408	48.248732	-121.030938
227402	2968		0.171 ± 0.011	1984	27	1709	23	12821	48.169384	-120.928175
227501	3500		0.155 ± 0.010	1984	22	2097	26	5769	48.109951	-120.957481
227502	3501		0.053 ± 0.006	1984	22	2306	75	6560	48.107900	-120.969688
227503	3499		0.046 ± 0.006	1984	32	2073	30	13268	48.112457	-120.978969
227504	3485		0.043 ± 0.005	1984	20	2148	259	134	48.088098	-121.002224
227505	10472	Butterfly Glacier	0.413 ± 0.017	1984	29	2284	28	8341	48.079195	-121.017200
227506	3466		0.314 ± 0.015	1984	36	2045	359	10949	48.081737	-121.027536
227507	3493		0.027 ± 0.004	1984	45	2221	9	11091	48.079970	-121.034170
227508	3604	Honeycomb Glacier	3.432 ± 0.048	1984	15	2120	42	4401	48.073527	-121.064302
227601	3498		0.143 ± 0.010	1984	30	2162	359	6851	48.085174	-121.063578
227602	3467		0.171 ± 0.011	1984	29	2096	349	9852	48.084567	-121.071172
227603	9978	Suiattle Glacier	2.963 ± 0.045	1984	18	2190	17	2339	48.074270	-121.092249
227604	9979		0.870 ± 0.024	1984	18	2238	94	4821	48.085637	-121.105110
227605	3602		1.561 ± 0.032	1984	21	2459	143	19887	48.097179	-121.102404
227606	3600	Cool Glacier	1.698 ± 0.034	1984	25	2592	106	19652	48.106542	-121.097731
227607	3599	Chocolate Glacier	2.525 ± 0.041	1984	25	2456	72	7500	48.115111	-121.092042
227608	3598	North Guardian Glacier	1.087 ± 0.027	1984	24	2281	57	9956	48.122994	-121.090968
227609	3597	Dusty Glacier	1.376 ± 0.030	1984	25	2449	51	9680	48.126626	-121.099712
227701	3547		0.279 ± 0.014	1984	22	2153	25	6847	48.136660	-121.094008
227702	3595; 3596	Ermine Glacier	1.494 ± 0.032	1984	21	2281	3	5104	48.133786	-121.106095
227703	3595	Vista Glacier	1.009 ± 0.026	1984	23	2211	33	7287	48.136622	-121.115085
227801	3546		0.139 ± 0.010	1984	24	1974	356	5185	48.150760	-121.112231
227802	3593	Ptarmigan Glacier	1.205 ± 0.028	1984	27	2158	350	8150	48.139165	-121.127719
227803	3440	Milk Lake Glacier	0.256 ± 0.013	1984	12	1864	88	11542	48.151242	-121.155104
227904	3445		0.105 ± 0.008	1963	22	1786	347	6837	48.212983	-121.418072
228101	3594	Kennedy Glacier	1.569 ± 0.032	1984	28	2479	309	11136	48.124130	-121.123257
228102	3592	Scimitar Glacier	0.786 ± 0.023	1984	30	2462	320	9135	48.118135	-121.129267
228103	3534		0.090 ± 0.008	1984	28	2282	261	22034	48.115027	-121.137184
228104	3464	Sitkum Glacier	0.355 ± 0.015	1984	26	2724	245	26786	48.109781	-121.126181
228105	3464	Sitkum Glacier	0.514 ± 0.019	1984	24	2262	296	15888	48.109905	-121.138782
228201	3464	Sitkum Glacier	0.365 ± 0.016	1984	31	2588	203	24222	48.103941	-121.121917
228202	3454		0.247 ± 0.013	1984	27	2058	313	7840	48.078645	-121.124810
228203	3601	White Chuck Glacier	2.822 ± 0.043	1984	15	2145	279	9721	48.067106	-121.113957
228204	3528		0.142 ± 0.010	1984	32	1966	15	10156	48.084741	-121.203923
228307	3444		0.034 ± 0.005	1963	31	1836	358	10794	48.145571	-121.379417
228401	3505		0.684 ± 0.021	1958	22	1641	29	14420	47.972325	-121.328649
228402	3506		0.104 ± 0.008	1958	34	1775	66	17201	47.977113	-121.337181

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
228403	3523		0.038 ± 0.005	1958	36	1836	56	13840	47.982799	-121.341980
228404	3522		0.404 ± 0.016	1958	23	1488	66	19941	47.989503	-121.337949
228406	3438		0.513 ± 0.019	1963	29	1950	57	14411	48.043745	-121.333965
228407	3438		0.106 ± 0.008	1963	25	1883	59	15796	48.048020	-121.336115
228501	3519		0.068 ± 0.007	1958	29	1585	23	12223	47.997045	-121.351905
228503	3521		0.073 ± 0.007	1958	31	1935	37	12635	47.992564	-121.348197
228504	3520		0.029 ± 0.004	1958	26	2094	342	6699	47.991826	-121.352294
228505	3518		0.108 ± 0.009	1958	29	1737	22	12310	47.996534	-121.359261
228603	3516		0.156 ± 0.010	1958	31	1833	360	9785	47.969645	-121.353680
228604	3517		0.265 ± 0.013	1958	25	1916	291	14139	47.966096	-121.362573
231101	3424; 3426	So-Bahli-Alhi Glacier	0.382 ± 0.016	1983	31	1812	352	8269	48.214668	-121.680735
231102	3423		0.077 ± 0.007	1983	24	1589	300	10148	48.201022	-121.675453
231103	3418		0.047 ± 0.006	1983	19	1343	350	15938	48.180518	-121.688427
231104	3419		0.132 ± 0.009	1983	35	1804	1	9667	48.175795	-121.690654
231105	3420	Quest-Alb Glacier	0.649 ± 0.021	1983	25	1672	320	8474	48.170459	-121.698054
233101	3553; 3514		0.244 ± 0.013	1979	29	1389	318	16033	48.017917	-121.520794
233201	(Granshaw and Fountain 2006)		0.043 ± 0.005	1958	27	1885	104	12635	47.950899	-121.358726
233202	3513		0.037 ± 0.005	1958	29	1978	97	13270	47.954614	-121.356846
233203	3515		0.058 ± 0.006	1958	37	2026	74	15371	47.960466	-121.358743
233204	3512	Columbia Glacier	0.803 ± 0.023	1958	15	1616	154	13235	47.962417	-121.348465
233205	3509		0.087 ± 0.008	1958	29	1936	225	6278	47.968716	-121.340693
233206	3511		0.071 ± 0.007	1958	27	2099	116	21574	47.962035	-121.333502
233207	3510		0.017 ± 0.003	1958	34	2030	129	19799	47.963897	-121.330505
233208	3503		0.122 ± 0.009	1958	18	1319	111	28010	47.965837	-121.318288
233209	3504		0.053 ± 0.006	1958	21	1509	49	17984	47.970418	-121.310273
233401	3432		0.116 ± 0.009	1958	19	1919	351	11029	47.585497	-121.176865
233402	3608	Lynch Glacier	0.878 ± 0.024	1958	19	2084	9	5515	47.572214	-121.180507
233403	3431		0.133 ± 0.009	1958	32	1985	312	4732	47.571371	-121.190610
233404	3430		0.291 ± 0.014	1958	18	1822	349	6582	47.570448	-121.196340
233405	3427		0.905 ± 0.025	1958	20	2099	48	7369	47.571952	-121.209701
233406	3428		0.141 ± 0.010	1958	24	1993	320	5111	47.576369	-121.220347
233407	3429	Hinman Glacier	1.259 ± 0.029	1958	16	1921	344	6819	47.574730	-121.228776
233408	3411		0.021 ± 0.004	1958	22	1718	36	14635	47.554424	-121.281377
233409	3404		0.087 ± 0.008	1958	20	1704	9	13335	47.555681	-121.290870
234203	3415		0.142 ± 0.010	1958	24	1798	324	4403	47.522595	-121.283024
234204	3416		0.376 ± 0.016	1958	20	1993	42	7137	47.516656	-121.288942
241302	3399		0.127 ± 0.009	1957	34	1969	120	15132	47.489234	-121.299865
241303	3400		0.163 ± 0.010	1957	32	1919	107	13596	47.494687	-121.295897
241304	3401		0.034 ± 0.005	1957	32	1713	146	18114	47.497277	-121.290612
241305	3402		0.460 ± 0.018	1958	29	1814	119	17133	47.502594	-121.284939
241306	3417		0.158 ± 0.010	1958	26	1683	67	18653	47.509380	-121.279716
241307	3416		0.214 ± 0.012	1958	22	2069	38	6069	47.511673	-121.287716
241501	3436		0.192 ± 0.011	1958	19	2003	65	10474	47.559010	-121.162270

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
241502	3433		0.049 ± 0.006	1958	25	2052	4	9805	47.565423	-121.162763
241503	3434		0.038 ± 0.005	1958	29	2016	1	9843	47.566156	-121.159347
241504	3607		0.435 ± 0.017	1958	25	2212	47	10332	47.566368	-121.172187
242201	3382		0.050 ± 0.006	1957	33	2270	51	8078	47.472119	-120.784918
242202	3369		0.111 ± 0.009	1957	26	2369	21	12803	47.487063	-120.813042
242203	3378		0.118 ± 0.009	1957	21	2449	35	7028	47.471819	-120.814654
242204	3377	Snow Creek Glacier	0.058 ± 0.006	1957	23	2439	18	5147	47.473905	-120.818758
242205	3377	Snow Creek Glacier	0.047 ± 0.006	1957	22	2468	39	6274	47.473625	-120.822061
242206	3370		0.036 ± 0.005	1957	28	2566	83	6606	47.475416	-120.826456
242207	3370		0.095 ± 0.008	1957	28	2490	59	9878	47.478389	-120.828608
242208	3368	Colchuck Glacier	0.066 ± 0.007	1957	38	2265	1	11930	47.478798	-120.838621
242209	3368	Colchuck Glacier	0.114 ± 0.009	1957	32	2100	8	11577	47.480924	-120.840082
242210	3373		0.021 ± 0.004	1957	33	2065	351	11336	47.470696	-120.869167
242211	3384	Sherpa Glacier	0.141 ± 0.010	1957	36	2166	30	13290	47.475423	-120.890013
242212	3395	Stuart Glacier	0.143 ± 0.010	1957	32	2235	22	10754	47.479602	-120.901018
242213	3391		0.093 ± 0.008	1957	31	2277	49	10523	47.481016	-120.909199
242214	3390		0.012 ± 0.003	1957	29	2326	73	5545	47.483156	-120.911469
242401	3566		0.164 ± 0.010	1963	28	2312	79	6715	47.700484	-120.930952
242601	3437		0.073 ± 0.007	1963	30	2038	341	8064	47.964245	-120.991458
242606	3588		0.114 ± 0.009	1984	32	2002	357	10510	48.010750	-121.086422
242607	3589		0.244 ± 0.013	1984	29	2001	11	10308	48.010968	-121.095021
242608	3590		0.267 ± 0.013	1984	25	2094	355	3790	48.009320	-121.103398
242609	3591		0.124 ± 0.009	1984	28	1955	345	5267	48.009331	-121.111762
242610	3603	White River Glacier	1.291 ± 0.029	1984	17	2258	191	16429	48.058131	-121.095750
242611	3603	White River Glacier	0.328 ± 0.015	1984	15	2175	84	9177	48.054037	-121.085432
242612	3604	Honeycomb Glacier	0.526 ± 0.019	1984	21	2314	90	13731	48.063400	-121.074275
242701	10475	Clark Glacier	1.312 ± 0.030	1984	26	2267	26	9520	48.049334	-120.954284
242703	10474	Richardson Glacier	0.746 ± 0.022	1984	22	2259	54	9573	48.056361	-120.974305
242704	3492		0.060 ± 0.006	1984	26	1896	49	17431	48.062927	-120.969817
242705	3492		0.074 ± 0.007	1984	24	1999	64	20332	48.063417	-120.974148
242706	10473	Pit Glacier	0.905 ± 0.025	1984	22	2241	70	8931	48.066208	-120.982565
242707	10472	Butterfly Glacier	1.287 ± 0.029	1984	27	2222	1	7830	48.069404	-120.998128
242708	10472	Butterfly Glacier	0.424 ± 0.017	1984	28	2296	55	12958	48.074577	-121.010795
242709	3489		0.142 ± 0.010	1984	16	2478	265	14385	48.090637	-120.915354
242801	3490		0.080 ± 0.007	1984	24	2273	60	10968	48.063738	-120.903184
242802	3491		0.319 ± 0.015	1984	28	2091	47	15552	48.070829	-120.910468
242803	3488		0.089 ± 0.008	1984	35	2311	61	15489	48.092005	-120.907659
242804	3502		0.127 ± 0.009	1984	32	1795	4	11298	48.097559	-120.916015
242805	2971	Spider Glacier	0.057 ± 0.006	1984	22	1956	115	24233	48.162640	-120.879981
243101	2998		0.019 ± 0.004	1984	25	1794	359	12091	48.099520	-120.759079
243102	2999; 3000		0.106 ± 0.008	1984	33	2126	12	11737	48.098442	-120.769437
243103	3001; 3002; 3003		0.087 ± 0.008	1984	34	2085	23	11987	48.101342	-120.776491
243104	3005		0.056 ± 0.006	1984	28	2221	47	14132	48.104379	-120.791227

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243105	3006; 3007		0.094 ± 0.008	1984	30	2241	38	14319	48.114804	-120.796174
243106	2985		0.084 ± 0.007	1984	22	2262	28	5055	48.126293	-120.802909
243201	2980		0.125 ± 0.009	1984	24	2157	26	12251	48.131958	-120.761892
243202	2982		0.121 ± 0.009	1984	27	2185	15	12052	48.137164	-120.774053
243203	2984	Entiat Glacier	0.803 ± 0.023	1984	32	2260	13	9487	48.141031	-120.795035
243204	2975		0.331 ± 0.015	1984	26	1936	68	20704	48.148368	-120.802902
243205	2990		0.141 ± 0.010	1984	31	2322	134	13865	48.156717	-120.806363
244201	2989		0.178 ± 0.011	1984	30	2412	52	8646	48.164346	-120.797432
244202	2988		0.200 ± 0.012	1984	33	2205	57	16330	48.171924	-120.795710
244204	2987		0.186 ± 0.011	1984	32	2348	335	13949	48.166768	-120.808242
244205	2977		0.238 ± 0.013	1984	28	2184	337	8029	48.154487	-120.821305
244207	2993		0.192 ± 0.011	1984	29	2389	86	13596	48.186601	-120.847250
244209	2991		0.036 ± 0.005	1984	28	2037	6	11334	48.193773	-120.838703
244210	2992		0.084 ± 0.008	1984	35	2174	34	13359	48.192491	-120.845396
244211	3012		0.044 ± 0.005	1984	41	2378	357	8626	48.181470	-120.860988
244212	2971	Spider Glacier	0.058 ± 0.006	1984	23	2126	123	14636	48.167691	-120.881820
244213	2967	Lyman Glacier	0.464 ± 0.018	1984	20	1957	16	11475	48.171757	-120.896359
244214	2969		0.073 ± 0.007	1984	41	2269	54	17211	48.175300	-120.908579
244215	2970		0.117 ± 0.009	1984	38	2133	36	13827	48.178992	-120.910784
244217	2995	Isella Glacier	0.527 ± 0.019	1984	26	2483	153	14562	48.233326	-120.868164
244218	2997	Mary Green Glacier	0.564 ± 0.019	1984	26	2398	89	13067	48.238056	-120.856856
244220	2996		0.075 ± 0.007	1984	32	2186	77	21027	48.246290	-120.851436
244221	2918	Company Glacier	1.252 ± 0.029	1984	32	2202	33	13632	48.246986	-120.868434
244222	2994		0.207 ± 0.012	1984	27	2357	71	14341	48.240425	-120.811307
244223	2933		0.015 ± 0.003	1958	36	2215	20	11284	48.252656	-120.762192
244301	2937		0.005 ± 0.002	1958	41	2091	24	12287	48.280768	-120.863976
244302	2913	Dark Glacier	0.678 ± 0.021	1958	34	2188	2	11798	48.259384	-120.886773
244303	2974	Grant Glacier	0.364 ± 0.016	1984	26	2219	11	7296	48.226544	-120.899014
244306	2910		0.063 ± 0.006	1958	28	2099	359	5686	48.264343	-120.960445
244307	2877		0.264 ± 0.013	1958	25	1711	27	13863	48.258025	-120.983499
244308	2919		0.222 ± 0.012	1958	23	2267	126	7476	48.296552	-120.999377
244401	2900		0.139 ± 0.010	1958	26	1784	33	14666	48.311722	-120.958987
244402	2891		0.120 ± 0.009	1958	14	1720	342	16090	48.310536	-120.978013
244403	2897	Blue Glacier	0.354 ± 0.015	1958	31	2230	54	14191	48.308378	-120.990946
244404	2876		0.145 ± 0.010	1958	31	2032	280	358	48.317995	-120.999962
244405	2883		0.017 ± 0.003	1958	21	2157	239	133	48.314389	-120.996562
244406	2893		0.088 ± 0.008	1958	35	2154	297	8355	48.311351	-120.997449
244407	10467	Chickamin Glacier	4.845 ± 0.057	1958	24	2107	15	9800	48.311192	-121.015776
244408	2792	Dana Glacier	1.584 ± 0.033	1958	24	2099	3	8311	48.316682	-121.046761
244409	2792	Dana Glacier	0.938 ± 0.025	1958	27	2164	59	11249	48.321515	-121.062800
244410	2784		0.049 ± 0.006	1958	32	2158	66	17925	48.331489	-121.068466
244411	2787		0.055 ± 0.006	1958	32	2088	102	22016	48.335672	-121.067403
244412	2798		0.050 ± 0.006	1958	24	1959	103	23560	48.341837	-121.062327

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244413	2799		0.043 ± 0.005	1958	19	1922	191	3	48.342422	-121.050066
244414	2805		0.077 ± 0.007	1958	35	2063	122	16692	48.351555	-121.039497
244415	2775	LeConte Glacier	0.117 ± 0.009	1958	29	2344	110	10820	48.355141	-121.030974
244416	2820		0.116 ± 0.009	1958	39	2086	104	24168	48.356833	-121.026044
244417	2775	LeConte Glacier	0.242 ± 0.013	1958	31	2159	79	13619	48.362794	-121.023975
244501	2821		0.027 ± 0.004	1958	20	1647	3	14455	48.372960	-121.010442
244502	2822		0.030 ± 0.005	1958	27	1928	347	11660	48.368987	-121.021274
244503	2775	LeConte Glacier	0.165 ± 0.011	1958	28	2128	23	7774	48.366944	-121.026007
244504	2775	LeConte Glacier	1.581 ± 0.033	1958	23	2194	345	8244	48.363878	-121.036953
244505	2552		0.331 ± 0.015	1958	30	2066	68	19393	48.378303	-121.054803
244506	2555		0.031 ± 0.005	1958	27	2017	72	21072	48.402777	-121.060135
244507	2556		0.141 ± 0.010	1958	32	2170	177	6441	48.410019	-121.051834
244508	2578		0.145 ± 0.010	1958	30	2238	118	16080	48.406409	-121.032279
244509	2577		0.023 ± 0.004	1958	42	2056	97	23466	48.408590	-121.020166
244510	2576		0.050 ± 0.006	1958	39	1843	6	12951	48.412189	-121.018302
244511	2572	Spider Glacier	0.245 ± 0.013	1958	33	2008	358	11209	48.412289	-121.025970
244512	2572	Spider Glacier	0.314 ± 0.015	1958	35	2039	22	12028	48.414425	-121.036448
244513	2569		0.036 ± 0.005	1958	31	2154	42	12953	48.417905	-121.044169
244514	2568		0.056 ± 0.006	1958	32	1921	73	21288	48.420752	-121.042669
244515	2571		0.102 ± 0.008	1958	22	1653	59	18920	48.420380	-121.035983
244516	2573		0.099 ± 0.008	1958	15	1338	98	26587	48.421328	-121.025686
244517	2575		0.046 ± 0.006	1958	30	1159	29	13640	48.419025	-121.007521
244518	2587		0.019 ± 0.004	1958	35	2086	185	508	48.429956	-121.037408
244519	2586		0.024 ± 0.004	1958	38	2013	106	20329	48.430986	-121.028868
244601	2664		0.093 ± 0.008	1958	30	1925	334	12489	48.434029	-120.980205
244602	2585	South Glacier	0.278 ± 0.014	1958	35	2069	34	12802	48.434481	-121.033126
244603	2583	S Glacier	0.129 ± 0.009	1958	27	1587	68	20818	48.440407	-121.029094
244604	2582		0.075 ± 0.007	1958	22	1591	126	28727	48.448105	-121.023612
244605	2594		0.024 ± 0.004	1958	28	2006	100	10227	48.448051	-121.030165
244606	2595		0.032 ± 0.005	1958	29	2019	131	3306	48.446769	-121.033034
244607	2598; 2603	Yawning Glacier	0.160 ± 0.010	1958	30	1831	359	12690	48.449491	-121.038458
244608	2602		0.060 ± 0.006	1958	33	2004	18	13108	48.449513	-121.048475
244609	2604; 2622		0.293 ± 0.014	1958	26	1957	43	15182	48.453529	-121.055023
244610	3282	Sahale Glacier	0.155 ± 0.010	1958	28	2416	173	25327	48.487673	-121.040945
244611	3274	Davenport Glacier	0.264 ± 0.013	1958	27	2278	138	10191	48.492188	-121.030333
244612	3272		0.032 ± 0.005	1958	27	2208	265	7607	48.482759	-120.999838
244613	2636		0.134 ± 0.009	1958	19	2286	291	7012	48.478513	-120.991513
244614	2637; 2655		0.078 ± 0.007	1958	20	2168	178	2828	48.473908	-120.990924
244615	2651; 2656		0.038 ± 0.005	1958	26	2328	197	15234	48.471631	-120.975740
244616	2658		0.053 ± 0.006	1958	39	2143	40	13826	48.469464	-120.966486
244617	2650		0.052 ± 0.006	1958	38	1859	33	14027	48.473997	-120.967959
244618	2639		0.021 ± 0.004	1958	45	1692	43	15055	48.479315	-120.974669
244619	3306		0.029 ± 0.004	1958	23	1566	68	21527	48.484247	-120.978683

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244620	3307; 3309		0.269 ± 0.013	1958	27	2013	62	19194	48.483666	-120.990238
244621	3309	Buckner Glacier	0.293 ± 0.014	1958	34	2340	125	17207	48.489827	-120.995724
244622	3287		0.275 ± 0.014	1958	35	2239	120	19022	48.495458	-120.990164
244623	3304; 3305		0.082 ± 0.007	1958	30	2292	245	6209	48.483853	-120.919697
244624	2647		0.019 ± 0.004	1958	24	2122	80	21105	48.473577	-120.906225
244625	2648		0.013 ± 0.003	1958	36	2174	44	14291	48.471774	-120.906093
244701	2645		0.035 ± 0.005	1958	35	2122	67	19728	48.478254	-120.889991
244702	3311		0.068 ± 0.007	1958	36	2222	79	16972	48.481529	-120.892250
244703	3297; 3298; 3301; 3302		0.584 ± 0.020	1958	35	1970	27	12978	48.487228	-120.903460
244704	3296		0.197 ± 0.011	1958	37	2167	26	13721	48.489526	-120.916929
244705	3284		0.045 ± 0.006	1958	41	1639	34	13918	48.496498	-120.915675
244706	3283		0.018 ± 0.003	1958	32	1912	37	15297	48.496788	-120.926075
244707	3292		0.069 ± 0.007	1958	37	2457	149	15219	48.490611	-120.927820
244708	3156; 3285	Wyeth Glacier	0.841 ± 0.024	1958	29	2252	32	12041	48.495332	-120.940589
244709	3155		0.104 ± 0.008	1958	36	2068	62	17824	48.511117	-120.945782
244710	3161; 3162; 3163; 3164; 3165		0.251 ± 0.013	1958	36	2245	119	15249	48.524763	-120.947603
244711	3247		0.049 ± 0.006	1958	34	2321	325	10302	48.529220	-120.812261
244712	3242		0.247 ± 0.013	1958	34	2155	341	12484	48.527464	-120.820207
244713	3234		0.078 ± 0.007	1958	25	2214	322	3082	48.504098	-120.793194
244714	3315; 3316; 3317		0.082 ± 0.007	1958	28	2080	349	10815	48.492862	-120.818588
244801	3314		0.033 ± 0.005	1958	19	1898	67	22068	48.497327	-120.755178
244802	3319		0.036 ± 0.005	1958	27	2190	59	16719	48.489959	-120.754465
244803	3320	Lyell Glacier	0.252 ± 0.013	1968	26	2057	11	12535	48.488253	-120.745696
244804	3326		0.021 ± 0.004	1968	17	1968	66	23022	48.488464	-120.734143
244805	2687; 2692		0.141 ± 0.010	1958	36	2099	28	12655	48.406639	-120.775159
244806	2686; 2694		0.064 ± 0.007	1958	33	2127	36	13690	48.409134	-120.780257
244807	2693	Sandalee Glacier	0.101 ± 0.008	1958	31	2192	4	10207	48.408514	-120.784353
244808	2696	Sandalee Glacier	0.216 ± 0.012	1958	26	2158	10	9712	48.409341	-120.789954
244809	2695	Sandalee Glacier	0.090 ± 0.008	1958	32	2302	38	9693	48.409159	-120.795142
244810	2695	Sandalee Glacier	0.165 ± 0.011	1958	28	2260	29	9024	48.411269	-120.797997
244811	2685		0.022 ± 0.004	1958	23	2235	295	6524	48.409712	-120.804428
245101	2534		0.039 ± 0.005	1968	35	2351	22	10311	48.252727	-120.428273
245302	3271		0.075 ± 0.007	1985	34	2418	360	9516	48.507955	-120.484308
245303	3270		0.068 ± 0.007	1958	29	2222	21	11015	48.549704	-120.574034
245304	3266		0.109 ± 0.009	1958	33	2391	34	6969	48.550433	-120.581819
245305	3265		0.092 ± 0.008	1958	29	2440	27	6352	48.551571	-120.586285
245306	3265		0.024 ± 0.004	1958	35	2383	43	6959	48.553664	-120.588578
245307	3265		0.034 ± 0.005	1958	32	2286	33	10515	48.555529	-120.590182
245401	3090		0.017 ± 0.003	1958	44	2198	16	13034	48.587822	-120.698106
245402	3079		0.063 ± 0.006	1958	31	2119	36	15056	48.589477	-120.700739
245403	3080		0.069 ± 0.007	1958	22	2090	5	11787	48.594116	-120.708858
245405	3081		0.043 ± 0.005	1958	36	2079	334	12938	48.606315	-120.733547
245501	2050		0.027 ± 0.004	1958	21	2380	72	16811	48.727505	-120.568529

BasinID	RECNO (s)	Glacier Name	Area (km^2)	Year	S_{mean}	Z_{mean}	A_{mean}	I_{mean}	Latitude	Longitude
245503	2451		0.035 ± 0.005	1968	35	2365	32	11530	48.826194	-120.526267
245504	2452		0.022 ± 0.004	1968	36	2463	42	6941	48.826936	-120.530826
245505	2453		0.017 ± 0.003	1968	30	2411	68	13126	48.828932	-120.531755
245506	2447		0.002 ± 0.001	1968	27	2388	106	20536	48.830222	-120.531431
245507	2476		0.021 ± 0.004	1968	27	2277	38	15438	48.835465	-120.528301
245508	2449		0.067 ± 0.007	1968	35	2311	28	11575	48.866375	-120.527610
245509	2450		0.044 ± 0.005	1968	34	2284	36	10895	48.869056	-120.532636
246301	2467		0.015 ± 0.003	1968	32	2328	351	8880	48.854324	-120.542841
246302	2456		0.046 ± 0.006	1968	37	2382	355	8512	48.831123	-120.538882
246303	2455		0.044 ± 0.005	1968	31	2278	5	10822	48.831590	-120.548602
246304	2462		0.017 ± 0.003	1968	39	2295	14	10594	48.833157	-120.551911
246305	2468		0.036 ± 0.005	1968	33	2256	331	10627	48.834386	-120.556347
246306	2454		0.026 ± 0.004	1968	29	2222	31	13683	48.830022	-120.571202
246307	2448		0.050 ± 0.006	1968	37	2302	12	11923	48.833366	-120.576150
246501	2369		0.059 ± 0.006	1968	32	2071	35	13389	48.981290	-120.854641
246502	2371		0.060 ± 0.006	1968	23	2036	42	15110	48.984269	-120.857956
2211011	2501	Squak Glacier	2.128 ± 0.038	1975	22	2223	155	25071	48.751062	-121.813586
22110301	2502	Boulder Glacier	2.439 ± 0.038	1975	9999	9999	9999	9969	48.776969	-121.790165

Appendix B – Temporal Glacier Inventories

Each temporal inventory is compiled below for each individual glacier. The BasinID matches the 24K subset, and features with 'NoData' were not used in the analysis.

BasinID	1900 Area (km^2)
211401	0.222 ± 0.012
211402	0.452 ± 0.017
211403	0.226 ± 0.012
211404	0.042 ± 0.005
211405	0.166 ± 0.011
211406	0.063 ± 0.006
211407	0.048 ± 0.006
211408	0.383 ± 0.016
211409	0.089 ± 0.008
211410	0.053 ± 0.006
211411	0.072 ± 0.007
211412	0.275 ± 0.014
211413	0.123 ± 0.009
211414	0.029 ± 0.004
211415	0.102 ± 0.008
211501	0.153 ± 0.010
211502	0.189 ± 0.011
211503	0.050 ± 0.006
211504	0.296 ± 0.014
211505	0.220 ± 0.012
211506	3.584 ± 0.049
211507	1.698 ± 0.034
211508	0.725 ± 0.022
211509	0.342 ± 0.015
211510	0.302 ± 0.014
211601	NoData
211602	0.062 ± 0.006
211603	0.723 ± 0.022
211604	0.342 ± 0.015
211701	0.082 ± 0.007
211702	0.059 ± 0.006
211801	0.506 ± 0.018
211802	0.332 ± 0.015
211803	0.224 ± 0.012
211804	0.972 ± 0.026
211901	0.188 ± 0.011
211902	0.100 ± 0.008
212301	0.356 ± 0.015
212302	1.076 ± 0.027
212303	1.286 ± 0.029
212304	5.671 ± 0.062
212305	0.611 ± 0.020
212306	3.275 ± 0.047
212307	0.182 ± 0.011
212401	1.319 ± 0.030
212402	1.516 ± 0.032
212702	5.095 ± 0.058
212703	5.447 ± 0.060
213105	6.509 ± 0.066
221101	4.191 ± 0.053
221103	5.479 ± 0.061
221204	1.480 ± 0.031
221205	0.532 ± 0.019
221206	0.383 ± 0.016
221301	5.571 ± 0.061
221302	3.576 ± 0.049

BasinID	1900 Area (km^2)
221303	0.849 ± 0.024
221304	0.593 ± 0.020
221401	0.647 ± 0.021
221402	0.704 ± 0.022
221403	0.795 ± 0.023
221404	0.560 ± 0.019
221406	0.326 ± 0.015
221501	0.641 ± 0.021
221502	0.097 ± 0.008
221503	0.297 ± 0.014
221504	0.181 ± 0.011
221601	0.107 ± 0.008
221602	0.122 ± 0.009
221603	1.256 ± 0.029
221604	0.579 ± 0.020
221605	NoData
221606	1.168 ± 0.028
221701	0.623 ± 0.020
221702	0.609 ± 0.020
221703	NoData
221704	0.883 ± 0.024
221705	0.209 ± 0.012
221706	0.356 ± 0.015
221707	0.092 ± 0.008
221708	NoData
221709	0.235 ± 0.013
221710	0.199 ± 0.012
221711	0.134 ± 0.009
221712	0.050 ± 0.006
221713	NoData
221714	0.588 ± 0.020
221801	0.287 ± 0.014
221802	0.118 ± 0.009
221803	0.246 ± 0.013
221804	0.556 ± 0.019
221805	0.580 ± 0.020
221806	0.321 ± 0.015
221807	0.141 ± 0.010
221808	0.364 ± 0.016
221809	1.510 ± 0.032
221901	1.220 ± 0.029
221902	0.164 ± 0.010
221903	0.306 ± 0.014
222101	NoData
222102	1.271 ± 0.029
222103	0.516 ± 0.019
222202	0.211 ± 0.012
222204	0.136 ± 0.010
222205	1.589 ± 0.033
222206	1.483 ± 0.032
222207	0.436 ± 0.017
222208	0.787 ± 0.023
222209	0.175 ± 0.011
222210	0.083 ± 0.007
222301	0.921 ± 0.025
222302	0.610 ± 0.020

BasinID	1900 Area (km^2)
222303	0.219 ± 0.012
222304	0.079 ± 0.007
222305	0.476 ± 0.018
222306	0.369 ± 0.016
222307	0.144 ± 0.010
222308	0.367 ± 0.016
222309	0.420 ± 0.017
222311	0.213 ± 0.012
222312	0.284 ± 0.014
222313	0.405 ± 0.016
222314	1.249 ± 0.029
222315	0.355 ± 0.015
222316	0.815 ± 0.023
222401	0.446 ± 0.017
222402	0.490 ± 0.018
222403	0.396 ± 0.016
222404	0.245 ± 0.013
222405	0.344 ± 0.015
222406	0.356 ± 0.015
222407	0.463 ± 0.018
222408	0.699 ± 0.022
222501	1.218 ± 0.029
222502	0.691 ± 0.022
222601	0.183 ± 0.011
222602	0.364 ± 0.016
222603	0.877 ± 0.024
222701	0.362 ± 0.016
223101	1.427 ± 0.031
223102	1.591 ± 0.033
223103	0.299 ± 0.014
223104	0.204 ± 0.012
223105	0.974 ± 0.026
223201	0.132 ± 0.009
223202	0.902 ± 0.025
223203	0.594 ± 0.020
223204	0.611 ± 0.020
223205	3.597 ± 0.049
223206	0.714 ± 0.022
223207	1.471 ± 0.031
223301	1.754 ± 0.034
223302	5.209 ± 0.059
223303	0.463 ± 0.018
223304	0.564 ± 0.019
223305	0.176 ± 0.011
223401	0.303 ± 0.014
223402	0.123 ± 0.009
223403	0.262 ± 0.013
223404	0.230 ± 0.012
223405	0.359 ± 0.015
223406	0.164 ± 0.010
223407	0.663 ± 0.021
223408	0.537 ± 0.019
223501	0.165 ± 0.011
223502	0.705 ± 0.022
223503	0.362 ± 0.016
223504	0.548 ± 0.019

BasinID	1900 Area (km^2)
223601	0.158 ± 0.010
223602	0.332 ± 0.015
223603	0.466 ± 0.018
223604	0.433 ± 0.017
223605	0.096 ± 0.008
223606	1.183 ± 0.028
223607	0.311 ± 0.014
223609	0.283 ± 0.014
223610	0.974 ± 0.026
223611	0.546 ± 0.019
223701	0.244 ± 0.013
223702	1.137 ± 0.028
223703	0.268 ± 0.013
224701	0.876 ± 0.024
224702	0.311 ± 0.014
224703	1.085 ± 0.027
224704	0.376 ± 0.016
224705	0.157 ± 0.010
224706	1.021 ± 0.026
224707	0.107 ± 0.008
224708	0.327 ± 0.015
224709	0.118 ± 0.009
224710	0.138 ± 0.010
224711	0.170 ± 0.011
224713	0.138 ± 0.010
224714	0.325 ± 0.015
224801	0.558 ± 0.019
225101	0.144 ± 0.010
225102	0.114 ± 0.009
225103	0.344 ± 0.015
225104	0.126 ± 0.009
225105	0.625 ± 0.020
225106	0.379 ± 0.016
225107	0.692 ± 0.022
225108	1.000 ± 0.026
225109	1.587 ± 0.033
225110	0.441 ± 0.017
225111	0.490 ± 0.018
225112	0.251 ± 0.013
225113	0.696 ± 0.022
225114	1.058 ± 0.027
225115	1.713 ± 0.034
225201	0.281 ± 0.014
225202	0.171 ± 0.011
225203	1.019 ± 0.026
225204	0.566 ± 0.019
225205	9.632 ± 0.080
225301	0.478 ± 0.018
225302	0.850 ± 0.024
225303	3.956 ± 0.051
225304	0.824 ± 0.023
225305	0.515 ± 0.019
225306	6.401 ± 0.065
225307	0.695 ± 0.022
225308	0.371 ± 0.016
225309	3.685 ± 0.050

BasinID	1900 Area (km^2)	BasinID	1900 Area (km^2)	BasinID	1900 Area (km^2)	BasinID	1900 Area (km^2)
225310	2.772 ± 0.043	226102	0.504 ± 0.018	244602	0.607 ± 0.020	244705	0.135 ± 0.010
225401	0.388 ± 0.016	226103	2.248 ± 0.039	244603	0.579 ± 0.020	244706	0.157 ± 0.010
225402	0.698 ± 0.022	226104	0.261 ± 0.013	244604	0.183 ± 0.011	244707	0.147 ± 0.010
225403	0.266 ± 0.013	226105	1.101 ± 0.027	244605	0.047 ± 0.006	244708	1.836 ± 0.035
225501	1.747 ± 0.034	226106	0.707 ± 0.022	244606	0.051 ± 0.006	244709	0.277 ± 0.014
225502	NoData	226107	0.489 ± 0.018	244607	0.279 ± 0.014	244710	0.624 ± 0.020
225503	0.070 ± 0.007	226108	0.672 ± 0.021	244608	0.228 ± 0.012	244711	0.092 ± 0.008
225504	0.967 ± 0.025	226110	0.655 ± 0.021	244609	0.522 ± 0.019	244712	0.486 ± 0.018
225505	0.393 ± 0.016	226201	0.515 ± 0.019	244610	0.553 ± 0.019	244713	0.143 ± 0.010
225506	0.440 ± 0.017	226202	0.456 ± 0.017	244611	1.121 ± 0.027	244714	0.216 ± 0.012
225507	0.145 ± 0.010	226203	4.199 ± 0.053	244612	0.090 ± 0.008	244801	0.070 ± 0.007
225508	0.295 ± 0.014	226205	0.201 ± 0.012	244613	0.211 ± 0.012	244802	0.214 ± 0.012
225509	7.189 ± 0.069	226206	0.341 ± 0.015	244614	0.123 ± 0.009	244803	0.306 ± 0.014
225510	0.461 ± 0.018	226207	0.976 ± 0.026	244616	0.072 ± 0.007	244805	0.399 ± 0.016
225511	0.243 ± 0.013	226208	0.976 ± 0.026	244617	0.087 ± 0.008	244806	0.184 ± 0.011
225512	1.500 ± 0.032	226209	1.990 ± 0.037	244618	0.048 ± 0.006	244807	0.391 ± 0.016
225513	0.302 ± 0.014	226210	0.269 ± 0.013	244620	0.783 ± 0.023	244808	0.444 ± 0.017
225514	0.575 ± 0.020	226211	0.155 ± 0.010	244621	0.749 ± 0.022	244809	0.179 ± 0.011
225601	0.427 ± 0.017	226212	0.392 ± 0.016	244622	0.700 ± 0.022	244810	0.398 ± 0.016
225602	4.846 ± 0.057	226213	0.580 ± 0.020	244623	0.148 ± 0.010	244811	0.397 ± 0.016
225701	1.609 ± 0.033	226406	3.226 ± 0.046	244702	0.124 ± 0.009	224712	0.360 ± 0.016
225702	0.578 ± 0.020	224703	1.085 ± 0.027	244703	1.173 ± 0.028		
226101	1.041 ± 0.026	244601	0.345 ± 0.015	244704	0.388 ± 0.016		

BasinID	1958 Area (km^2)	Source Year	BasinID	1958 Area (km^2)	Source Year	BasinID	1958 Area (km^2)	Source Year
211301	NoData	1958	224709	0.034 ± 0.005	1958	225402	0.295 ± 0.014	1958
211502	0.072 ± 0.007	1958	224710	0.055 ± 0.006	1958	225403	0.152 ± 0.010	1958
211602	0.058 ± 0.006	1958	224711	0.060 ± 0.006	1958	225501	1.208 ± 0.028	1958
221806	0.140 ± 0.010	1958	224713	0.048 ± 0.006	1959	225502	0.067 ± 0.007	1958
222203	0.103 ± 0.008	1958	224714	NoData	1959	225503	0.054 ± 0.054	1958
222210	0.082 ± 0.007	1958	224801	0.077 ± 0.007	1958	225504	0.404 ± 0.016	1958
222401	0.355 ± 0.015	1958	225101	0.070 ± 0.007	1958	225505	0.195 ± 0.011	1958
222402	0.186 ± 0.011	1958	225102	0.046 ± 0.006	1958	225506	0.178 ± 0.011	1958
222403	NoData	1958	225103	0.025 ± 0.004	1958	225507	0.053 ± 0.006	1958
222501	0.462 ± 0.018	1958	225104	0.025 ± 0.004	1958	225508	0.098 ± 0.008	1958
222502	0.181 ± 0.011	1958	225105	0.169 ± 0.011	1958	225509	4.971 ± 0.058	1958
222601	0.077 ± 0.077	1958	225106	0.104 ± 0.008	1958	225510	0.299 ± 0.014	1958
222602	0.091 ± 0.008	1958	225107	0.184 ± 0.011	1958	225511	0.099 ± 0.008	1958
223608	0.409 ± 0.017	1958	225108	0.459 ± 0.018	1958	225512	0.874 ± 0.024	1958
223609	0.122 ± 0.009	1958	225109	0.968 ± 0.025	1958	225513	0.124 ± 0.009	1958
223610	0.805 ± 0.023	1958	225110	0.194 ± 0.011	1958	225514	0.216 ± 0.012	1958
224401	0.161 ± 0.010	1959	225111	0.189 ± 0.011	1958	225601	0.184 ± 0.185	1958
224402	0.363 ± 0.016	1959	225112	0.067 ± 0.007	1958	225602	3.898 ± 0.051	1958
224403	NoData	1959	225113	0.200 ± 0.012	1958	225701	1.039 ± 0.026	1958
224601	NoData	1958	225114	0.728 ± 0.022	1958	225702	0.199 ± 0.012	1958
224602	0.172 ± 0.011	1958	225115	0.948 ± 0.025	1958	226101	0.056 ± 0.006	1958
224603	0.081 ± 0.007	1958	225201	0.086 ± 0.008	1958	226102	0.071 ± 0.007	1958
224604	0.064 ± 0.007	1958	225202	0.059 ± 0.006	1958	226103	0.731 ± 0.022	1958
224605	0.056 ± 0.006	1958	225203	0.227 ± 0.012	1958	226104	NoData	1958
224606	0.077 ± 0.007	1958	225204	0.166 ± 0.011	1958	226105	0.411 ± 0.017	1958
224607	0.044 ± 0.005	1958	225205	6.758 ± 0.067	1958	226106	0.201 ± 0.012	1958
224608	0.076 ± 0.077	1958	225301	NoData	1958	226107	0.105 ± 0.008	1958
224609	0.060 ± 0.006	1958	225302	NoData	1958	226108	0.300 ± 0.014	1958
224610	NoData	1959	225303	1.726 ± 0.034	1958	226109	0.267 ± 0.013	1958
224701	0.540 ± 0.019	1958	225304	0.154 ± 0.010	1958	226201	0.086 ± 0.008	1958
224702	0.214 ± 0.012	1958	225305	0.100 ± 0.008	1958	226202	0.082 ± 0.007	1958
224703	0.810 ± 0.023	1958	225306	4.479 ± 0.055	1958	226203	2.025 ± 0.037	1958
224704	0.141 ± 0.010	1958	225307	0.547 ± 0.019	1958	226205	0.061 ± 0.006	1958
224705	NoData	1958	225308	0.118 ± 0.009	1958	226206	0.070 ± 0.007	1958
224706	0.831 ± 0.024	1958	225309	2.203 ± 0.038	1958	226207	0.322 ± 0.015	1958
224707	0.059 ± 0.006	1958	225310	1.758 ± 0.034	1958	226208	0.147 ± 0.147	1958
224708	0.123 ± 0.009	1958	225401	0.226 ± 0.012	1958	226209	NoData	1958

BasinID	1958 Area (km^2)	Source Year	BasinID	1958 Area (km^2)	Source Year	BasinID	1958 Area (km^2)	Source Year
226210	0.055 ± 0.006	1958	228503	NoData	1958	244410	0.049 ± 0.006	1958
226211	0.060 ± 0.006	1958	228504	0.029 ± 0.004	1958	244411	0.055 ± 0.006	1958
226212	0.126 ± 0.009	1958	228505	0.108 ± 0.009	1958	244412	0.050 ± 0.006	1958
226213	0.270 ± 0.013	1958	228603	0.156 ± 0.010	1958	244413	0.043 ± 0.005	1958
226301	0.042 ± 0.005	1958	228604	0.265 ± 0.013	1958	244414	0.077 ± 0.007	1958
226302	0.077 ± 0.007	1958	233201	0.043 ± 0.005	1958	244415	0.117 ± 0.009	1958
226303	0.988 ± 0.026	1958	233202	0.037 ± 0.005	1958	244416	0.116 ± 0.009	1958
226304	0.287 ± 0.014	1958	233203	NoData	1958	244417	0.242 ± 0.013	1958
226305	0.074 ± 0.007	1958	233204	0.803 ± 0.023	1958	244501	0.027 ± 0.004	1958
226306	0.059 ± 0.006	1958	233205	0.087 ± 0.008	1958	244502	0.030 ± 0.005	1958
226307	0.074 ± 0.007	1958	233206	0.071 ± 0.007	1958	244503	0.165 ± 0.011	1958
226308	0.070 ± 0.007	1958	233207	NoData	1958	244504	1.581 ± 0.033	1958
226401	0.054 ± 0.006	1958	233208	0.122 ± 0.009	1958	244505	0.331 ± 0.015	1958
226402	0.048 ± 0.006	1958	233209	0.053 ± 0.006	1958	244506	0.031 ± 0.005	1958
226403	0.031 ± 0.005	1958	233401	0.116 ± 0.009	1958	244507	0.141 ± 0.010	1958
226404	0.214 ± 0.012	1958	233402	0.878 ± 0.024	1958	244508	0.145 ± 0.010	1958
226405	0.063 ± 0.007	1958	233403	0.133 ± 0.009	1958	244509	0.023 ± 0.004	1958
226406	2.924 ± 0.044	1958	233404	0.291 ± 0.014	1958	244510	NoData	1958
226407	0.492 ± 0.018	1958	233405	0.905 ± 0.025	1958	244511	0.245 ± 0.013	1958
226408	0.549 ± 0.019	1958	233406	0.141 ± 0.010	1958	244512	0.314 ± 0.015	1958
226410	0.035 ± 0.005	1958	233407	1.259 ± 0.029	1958	244513	0.036 ± 0.036	1958
226411	0.089 ± 0.008	1958	233408	NoData	1958	244514	0.056 ± 0.006	1958
226412	0.062 ± 0.006	1958	233409	0.087 ± 0.008	1958	244515	0.102 ± 0.102	1958
226413	0.047 ± 0.006	1958	234203	0.142 ± 0.010	1958	244516	0.099 ± 0.008	1958
226501	0.193 ± 0.011	1958	234204	0.376 ± 0.016	1958	244517	0.046 ± 0.006	1958
226502	0.819 ± 0.023	1958	241302	0.127 ± 0.009	1957	244518	0.019 ± 0.004	1958
226503	0.072 ± 0.007	1958	241303	0.163 ± 0.010	1957	244519	0.024 ± 0.004	1958
226504	NoData	1958	241304	NoData	1957	244601	0.093 ± 0.008	1958
226505	0.116 ± 0.009	1958	241305	0.460 ± 0.018	1958	244602	0.278 ± 0.014	1958
226601	0.047 ± 0.006	1958	241306	0.158 ± 0.010	1958	244603	0.129 ± 0.009	1958
227103	0.086 ± 0.086	1958	241307	0.214 ± 0.012	1958	244604	0.075 ± 0.007	1958
227104	NoData	1958	241501	0.192 ± 0.011	1958	244605	0.024 ± 0.004	1958
227105	NoData	1958	241502	0.049 ± 0.006	1958	244606	0.032 ± 0.005	1958
227106	0.033 ± 0.005	1958	241503	0.038 ± 0.005	1958	244607	0.160 ± 0.010	1958
227107	NoData	1958	241504	0.435 ± 0.017	1958	244608	0.060 ± 0.006	1958
227201	0.028 ± 0.004	1958	242201	0.050 ± 0.006	1957	244609	0.293 ± 0.014	1958
227202	0.080 ± 0.007	1958	242202	0.111 ± 0.009	1957	244610	0.155 ± 0.010	1958
227203	0.254 ± 0.013	1958	242203	0.118 ± 0.009	1957	244611	NoData	1958
227204	0.743 ± 0.022	1958	242204	0.058 ± 0.006	1957	244612	NoData	1958
227205	0.080 ± 0.007	1958	242205	0.047 ± 0.006	1957	244613	0.134 ± 0.009	1958
227206	0.025 ± 0.004	1958	242206	0.036 ± 0.005	1957	244614	0.078 ± 0.007	1958
227207	0.077 ± 0.007	1958	242207	NoData	1957	244615	0.038 ± 0.005	1958
227208	0.040 ± 0.005	1958	242208	0.066 ± 0.007	1957	244616	0.053 ± 0.006	1958
227209	0.087 ± 0.008	1958	242209	0.114 ± 0.009	1957	244617	0.052 ± 0.006	1958
227210	0.928 ± 0.025	1958	242210	0.021 ± 0.004	1957	244618	0.021 ± 0.004	1958
227211	0.105 ± 0.008	1958	242211	0.141 ± 0.010	1957	244619	NoData	1958
227212	0.031 ± 0.005	1958	242212	NoData	1957	244620	NoData	1958
227301	0.156 ± 0.010	1958	242213	0.093 ± 0.008	1957	244621	0.293 ± 0.014	1958
227302	0.103 ± 0.008	1958	242214	0.012 ± 0.003	1957	244622	0.275 ± 0.014	1958
227303	0.040 ± 0.005	1958	244223	NoData	1958	244623	0.082 ± 0.007	1958
227304	0.115 ± 0.009	1958	244301	0.005 ± 0.002	1958	244624	0.019 ± 0.004	1958
227305	0.033 ± 0.005	1958	244302	0.678 ± 0.021	1958	244625	0.013 ± 0.003	1958
227306	1.062 ± 0.027	1958	244306	0.063 ± 0.006	1958	244701	0.035 ± 0.005	1958
227307	0.121 ± 0.009	1958	244307	0.264 ± 0.013	1958	244702	NoData	1958
227308	0.181 ± 0.011	1958	244308	NoData	1958	244703	0.584 ± 0.020	1958
227309	0.110 ± 0.009	1958	244401	0.139 ± 0.010	1958	244704	0.197 ± 0.011	1958
227310	0.325 ± 0.015	1958	244402	0.120 ± 0.009	1958	244705	0.045 ± 0.006	1958
227311	0.095 ± 0.008	1958	244403	0.354 ± 0.015	1958	244706	NoData	1958
224703	0.810 ± 0.023	1958	244404	0.145 ± 0.010	1958	244707	0.069 ± 0.007	1958
228401	0.684 ± 0.021	1958	244405	0.017 ± 0.003	1958	244708	NoData	1958
228402	0.104 ± 0.008	1958	244406	0.088 ± 0.008	1958	244709	0.104 ± 0.008	1958
228403	0.038 ± 0.005	1958	244407	4.845 ± 0.057	1958	244710	0.251 ± 0.013	1958
228404	0.404 ± 0.016	1958	244408	1.584 ± 0.033	1958	244711	0.049 ± 0.006	1958
228501	0.068 ± 0.007	1958	244409	0.938 ± 0.025	1958	244712	0.247 ± 0.013	1958

BasinID	1958 Area (km²)	Source Year
244713	0.078 ± 0.007	1958
244714	NoData	1958
244801	0.033 ± 0.005	1958
244802	0.036 ± 0.005	1958
244805	0.141 ± 0.010	1958
244806	0.064 ± 0.007	1958
244807	NoData	1958

BasinID	1958 Area (km²)	Source Year
244808	0.216 ± 0.012	1958
244809	0.090 ± 0.008	1958
244810	0.165 ± 0.011	1958
244811	0.022 ± 0.004	1958
245303	0.068 ± 0.007	1958
245304	0.109 ± 0.009	1958
245305	NoData	1958
245306	0.024 ± 0.004	1958
245307	0.034 ± 0.005	1958

BasinID	1958 Area (km²)	Source Year
245401	0.017 ± 0.003	1958
245402	0.063 ± 0.006	1958
245403	NoData	1958
245405	0.043 ± 0.005	1958
245501	NoData	1958
224712	0.109 ± 0.009	1958

BasinID	1968 Area (km²)	Source Year
211504	0.113 ± 0.009	1968
222405	0.126 ± 0.009	1968
223501	0.052 ± 0.006	1968
223504	0.351 ± 0.015	1968
223601	0.065 ± 0.065	1968
223602	0.110 ± 0.009	1968
223603	0.296 ± 0.014	1968
223604	0.149 ± 0.010	1968
223605	0.068 ± 0.007	1968
223606	0.833 ± 0.024	1968
223607	0.197 ± 0.011	1968
223701	0.148 ± 0.010	1968
223702	0.543 ± 0.019	1968
223703	0.109 ± 0.009	1968
224201	0.036 ± 0.005	1968
224202	0.034 ± 0.005	1968
224203	0.063 ± 0.006	1968

BasinID	1968 Area (km²)	Source Year
224404	0.436 ± 0.017	1968
224405	1.801 ± 0.035	1968
224501	0.018 ± 0.003	1968
224502	0.212 ± 0.012	1968
226602	1.088 ± 0.027	1963
226603	0.117 ± 0.009	1963
226604	0.036 ± 0.005	1963
226701	0.254 ± 0.013	1963
226702	NoData	1963
226803	0.090 ± 0.008	1963
226804	0.069 ± 0.007	1963
226904	NoData	1963
226905	NoData	1963
227904	NoData	1963
228307	NoData	1963
228406	0.513 ± 0.019	1963
228407	0.106 ± 0.008	1963
242401	0.164 ± 0.010	1963
242601	0.073 ± 0.007	1963

BasinID	1968 Area (km²)	Source Year
244803	0.252 ± 0.013	1968
244804	0.021 ± 0.004	1968
245101	0.039 ± 0.005	1968
246501	0.059 ± 0.006	1968
246502	0.060 ± 0.006	1968
245503	0.035 ± 0.005	1968
245504	0.022 ± 0.004	1968
245505	0.017 ± 0.003	1968
245506	0.002 ± 0.001	1968
245507	0.021 ± 0.004	1968
245508	0.067 ± 0.007	1968
245509	0.044 ± 0.005	1968
246301	0.015 ± 0.003	1968
246302	0.046 ± 0.006	1968
246303	0.044 ± 0.005	1968
246304	0.017 ± 0.003	1968
246305	0.036 ± 0.005	1968
246306	0.026 ± 0.004	1968
246307	0.050 ± 0.006	1968

BasinID	1974 Area (km²)	Source Year
211201	0.048 ± 0.006	1974
211202	0.012 ± 0.003	1974
211203	0.081 ± 0.007	1974
211204	0.036 ± 0.005	1974
211302	0.057 ± 0.006	1974
211305	0.114 ± 0.009	1974
211306	0.025 ± 0.004	1974
211401	0.105 ± 0.008	1974
211402	0.120 ± 0.009	1974
211403	0.040 ± 0.005	1974
211404	0.020 ± 0.004	1974
211405	0.062 ± 0.006	1974
211406	0.047 ± 0.006	1974
211407	0.034 ± 0.005	1974
211408	0.143 ± 0.010	1974
211409	0.078 ± 0.007	1974
211410	0.036 ± 0.005	1974
211411	0.011 ± 0.003	1974
211412	0.086 ± 0.008	1974
211413	0.060 ± 0.006	1974
211414	0.028 ± 0.004	1974
211415	0.060 ± 0.006	1974
211416	0.048 ± 0.006	1974
211801	0.260 ± 0.013	1974
211802	0.179 ± 0.011	1974
211803	0.082 ± 0.007	1974

BasinID	1974 Area (km²)	Source Year
211804	0.509 ± 0.018	1974
211901	0.159 ± 0.010	1974
211902	0.097 ± 0.008	1974
211905	0.314 ± 0.015	1974
212201	0.538 ± 0.019	1974
212202	0.049 ± 0.006	1974
212203	0.043 ± 0.005	1974
212204	0.037 ± 0.005	1974
212205	0.093 ± 0.008	1974
212206	0.062 ± 0.006	1974
212207	0.076 ± 0.007	1974
212208	0.099 ± 0.008	1974
212209	0.136 ± 0.010	1974
212210	0.039 ± 0.005	1974
212211	0.041 ± 0.005	1974
212212	0.233 ± 0.012	1974
212301	0.034 ± 0.005	1974
212302	0.574 ± 0.020	1974
212303	0.577 ± 0.020	1974
212304	2.244 ± 0.039	1974
212305	0.166 ± 0.011	1974
212306	1.615 ± 0.033	1974
212307	0.106 ± 0.008	1974
212401	0.582 ± 0.020	1974
212402	0.807 ± 0.023	1974
212403	0.158 ± 0.010	1974

BasinID	1974 Area (km²)	Source Year
212404	0.082 ± 0.007	1974
212501	0.159 ± 0.010	1974
212601	0.157 ± 0.010	1974
212602	0.560 ± 0.019	1974
212603	1.189 ± 0.028	1975
212604	5.397 ± 0.060	1975
212605	0.309 ± 0.014	1975
212606	0.328 ± 0.015	1975
212607	0.097 ± 0.008	1975
212608	0.727 ± 0.022	1975
212609	0.232 ± 0.012	1975
212610	0.128 ± 0.009	1975
212701	0.228 ± 0.012	1975
212702	3.571 ± 0.049	1975
212703	5.088 ± 0.058	1975
212704	1.746 ± 0.034	1975
213101	0.939 ± 0.025	1975
213102	0.221 ± 0.012	1975
213103	NoData	1975
213104	0.124 ± 0.009	1975
213105	4.996 ± 0.058	1975
213201	NoData	1974
213202	0.970 ± 0.025	1974
221101	2.888 ± 0.044	1975
221102	2.155 ± 0.038	1975
221103	3.851 ± 0.051	1975

BasinID	1974 Area (km^2)	Source Year
221104	3.149 ± 0.046	1975
221105	0.196 ± 0.011	1975
221106	0.205 ± 0.012	1975
221107	0.304 ± 0.014	1975
221108	1.784 ± 0.035	1975
221109	0.449 ± 0.017	1975
221201	0.077 ± 0.007	1974
221202	0.234 ± 0.013	1974
221203	0.188 ± 0.011	1974
221204	0.873 ± 0.024	1974
221205	0.277 ± 0.014	1974
221206	0.119 ± 0.009	1974
221301	3.667 ± 0.050	1974
221302	2.385 ± 0.040	1974
221303	0.257 ± 0.013	1974
221304	0.284 ± 0.014	1974
221401	0.276 ± 0.014	1974
221402	0.113 ± 0.009	1974
221403	0.272 ± 0.014	1974
221404	0.020 ± 0.004	1974
221405	0.230 ± 0.012	1974
221406	0.044 ± 0.005	1974
221501	0.423 ± 0.017	1974
221502	0.083 ± 0.007	1974
221504	0.116 ± 0.009	1974
221701	0.259 ± 0.013	1974
221702	0.096 ± 0.008	1974
221703	0.114 ± 0.009	1974
221714	0.473 ± 0.018	1974
221801	0.250 ± 0.013	1974
221802	0.083 ± 0.007	1974
221803	0.094 ± 0.008	1974
221804	0.276 ± 0.014	1974
221805	0.241 ± 0.013	1974
221901	0.779 ± 0.023	1974
221902	0.111 ± 0.009	1974
221903	0.144 ± 0.010	1974
221904	0.269 ± 0.013	1974
222101	1.294 ± 0.029	1974
222205	0.890 ± 0.024	1974
222206	1.149 ± 0.028	1974
222207	0.112 ± 0.009	1974
222308	0.159 ± 0.010	1974
222309	0.287 ± 0.014	1974
233101	0.244 ± 0.013	1979
223302	3.397 ± 0.048	1975
2211011	2.128 ± 0.038	1975
22110301	2.439 ± 0.040	1975

BasinID	1983 Area (km^2)	Source Year
211102	0.035 ± 0.005	1983
211103	0.015 ± 0.003	1983
211104	0.530 ± 0.019	1983
211205	0.015 ± 0.003	1983
211206	0.081 ± 0.007	1983
211207	0.021 ± 0.004	1983
211208	NoData	1983
211209	0.173 ± 0.011	1983
211210	0.839 ± 0.024	1983
211211	0.232 ± 0.012	1983
211501	0.109 ± 0.109	1983
211503	0.048 ± 0.006	1983
211505	0.120 ± 0.009	1983
211506	2.041 ± 0.037	1983
211507	1.177 ± 0.028	1983
211508	0.430 ± 0.017	1983
211509	0.181 ± 0.011	1983
211510	0.176 ± 0.011	1983
211601	0.038 ± 0.039	1983
211603	0.196 ± 0.011	1983
211604	NoData	1983
211701	0.046 ± 0.006	1983
211702	0.040 ± 0.005	1983
212101	0.172 ± 0.011	1983
212102	0.016 ± 0.003	1983
221503	0.178 ± 0.011	1983
221601	0.088 ± 0.008	1983
221602	0.113 ± 0.009	1983
221603	0.798 ± 0.023	1983
221604	0.160 ± 0.010	1983
221605	0.200 ± 0.012	1983
221606	0.697 ± 0.022	1983
221704	0.438 ± 0.017	1985
221705	0.103 ± 0.008	1985
221706	0.153 ± 0.010	1985
221707	0.085 ± 0.008	1985
221708	0.100 ± 0.008	1985
221709	0.140 ± 0.010	1985
221710	0.071 ± 0.007	1985
221711	0.131 ± 0.009	1985
221712	0.041 ± 0.005	1985
221713	0.066 ± 0.007	1985
221807	NoData	1985
221808	0.128 ± 0.009	1985
221809	1.123 ± 0.027	1985
222102	0.236 ± 0.013	1985
222103	0.094 ± 0.008	1985
222201	0.043 ± 0.005	1985
222202	0.185 ± 0.011	1985
222204	0.071 ± 0.007	1985
222208	0.352 ± 0.015	1985
222209	0.039 ± 0.005	1985
222301	0.536 ± 0.019	1983
222302	0.210 ± 0.012	1983
222303	0.125 ± 0.009	1983
222304	NoData	1983
222305	0.205 ± 0.012	1983
222306	0.211 ± 0.012	1983
222307	0.084 ± 0.007	1983
222310	0.054 ± 0.006	1983
222311	0.150 ± 0.010	1983
222312	0.103 ± 0.008	1983
222313	0.235 ± 0.013	1983
222314	0.728 ± 0.022	1983
222315	0.190 ± 0.011	1983
222316	NoData	1983
222404	0.169 ± 0.011	1983
222406	0.097 ± 0.008	1983
222407	NoData	1983
222408	0.286 ± 0.014	1983
222603	0.355 ± 0.015	1983
222701	0.166 ± 0.011	1983
223101	0.533 ± 0.019	1983
223102	0.945 ± 0.025	1983
223103	0.142 ± 0.010	1983
223104	0.105 ± 0.008	1983
223105	0.629 ± 0.021	1983
223201	0.122 ± 0.009	1983
223202	0.358 ± 0.015	1983
223203	0.393 ± 0.016	1983
223204	0.375 ± 0.016	1983
223205	1.775 ± 0.034	1983
223206	0.307 ± 0.014	1983
223207	0.986 ± 0.026	1983
223301	1.008 ± 0.026	1983
223304	0.371 ± 0.016	1983
223305	0.050 ± 0.006	1983
223401	0.124 ± 0.009	1983
223402	0.057 ± 0.006	1983
223403	0.056 ± 0.006	1983
223404	0.064 ± 0.007	1983
223405	0.145 ± 0.010	1983
223406	0.138 ± 0.010	1983
223407	0.550 ± 0.019	1983
223408	0.100 ± 0.008	1983
223502	0.523 ± 0.019	1983
223503	0.226 ± 0.012	1983
223611	0.309 ± 0.014	1983
223612	0.200 ± 0.012	1983
226110	0.405 ± 0.016	1983
227312	0.324 ± 0.015	1984
227313	0.218 ± 0.012	1984
227402	0.171 ± 0.011	1984
227501	0.155 ± 0.010	1984
227502	0.053 ± 0.006	1984
227503	NoData	1984
227504	NoData	1984
227505	0.413 ± 0.017	1984
227506	0.314 ± 0.015	1984
227507	0.027 ± 0.004	1984
227508	3.432 ± 0.048	1984
227601	0.143 ± 0.010	1984
227602	0.171 ± 0.011	1984
227603	2.963 ± 0.045	1984
227604	0.870 ± 0.024	1984
227605	1.561 ± 0.032	1984
227606	1.698 ± 0.034	1984
227607	2.525 ± 0.041	1984
227608	1.087 ± 0.027	1984
227609	1.376 ± 0.030	1984
227701	0.279 ± 0.014	1984
227702	1.494 ± 0.032	1984
227703	1.009 ± 0.026	1984
227801	0.139 ± 0.010	1984
227802	1.205 ± 0.028	1984
227803	0.256 ± 0.013	1984
228101	1.569 ± 0.032	1984
228102	0.786 ± 0.023	1984
228103	0.090 ± 0.008	1984

BasinID	1983 Area (km^2)	Source Year
228104	0.355 ± 0.015	1984
228105	0.514 ± 0.019	1984
228201	0.365 ± 0.016	1984
228202	0.247 ± 0.013	1984
228203	2.822 ± 0.043	1984
228204	0.142 ± 0.010	1984
231101	0.382 ± 0.016	1983
231102	0.077 ± 0.007	1983
231103	0.047 ± 0.006	1983
231104	0.132 ± 0.009	1983
231105	0.649 ± 0.021	1983
242606	0.114 ± 0.009	1984
242607	0.244 ± 0.013	1984
242608	0.267 ± 0.013	1984
242609	0.124 ± 0.009	1984
242610	1.291 ± 0.029	1984
242611	0.328 ± 0.015	1984
242612	0.526 ± 0.019	1984
242701	1.312 ± 0.030	1984
242703	NoData	1984
242704	0.060 ± 0.006	1984
242705	0.074 ± 0.007	1984
242706	0.905 ± 0.025	1984
242707	1.287 ± 0.029	1984
242708	0.424 ± 0.017	1984
242709	0.142 ± 0.010	1984
242801	0.080 ± 0.007	1984
242802	0.319 ± 0.015	1984
242803	0.089 ± 0.008	1984
242804	0.127 ± 0.009	1984
242805	0.057 ± 0.006	1984
243101	0.019 ± 0.004	1984
243102	0.106 ± 0.008	1984
243103	0.087 ± 0.008	1984
243104	0.056 ± 0.006	1984
243105	0.094 ± 0.008	1984
243106	0.084 ± 0.007	1984
243201	0.125 ± 0.009	1984
243202	0.121 ± 0.009	1984
243203	0.803 ± 0.023	1984
243204	0.331 ± 0.015	1984
243205	0.141 ± 0.010	1984
244201	0.178 ± 0.011	1984
244202	0.200 ± 0.012	1984
244204	0.186 ± 0.011	1984
244205	0.238 ± 0.013	1984
244207	0.192 ± 0.011	1984
244209	NoData	1984
244210	0.084 ± 0.008	1984
244211	0.044 ± 0.005	1984
244212	0.058 ± 0.006	1984
244213	0.464 ± 0.018	1984
244214	NoData	1984
244215	0.117 ± 0.009	1984
244217	0.527 ± 0.019	1984
244218	NoData	1984
244220	0.075 ± 0.007	1984
244221	1.252 ± 0.029	1984
244222	0.207 ± 0.012	1984
244303	0.364 ± 0.016	1984
245302	0.075 ± 0.007	1985

BasinID	1990 Area (km^2)	Source Year
211101	0.031 ± 0.010	1993
211103	0.015 ± 0.010	1993
211104	0.514 ± 0.014	1993
211207	0.019 ± 0.010	1993
211208	0.043 ± 0.010	1993
211209	0.168 ± 0.011	1993
211210	0.778 ± 0.015	1993
211211	0.228 ± 0.012	1993
211403	0.037 ± 0.010	1990
211405	0.061 ± 0.010	1990
211406	0.037 ± 0.010	1990
211407	0.031 ± 0.010	1990
211408	0.125 ± 0.011	1990
211409	0.076 ± 0.011	1990
211410	0.035 ± 0.010	1990
211414	NoData	1990
211415	0.064 ± 0.011	1990
211501	0.123 ± 0.011	1990
211503	0.034 ± 0.010	1990
211504	NoData	1990
211506	1.978 ± 0.021	1990
211507	1.092 ± 0.017	1990
211508	0.361 ± 0.013	1990
211509	0.173 ± 0.011	1990
211510	0.184 ± 0.011	1990
211601	0.047 ± 0.010	1990
211603	0.154 ± 0.011	1990
211604	NoData	1990
211701	0.048 ± 0.010	1990
211702	0.041 ± 0.010	1990
211801	0.225 ± 0.012	1990
211802	0.172 ± 0.011	1990
211803	0.084 ± 0.011	1990
211804	0.502 ± 0.013	1990
211901	0.170 ± 0.011	1990
211902	0.099 ± 0.011	1990
212101	0.173 ± 0.011	1993
212102	0.016 ± 0.010	1993
212403	0.158 ± 0.011	1993
212404	0.065 ± 0.011	1993
212501	0.132 ± 0.011	1993
212601	0.153 ± 0.011	1993
212602	0.508 ± 0.014	1993
212603	1.307 ± 0.018	1993
212604	5.282 ± 0.031	1993
212605	0.356 ± 0.013	1993
212701	NoData	1993
212702	3.915 ± 0.027	1993
212703	4.886 ± 0.030	1993
213105	5.058 ± 0.030	1990
221101	2.823 ± 0.024	1993
221103	3.638 ± 0.026	1993
221104	3.252 ± 0.025	1993
221108	1.799 ± 0.020	1993
221201	NoData	1993
221202	0.214 ± 0.012	1993
221203	0.170 ± 0.011	1993
221501	0.378 ± 0.013	1990
221502	0.087 ± 0.011	1990
221503	0.149 ± 0.011	1990
221504	0.100 ± 0.011	1990
221602	0.110 ± 0.011	1990
221603	0.788 ± 0.015	1990
221604	0.159 ± 0.011	1990
221605	0.161 ± 0.011	1990
221606	0.661 ± 0.014	1990
221701	0.266 ± 0.012	1990
221702	0.094 ± 0.011	1990
221703	0.106 ± 0.011	1990
221713	0.063 ± 0.010	1990
221801	0.244 ± 0.012	1990
221804	0.264 ± 0.012	1990
221805	0.216 ± 0.012	1990
222308	0.160 ± 0.011	1990
222309	0.297 ± 0.012	1990
222310	0.031 ± 0.010	1990
222311	0.121 ± 0.011	1990
222312	0.112 ± 0.011	1990
222313	0.229 ± 0.012	1990
222314	0.770 ± 0.015	1990
222315	0.169 ± 0.011	1990
222316	0.175 ± 0.011	1990
222401	0.254 ± 0.012	1990
222403	0.245 ± 0.012	1990
222404	0.140 ± 0.011	1990
222405	0.109 ± 0.011	1990
222406	0.123 ± 0.011	1990
222407	0.086 ± 0.011	1990
222501	0.503 ± 0.013	1990
222601	0.080 ± 0.011	1989
222602	0.074 ± 0.011	1989
222603	0.285 ± 0.012	1989
222701	0.136 ± 0.011	1989
223101	0.510 ± 0.014	1990
223102	0.873 ± 0.016	1990
223103	0.136 ± 0.011	1990
223104	0.108 ± 0.011	1990
223105	0.615 ± 0.014	1990
223201	0.124 ± 0.011	1990
223202	0.336 ± 0.012	1990
223203	0.380 ± 0.013	1990
223204	0.377 ± 0.013	1990
223205	1.746 ± 0.020	1990
223206	0.314 ± 0.012	1990
223207	1.012 ± 0.016	1990
223302	3.311 ± 0.025	1990
223303	0.369 ± 0.013	1990
223304	0.334 ± 0.012	1990
223305	NoData	1990
223401	0.126 ± 0.011	1990
223402	0.060 ± 0.010	1990

BasinID	1990 Area (km²)	Source Year	BasinID	1990 Area (km²)	Source Year	BasinID	1990 Area (km²)	Source Year
223403	0.055 ± 0.010	1990	226102	0.062 ± 0.010	1989	243103	0.083 ± 0.011	1992
223405	0.154 ± 0.011	1990	226103	0.778 ± 0.015	1989	243104	0.053 ± 0.010	1992
223406	0.140 ± 0.011	1990	226104	0.135 ± 0.011	1989	243105	0.095 ± 0.011	1992
223407	0.535 ± 0.014	1990	226105	0.374 ± 0.013	1989	243106	0.037 ± 0.010	1992
223501	0.055 ± 0.010	1990	226106	0.182 ± 0.011	1989	243201	0.096 ± 0.011	1992
223502	0.485 ± 0.013	1990	226107	0.106 ± 0.011	1989	243202	0.096 ± 0.011	1992
223503	0.224 ± 0.012	1990	226108	0.294 ± 0.012	1989	243203	0.660 ± 0.014	1992
223504	0.376 ± 0.013	1990	226109	0.244 ± 0.012	1989	243204	0.307 ± 0.012	1992
223601	NoData	1990	226110	0.362 ± 0.013	1989	243205	0.119 ± 0.011	1992
223602	0.121 ± 0.011	1990	226201	0.083 ± 0.011	1989	244201	0.187 ± 0.011	1992
223603	0.270 ± 0.012	1990	226202	0.078 ± 0.011	1989	244202	0.185 ± 0.011	1992
223604	NoData	1990	226208	0.167 ± 0.011	1990	244203	0.034 ± 0.010	1992
223605	0.074 ± 0.011	1990	226410	0.029 ± 0.010	1989	244204	0.144 ± 0.011	1992
223606	0.752 ± 0.015	1990	226411	0.078 ± 0.011	1989	244205	0.214 ± 0.012	1992
223607	NoData	1990	226412	0.055 ± 0.010	1989	244206	0.047 ± 0.010	1992
223608	0.336 ± 0.012	1990	226601	0.033 ± 0.010	1989	244207	0.186 ± 0.011	1992
223609	0.077 ± 0.011	1990	227311	0.100 ± 0.011	1992	244209	0.048 ± 0.010	1992
223610	0.567 ± 0.014	1990	224703	0.816 ± 0.015	1990	244210	0.106 ± 0.011	1992
223611	0.285 ± 0.012	1990	227903	0.099 ± 0.011	1989	244211	0.045 ± 0.010	1992
223612	0.172 ± 0.011	1990	227904	0.132 ± 0.011	1989	244212	0.046 ± 0.010	1992
223701	0.097 ± 0.011	1990	228307	0.065 ± 0.011	1989	244217	0.492 ± 0.013	1992
223702	0.571 ± 0.014	1990	228401	0.678 ± 0.014	1989	244218	0.738 ± 0.015	1992
223703	0.073 ± 0.011	1990	228402	0.112 ± 0.011	1989	244220	0.070 ± 0.011	1992
224201	0.028 ± 0.010	1990	228403	NoData	1989	244221	1.223 ± 0.017	1992
224202	0.027 ± 0.010	1990	228404	0.390 ± 0.013	1989	244222	0.201 ± 0.012	1992
224203	0.057 ± 0.010	1990	228406	0.406 ± 0.013	1989	244223	0.019 ± 0.010	1992
224404	0.425 ± 0.013	1990	228407	0.090 ± 0.011	1989	244301	0.005 ± 0.010	1992
224405	1.621 ± 0.019	1990	228501	0.064 ± 0.011	1989	244302	0.684 ± 0.015	1992
224501	0.016 ± 0.010	1990	228503	0.090 ± 0.011	1989	244306	NoData	1992
224502	0.154 ± 0.011	1990	228504	0.028 ± 0.010	1989	244308	0.257 ± 0.012	1992
224603	0.083 ± 0.011	1990	228505	0.108 ± 0.011	1989	244401	NoData	1992
224604	0.047 ± 0.010	1990	228603	0.170 ± 0.011	1989	244402	0.123 ± 0.011	1992
224610	0.034 ± 0.010	1990	228604	0.256 ± 0.012	1989	244403	0.365 ± 0.013	1992
224701	0.550 ± 0.014	1990	231101	0.352 ± 0.013	1989	244404	0.063 ± 0.010	1992
224702	0.225 ± 0.012	1990	231102	NoData	1989	244406	0.093 ± 0.011	1992
224703	0.816 ± 0.015	1990	231103	NoData	1989	244611	0.499 ± 0.013	1990
224704	0.148 ± 0.011	1990	231104	0.148 ± 0.011	1989	244612	0.040 ± 0.010	1992
224706	0.772 ± 0.015	1990	231105	0.697 ± 0.015	1989	244613	NoData	1992
224714	0.217 ± 0.012	1990	233101	0.203 ± 0.012	1989	244614	NoData	1992
224801	0.075 ± 0.011	1990	233201	0.045 ± 0.010	1989	244615	NoData	1992
225114	0.610 ± 0.014	1990	233202	0.041 ± 0.010	1989	244616	0.061 ± 0.010	1992
225205	6.675 ± 0.034	1990	233203	0.072 ± 0.011	1989	244617	NoData	1992
225301	0.090 ± 0.011	1990	233204	0.821 ± 0.015	1989	244618	0.023 ± 0.010	1992
225303	1.862 ± 0.020	1990	233205	0.090 ± 0.011	1989	244619	NoData	1992
225305	0.110 ± 0.011	1990	233206	0.079 ± 0.011	1989	244621	0.335 ± 0.012	1992
225306	4.662 ± 0.029	1990	233207	0.025 ± 0.010	1989	244622	0.322 ± 0.012	1992
225307	NoData	1990	233209	0.026 ± 0.010	1989	244623	0.070 ± 0.011	1992
225309	2.215 ± 0.021	1990	242201	0.038 ± 0.010	1992	244701	0.028 ± 0.010	1992
225310	1.735 ± 0.020	1990	242202	0.093 ± 0.011	1992	244702	0.088 ± 0.011	1992
225401	0.231 ± 0.012	1990	242203	0.103 ± 0.011	1992	244703	0.541 ± 0.014	1992
225501	1.165 ± 0.017	1990	242204	0.016 ± 0.010	1992	244704	NoData	1992
225502	0.069 ± 0.011	1990	242205	0.019 ± 0.010	1992	244707	0.055 ± 0.010	1992
225503	0.063 ± 0.011	1990	242206	0.030 ± 0.010	1992	244708	0.964 ± 0.016	1992
225505	0.209 ± 0.012	1990	242207	0.126 ± 0.011	1992	244714	NoData	1990
225506	0.150 ± 0.011	1989	242208	0.052 ± 0.010	1992	244802	0.031 ± 0.010	1990
225510	0.261 ± 0.012	1989	242209	0.077 ± 0.011	1992	244803	0.225 ± 0.012	1990
225511	0.096 ± 0.011	1989	242210	0.013 ± 0.010	1992	244808	0.222 ± 0.012	1990
225512	0.799 ± 0.015	1989	242211	0.093 ± 0.011	1992	244809	0.097 ± 0.011	1990
225513	0.107 ± 0.011	1989	242212	0.158 ± 0.011	1992	244811	0.022 ± 0.010	1990
225514	0.201 ± 0.012	1989	242213	0.070 ± 0.011	1992	245101	0.043 ± 0.010	1990
225601	0.198 ± 0.011	1990	242601	0.070 ± 0.011	1992	245302	NoData	1990
225602	3.933 ± 0.027	1990	242805	0.045 ± 0.010	1992	245303	0.064 ± 0.011	1990
225701	1.032 ± 0.016	1990	243101	0.018 ± 0.010	1992	245304	NoData	1990
226101	0.049 ± 0.010	1989	243102	0.106 ± 0.011	1992	245305	0.141 ± 0.011	1990

BasinID	1990 Area (km^2)	Source Year
245306	NoData	1990
245307	0.026 ± 0.010	1990
245401	0.016 ± 0.010	1990
245402	NoData	1990
245403	0.043 ± 0.010	1990
245405	0.044 ± 0.010	1990
245501	NoData	1990
246501	0.057 ± 0.010	1990
246502	0.045 ± 0.010	1990
245503	NoData	1990
245504	NoData	1990
245507	0.021 ± 0.010	1990
245508	0.043 ± 0.010	1990
245509	0.026 ± 0.010	1990
246301	0.014 ± 0.010	1990
246302	NoData	1990
246303	0.047 ± 0.010	1990
246304	0.018 ± 0.010	1990
246305	0.018 ± 0.010	1990
246306	NoData	1990
246307	0.046 ± 0.010	1990

BasinID	1998 Area (km^2)
211201	0.038 ± 0.010
211202	0.009 ± 0.010
211203	0.053 ± 0.010
211204	0.038 ± 0.010
211301	NoData
211302	0.046 ± 0.010
211303	0.025 ± 0.010
211304	0.016 ± 0.010
211305	0.090 ± 0.011
211306	0.024 ± 0.010
211307	0.054 ± 0.010
211401	0.092 ± 0.011
211402	0.091 ± 0.011
211403	0.040 ± 0.010
211404	0.020 ± 0.010
211405	0.051 ± 0.010
211406	0.045 ± 0.010
211407	0.034 ± 0.010
211408	0.103 ± 0.011
211409	0.078 ± 0.011
211410	0.035 ± 0.010
211412	0.086 ± 0.011
211413	0.060 ± 0.010
211415	0.059 ± 0.010
211416	0.044 ± 0.010
211501	0.104 ± 0.011
211502	0.073 ± 0.011
211503	0.044 ± 0.010
211504	0.109 ± 0.011
211505	0.074 ± 0.011
211506	1.982 ± 0.021
211507	1.088 ± 0.017
211508	0.406 ± 0.013
211509	0.179 ± 0.011
211510	0.170 ± 0.011
211601	0.039 ± 0.010
211602	0.058 ± 0.010
211603	0.156 ± 0.011
211604	0.034 ± 0.010
211701	0.046 ± 0.010
211702	0.040 ± 0.010
211801	0.215 ± 0.012
211802	0.110 ± 0.011
211803	0.079 ± 0.011
211804	0.488 ± 0.013
211901	0.118 ± 0.011
211902	0.071 ± 0.011
211905	0.287 ± 0.012
212201	0.526 ± 0.014
212202	0.029 ± 0.010
212203	0.047 ± 0.010
212204	0.038 ± 0.010
212205	0.067 ± 0.011
212206	0.052 ± 0.010
212207	0.070 ± 0.011
212208	0.093 ± 0.011
212209	0.128 ± 0.011
212210	0.038 ± 0.010
212211	0.037 ± 0.010
212212	0.251 ± 0.012
212301	0.039 ± 0.010
212302	0.566 ± 0.014
212303	0.521 ± 0.014
212304	2.266 ± 0.022
212305	0.127 ± 0.011
212306	1.535 ± 0.019
212307	0.097 ± 0.011
212401	0.571 ± 0.014
212402	0.727 ± 0.015
212403	0.148 ± 0.011
213201	0.782 ± 0.015
213202	NoData
221204	0.849 ± 0.015
221205	0.219 ± 0.012
221206	0.116 ± 0.011
221301	3.453 ± 0.026
221302	2.498 ± 0.022
221303	0.245 ± 0.012
221304	0.294 ± 0.012
221401	0.231 ± 0.012
221402	0.087 ± 0.011
221403	0.262 ± 0.012
221404	0.021 ± 0.010
221405	0.215 ± 0.012
221406	0.037 ± 0.010
221501	0.342 ± 0.012
221502	0.026 ± 0.010
221503	0.144 ± 0.011
221601	0.084 ± 0.011
221602	0.105 ± 0.011
221603	0.759 ± 0.015
221604	0.108 ± 0.011
221605	0.165 ± 0.011
221606	0.575 ± 0.014
221701	0.218 ± 0.012
221702	0.080 ± 0.011
221703	0.088 ± 0.011
221704	0.362 ± 0.013
221705	0.106 ± 0.011
221706	0.162 ± 0.011
221707	0.075 ± 0.011
221708	0.078 ± 0.011
221709	0.128 ± 0.011
221710	0.069 ± 0.011
221711	0.124 ± 0.011
221712	0.041 ± 0.010
221713	0.062 ± 0.010
221714	0.390 ± 0.013
221801	0.231 ± 0.012
221802	0.064 ± 0.011
221803	0.081 ± 0.011
221804	0.242 ± 0.012
221805	0.186 ± 0.011
221808	0.131 ± 0.011
221809	1.121 ± 0.017
221901	0.723 ± 0.015
221902	0.117 ± 0.011
221903	0.111 ± 0.011
221904	0.243 ± 0.012
222101	1.320 ± 0.018
222102	NoData
222103	0.069 ± 0.011
222201	0.039 ± 0.010
222202	0.191 ± 0.011
222203	0.065 ± 0.011
222204	0.070 ± 0.011
222205	0.788 ± 0.015
222206	1.120 ± 0.017
222207	0.099 ± 0.011
222209	0.031 ± 0.010
222210	0.063 ± 0.010
222301	0.518 ± 0.014
222302	0.232 ± 0.012
222303	0.129 ± 0.011
222304	0.033 ± 0.010
222305	0.186 ± 0.011
222306	0.222 ± 0.012
222307	0.081 ± 0.011
222308	0.137 ± 0.011
222309	0.257 ± 0.012
222310	NoData
222311	0.098 ± 0.011
222312	0.103 ± 0.011
222313	0.180 ± 0.011
222314	0.715 ± 0.015
222316	0.157 ± 0.011
222401	0.238 ± 0.012
222402	0.182 ± 0.011
222403	0.167 ± 0.011
222404	0.090 ± 0.011
222405	0.112 ± 0.011
222406	0.067 ± 0.011
222407	NoData
222408	0.249 ± 0.012
222501	0.467 ± 0.013
222502	0.203 ± 0.012
222601	0.091 ± 0.011
222602	0.085 ± 0.011
222603	0.255 ± 0.012
222701	0.157 ± 0.011
223101	0.517 ± 0.014
223102	0.873 ± 0.016
223103	0.111 ± 0.011
223104	0.079 ± 0.011
223105	0.601 ± 0.014
223201	0.134 ± 0.011
223202	0.313 ± 0.012
223203	0.372 ± 0.013
223204	0.300 ± 0.012
223205	1.640 ± 0.019
223206	0.280 ± 0.012
223207	0.955 ± 0.016
223301	0.707 ± 0.015
BasinID	1998 (km^2)
223302	3.332 ± 0.025
223303	0.325 ± 0.012
223304	0.269 ± 0.012
223305	NoData
223401	0.107 ± 0.011
223402	0.050 ± 0.010
223403	0.055 ± 0.010
223404	0.055 ± 0.010
223405	0.134 ± 0.011
223406	0.134 ± 0.011
223407	0.489 ± 0.013
223408	0.085 ± 0.011
223501	0.050 ± 0.010
223502	0.429 ± 0.013
223503	0.195 ± 0.011
223504	0.302 ± 0.012
223601	0.062 ± 0.010
223602	0.104 ± 0.011
223603	0.244 ± 0.012
223604	0.115 ± 0.011
223605	0.064 ± 0.011
223606	0.668 ± 0.014
223607	0.173 ± 0.011
223609	NoData
223611	0.303 ± 0.012
223612	0.168 ± 0.011
223701	NoData
223702	0.512 ± 0.014
223703	0.096 ± 0.011
224201	0.020 ± 0.010

BasinID	1998 Area (km^2)
224202	0.023 ± 0.010
224203	0.052 ± 0.010
224402	0.299 ± 0.012
224403	NoData
224404	0.352 ± 0.013
224405	1.629 ± 0.019
224501	0.015 ± 0.010
224502	0.160 ± 0.011
224601	0.072 ± 0.011
224602	0.115 ± 0.011
224603	0.088 ± 0.011
224604	0.058 ± 0.010
224605	0.051 ± 0.010
224606	0.050 ± 0.010
224607	0.047 ± 0.010
224608	0.087 ± 0.011
224609	0.053 ± 0.010
224610	0.026 ± 0.010
224701	0.521 ± 0.014
224702	0.218 ± 0.012
224703	0.800 ± 0.015
224704	0.141 ± 0.011
224705	0.124 ± 0.011
224706	0.752 ± 0.015
224707	0.046 ± 0.010
224708	0.106 ± 0.011
224709	0.030 ± 0.010
224710	0.050 ± 0.010
224711	0.057 ± 0.010
224713	0.046 ± 0.010
224714	0.161 ± 0.011
224801	0.077 ± 0.011
225101	0.065 ± 0.011
225102	0.049 ± 0.010
225103	NoData
225104	0.023 ± 0.010
225105	0.156 ± 0.011
225106	0.096 ± 0.011
225107	0.201 ± 0.012
225108	0.433 ± 0.013
225109	0.868 ± 0.016
225110	0.201 ± 0.012
225111	0.182 ± 0.011
225112	0.069 ± 0.011
225113	0.208 ± 0.012
225114	0.549 ± 0.014
225115	0.991 ± 0.016
225201	0.091 ± 0.011
225202	NoData
225203	0.225 ± 0.012
225204	0.144 ± 0.011
225205	6.536 ± 0.034
225301	0.077 ± 0.011
225302	0.302 ± 0.012
225303	1.658 ± 0.019
225304	0.158 ± 0.011
225305	0.107 ± 0.011
225306	4.461 ± 0.029
225307	0.537 ± 0.014
225308	0.119 ± 0.011
225309	2.115 ± 0.021
225310	1.685 ± 0.019
225401	0.220 ± 0.012
225402	0.295 ± 0.012
225403	0.152 ± 0.011
225501	1.105 ± 0.017
225502	0.067 ± 0.011
225503	0.054 ± 0.010
225504	0.398 ± 0.013
225505	0.188 ± 0.011
225506	0.125 ± 0.011
225507	0.053 ± 0.010
225508	0.098 ± 0.011
225510	0.280 ± 0.012
225511	0.082 ± 0.011
225512	0.822 ± 0.015
225513	0.118 ± 0.011
225514	0.212 ± 0.012
225601	0.213 ± 0.012
225602	3.817 ± 0.027
225701	1.063 ± 0.016
225702	0.195 ± 0.011
226101	0.057 ± 0.010
226102	0.070 ± 0.011
226103	0.730 ± 0.015
226104	0.149 ± 0.011
226105	0.353 ± 0.013
226106	0.188 ± 0.011
226107	0.101 ± 0.011
226108	0.237 ± 0.012
226109	0.266 ± 0.012
226110	0.397 ± 0.013
226201	0.087 ± 0.011
226202	0.080 ± 0.011
226203	1.939 ± 0.020
226205	0.035 ± 0.010
226206	0.042 ± 0.010
226207	0.322 ± 0.012
226208	0.144 ± 0.011
226209	0.915 ± 0.016
226210	0.050 ± 0.010
226211	0.053 ± 0.010
226212	0.122 ± 0.011
226213	0.263 ± 0.012
226301	0.043 ± 0.010
226302	0.086 ± 0.011
226303	0.984 ± 0.016
226304	0.283 ± 0.012
226305	0.081 ± 0.011
226306	0.071 ± 0.011
226307	0.066 ± 0.011
226308	0.039 ± 0.010
226401	0.052 ± 0.010
226402	0.053 ± 0.010
226403	0.032 ± 0.010
226404	0.173 ± 0.011
226405	0.070 ± 0.011
226406	2.269 ± 0.022
226407	0.451 ± 0.013
226408	0.432 ± 0.013
226410	0.031 ± 0.010
226411	0.095 ± 0.011
226413	0.051 ± 0.010
226501	0.056 ± 0.010
226502	0.787 ± 0.015
226503	0.068 ± 0.011
226504	0.065 ± 0.011
226505	0.109 ± 0.011
226601	0.035 ± 0.010
226602	1.186 ± 0.017
226702	0.831 ± 0.015
226801	0.044 ± 0.010
226802	0.051 ± 0.010
227103	NoData
227104	0.176 ± 0.011
227105	0.128 ± 0.011
227107	0.035 ± 0.010
227201	0.018 ± 0.010
227202	0.063 ± 0.010
227203	0.209 ± 0.012
227204	0.652 ± 0.014
227205	0.065 ± 0.011
227206	0.023 ± 0.010
227207	0.065 ± 0.011
227208	0.041 ± 0.010
227209	0.091 ± 0.011
227210	0.856 ± 0.015
227211	0.088 ± 0.011
227212	0.031 ± 0.010
227301	0.097 ± 0.011
227302	0.101 ± 0.011
227303	0.041 ± 0.010
227304	0.120 ± 0.011
227305	0.034 ± 0.010
227306	1.058 ± 0.016
227308	0.193 ± 0.011
227309	0.112 ± 0.011
227310	0.361 ± 0.013
227311	0.079 ± 0.011
227312	0.293 ± 0.012
227313	0.221 ± 0.012
227402	0.155 ± 0.011
224703	0.800 ± 0.015
227502	0.039 ± 0.010
227503	NoData
227504	0.010 ± 0.010
227505	0.326 ± 0.012
227506	0.222 ± 0.012
227507	0.019 ± 0.010
227508	3.167 ± 0.025
227601	0.119 ± 0.011
227602	0.121 ± 0.011
227603	2.730 ± 0.023
227604	0.740 ± 0.015
227605	1.314 ± 0.018
227606	1.549 ± 0.019
227607	2.463 ± 0.022
227608	0.969 ± 0.016
227609	1.380 ± 0.018
227701	0.230 ± 0.012
227702	1.461 ± 0.018
227703	0.860 ± 0.015
227801	0.080 ± 0.011
227802	1.034 ± 0.016
227901	0.071 ± 0.011
228103	0.107 ± 0.011
228201	0.287 ± 0.012
228202	0.123 ± 0.011
228203	1.907 ± 0.020
228401	0.724 ± 0.015
228503	0.089 ± 0.011
228504	0.028 ± 0.010
228506	0.336 ± 0.012
231101	0.369 ± 0.013
231102	0.066 ± 0.011
231103	NoData
231104	0.147 ± 0.011
231105	0.685 ± 0.015
233401	0.088 ± 0.011
233402	0.528 ± 0.014
233403	0.079 ± 0.011
233404	0.219 ± 0.012
233405	0.723 ± 0.015
233406	0.092 ± 0.011
233407	0.601 ± 0.014
233408	NoData
233409	0.075 ± 0.011
234201	0.061 ± 0.010
234203	0.138 ± 0.011
234204	0.385 ± 0.013
241303	0.202 ± 0.012
241304	0.058 ± 0.010
241305	NoData
241306	0.167 ± 0.011
241307	0.227 ± 0.012
241308	0.078 ± 0.011
241401	0.106 ± 0.011
241501	0.150 ± 0.011
241503	0.028 ± 0.010
241504	0.405 ± 0.013
241505	0.043 ± 0.010
242211	0.103 ± 0.011
242212	0.157 ± 0.011
242213	0.087 ± 0.011
242401	0.148 ± 0.011
242602	0.042 ± 0.010
242603	0.052 ± 0.010
242604	0.045 ± 0.010
242605	0.068 ± 0.011
242607	0.083 ± 0.011
242609	0.043 ± 0.010
242610	1.126 ± 0.017
242611	0.169 ± 0.011
242612	0.286 ± 0.012
242701	1.308 ± 0.018
242702	0.057 ± 0.010
242703	0.828 ± 0.015
242704	0.037 ± 0.010
242705	0.056 ± 0.010
242706	0.868 ± 0.016
242707	1.253 ± 0.017
242708	0.345 ± 0.012
242801	0.063 ± 0.011
242802	0.337 ± 0.012
244206	0.031 ± 0.010
244209	0.042 ± 0.010
244210	0.092 ± 0.011
244213	0.310 ± 0.012
244214	0.089 ± 0.011
244218	0.684 ± 0.015
244219	0.071 ± 0.011
244220	0.051 ± 0.010
244302	0.672 ± 0.014
244305	0.084 ± 0.011

BasinID	1998 Area (km^2)	BasinID	1998 Area (km^2)	BasinID	1998 Area (km^2)	BasinID	1998 Area (km^2)
244306	0.038 ± 0.010	244504	1.542 ± 0.019	244611	NoData	244710	0.301 ± 0.012
244307	0.202 ± 0.012	244505	0.292 ± 0.012	244612	0.036 ± 0.010	244711	0.046 ± 0.010
244308	0.234 ± 0.012	244506	0.030 ± 0.010	244613	0.137 ± 0.011	244712	0.256 ± 0.012
244401	0.108 ± 0.011	244507	0.158 ± 0.011	244614	0.052 ± 0.010	244713	0.079 ± 0.011
244402	0.081 ± 0.011	244508	0.151 ± 0.011	244615	0.040 ± 0.010	244714	0.059 ± 0.010
244403	0.296 ± 0.012	244509	NoData	244616	0.052 ± 0.010	244801	0.021 ± 0.010
244404	0.037 ± 0.010	244510	0.061 ± 0.010	244617	0.039 ± 0.010	244802	0.023 ± 0.010
244405	0.017 ± 0.010	244511	0.223 ± 0.012	244618	0.015 ± 0.010	244805	0.141 ± 0.011
244406	0.086 ± 0.011	244512	0.264 ± 0.012	244619	NoData	244806	0.057 ± 0.010
244407	4.721 ± 0.029	244513	0.039 ± 0.010	244620	0.309 ± 0.012	244807	0.113 ± 0.011
244408	1.522 ± 0.019	244514	0.055 ± 0.010	244621	0.296 ± 0.012	244808	0.203 ± 0.012
244409	0.930 ± 0.016	244515	0.112 ± 0.011	244622	0.240 ± 0.012	244809	0.089 ± 0.011
244410	0.045 ± 0.010	244516	0.063 ± 0.011	244623	0.056 ± 0.010	244810	0.134 ± 0.011
244411	0.054 ± 0.010	244517	0.035 ± 0.010	244624	NoData	244811	0.015 ± 0.010
244412	0.024 ± 0.010	244518	0.020 ± 0.010	244625	0.012 ± 0.010	245303	0.050 ± 0.010
244413	0.032 ± 0.010	244519	0.025 ± 0.010	244701	0.020 ± 0.010	245304	0.101 ± 0.011
244414	0.071 ± 0.011	244601	0.093 ± 0.011	244702	0.077 ± 0.011	245401	0.016 ± 0.010
244415	0.126 ± 0.011	244602	0.271 ± 0.012	244703	0.550 ± 0.014	245402	0.046 ± 0.010
244416	0.116 ± 0.011	244603	0.110 ± 0.011	244704	0.189 ± 0.011	245403	0.032 ± 0.010
244417	0.250 ± 0.012	244604	0.069 ± 0.011	244705	0.041 ± 0.010	245404	0.006 ± 0.010
244501	0.017 ± 0.010	244605	0.023 ± 0.010	244706	0.086 ± 0.011	245405	0.034 ± 0.010
244502	0.023 ± 0.010	244606	0.031 ± 0.010	244707	0.031 ± 0.010	245501	NoData
244503	0.144 ± 0.011	244607	0.156 ± 0.011	244708	0.888 ± 0.016	246501	0.043 ± 0.010
		244608	0.059 ± 0.010	244709	0.100 ± 0.011	246502	0.042 ± 0.010
		244609	0.290 ± 0.012			246302	0.039 ± 0.010
						224712	0.102 ± 0.011

BasinID	2009 Area (km^2)	Source Year	BasinID	2009 Area (km^2)	Source Year	BasinID	2009 Area (km^2)	Source Year
211101	0.021 ± 0.002	2009	211416	0.022 ± 0.010	2009	212211	0.024 ± 0.010	2009
211102	0.012 ± 0.010	2009	211501	0.096 ± 0.011	2009	212212	0.209 ± 0.012	2009
211103	0.006 ± 0.010	2009	211502	0.042 ± 0.010	2006	212301	0.031 ± 0.010	2009
211104	0.457 ± 0.013	2009	211503	0.024 ± 0.010	2009	212302	0.427 ± 0.013	2009
211201	0.033 ± 0.010	2009	211504	0.094 ± 0.011	2009	212303	0.358 ± 0.013	2009
211202	0.010 ± 0.010	2006	211505	0.059 ± 0.010	2009	212304	1.973 ± 0.020	2009
211203	0.049 ± 0.010	2006	211506	1.804 ± 0.020	2009	212305	0.062 ± 0.010	2009
211204	0.034 ± 0.010	2006	211507	0.965 ± 0.016	2009	212306	1.219 ± 0.017	2009
211205	0.005 ± 0.010	2009	211508	0.311 ± 0.012	2009	212307	0.100 ± 0.011	2009
211206	0.046 ± 0.010	2009	211509	0.146 ± 0.011	2009	212401	0.505 ± 0.013	2009
211207	0.015 ± 0.010	2009	211510	0.137 ± 0.011	2009	212402	0.551 ± 0.014	2009
211208	0.047 ± 0.010	2009	211601	0.037 ± 0.010	2009	212403	0.125 ± 0.011	2009
211209	0.151 ± 0.011	2009	211602	0.052 ± 0.010	2009	212404	0.047 ± 0.010	2009
211210	0.701 ± 0.015	2009	211603	0.091 ± 0.011	2009	212501	0.061 ± 0.010	2009
211211	0.194 ± 0.011	2009	211604	0.114 ± 0.011	2009	212601	0.064 ± 0.011	2009
211302	0.041 ± 0.010	2009	211701	0.034 ± 0.010	2009	212602	0.275 ± 0.012	2009
211303	0.013 ± 0.010	2009	211702	0.024 ± 0.010	2009	212603	1.130 ± 0.017	2009
211304	0.010 ± 0.010	2009	211801	0.189 ± 0.011	2009	212604	4.843 ± 0.030	2009
211305	0.054 ± 0.010	2006	211802	0.108 ± 0.011	2009	212605	0.213 ± 0.012	2009
211306	0.014 ± 0.010	2009	211803	0.051 ± 0.010	2009	212606	0.177 ± 0.011	2009
211307	0.032 ± 0.010	2009	211804	0.307 ± 0.012	2009	212607	0.055 ± 0.010	2009
211401	0.039 ± 0.010	2009	211901	0.061 ± 0.010	2009	212608	0.586 ± 0.014	2009
211402	0.037 ± 0.010	2009	211902	0.025 ± 0.010	2009	212609	0.116 ± 0.011	2009
211403	0.013 ± 0.010	2009	211905	0.133 ± 0.011	2009	212610	0.072 ± 0.011	2009
211404	0.009 ± 0.010	2009	212101	0.115 ± 0.011	2009	212701	0.199 ± 0.012	2009
211405	0.022 ± 0.010	2009	212102	0.014 ± 0.010	2009	212702	3.649 ± 0.026	2009
211406	0.024 ± 0.010	2009	212201	0.363 ± 0.013	2009	212703	4.636 ± 0.029	2009
211407	0.022 ± 0.010	2009	212202	0.013 ± 0.010	2009	212704	2.208 ± 0.021	2006
211408	0.068 ± 0.011	2009	212203	0.021 ± 0.010	2009	213101	0.838 ± 0.015	2009
211409	0.040 ± 0.010	2009	212204	0.008 ± 0.010	2009	213102	0.224 ± 0.012	2009
211410	0.020 ± 0.010	2009	212205	0.061 ± 0.010	2009	213104	0.085 ± 0.011	2009
211411	0.006 ± 0.010	2009	212206	0.029 ± 0.010	2009	213105	4.642 ± 0.029	2009
211412	0.047 ± 0.010	2009	212207	0.053 ± 0.010	2009	213201	0.581 ± 0.014	2009
211413	0.028 ± 0.010	2009	212208	0.062 ± 0.010	2009	213202	0.923 ± 0.016	2009
211414	0.014 ± 0.010	2009	212209	0.089 ± 0.011	2009	221101	2.674 ± 0.023	2009
211415	0.041 ± 0.010	2009	212210	0.021 ± 0.010	2009	221102	1.925 ± 0.020	2009

BasinID	2009 Area (km^2)	Source Year	BasinID	2009 Area (km^2)	Source Year	BasinID	2009 Area (km^2)	Source Year
221103	3.466 ± 0.026	2009	222202	0.134 ± 0.011	2009	223501	0.043 ± 0.010	2009
221104	2.945 ± 0.024	2009	222203	0.025 ± 0.010	2009	223502	0.405 ± 0.013	2009
221105	0.072 ± 0.011	2009	222204	0.053 ± 0.010	2009	223503	0.170 ± 0.011	2009
221106	0.155 ± 0.011	2009	222205	0.683 ± 0.015	2009	223504	0.284 ± 0.012	2009
221107	0.217 ± 0.012	2009	222206	0.972 ± 0.016	2009	223601	0.066 ± 0.011	2009
221108	1.734 ± 0.020	2009	222207	0.055 ± 0.010	2009	223602	0.101 ± 0.011	2009
221109	0.272 ± 0.012	2009	222208	0.230 ± 0.012	2009	223603	0.252 ± 0.012	2009
221110	0.152 ± 0.011	2009	222209	0.031 ± 0.010	2006	223604	0.138 ± 0.011	2009
221202	0.084 ± 0.011	2009	222210	0.032 ± 0.010	2009	223605	0.060 ± 0.010	2009
221203	0.113 ± 0.011	2009	222301	0.301 ± 0.012	2009	223606	0.479 ± 0.013	2009
221204	0.845 ± 0.015	2009	222302	0.090 ± 0.011	2009	223607	0.148 ± 0.011	2009
221205	0.182 ± 0.011	2009	222303	0.091 ± 0.011	2009	223608	0.306 ± 0.012	2009
221206	0.102 ± 0.011	2009	222304	0.019 ± 0.010	2009	223609	0.036 ± 0.010	2009
221301	3.089 ± 0.025	2009	222305	0.171 ± 0.011	2009	223610	0.493 ± 0.013	2009
221302	2.375 ± 0.022	2006	222306	0.147 ± 0.011	2009	223611	0.258 ± 0.012	2009
221303	0.127 ± 0.011	2009	222307	0.036 ± 0.010	2009	223612	0.138 ± 0.011	2009
221304	0.224 ± 0.012	2009	222308	0.078 ± 0.011	2009	223701	0.075 ± 0.011	2009
221401	0.133 ± 0.011	2009	222309	0.142 ± 0.011	2009	223702	0.478 ± 0.013	2009
221402	0.043 ± 0.010	2009	222310	0.010 ± 0.010	2009	223703	0.064 ± 0.011	2009
221403	0.120 ± 0.011	2009	222311	0.076 ± 0.011	2009	224201	0.015 ± 0.010	2006
221404	0.005 ± 0.010	2009	222312	0.083 ± 0.011	2009	224202	0.022 ± 0.010	2006
221405	0.089 ± 0.011	2009	222313	0.145 ± 0.011	2009	224203	0.041 ± 0.010	2006
221406	0.014 ± 0.010	2009	222314	0.610 ± 0.014	2009	224401	0.041 ± 0.010	2009
221501	0.279 ± 0.012	2009	222315	0.116 ± 0.011	2006	224402	0.247 ± 0.012	2009
221502	0.020 ± 0.010	2009	222316	0.046 ± 0.010	2006	224404	0.335 ± 0.012	2009
221503	0.105 ± 0.011	2009	222401	0.195 ± 0.011	2009	224405	1.552 ± 0.019	2009
221504	0.082 ± 0.011	2009	222402	0.156 ± 0.011	2009	224501	0.013 ± 0.010	2009
221601	0.058 ± 0.010	2009	222403	0.178 ± 0.011	2009	224502	0.142 ± 0.011	2009
221602	0.081 ± 0.011	2009	222404	0.077 ± 0.011	2009	224601	0.068 ± 0.011	2006
221603	0.656 ± 0.014	2009	222405	0.095 ± 0.011	2009	224602	0.095 ± 0.011	2006
221604	0.092 ± 0.011	2009	222406	0.102 ± 0.011	2009	224603	0.074 ± 0.011	2006
221605	0.103 ± 0.011	2009	222407	0.063 ± 0.011	2009	224605	0.043 ± 0.010	2006
221606	0.267 ± 0.012	2009	222408	0.267 ± 0.012	2009	224606	0.046 ± 0.010	2009
221701	0.179 ± 0.011	2009	222501	0.367 ± 0.013	2009	224607	0.033 ± 0.010	2006
221702	0.074 ± 0.011	2006	222502	0.159 ± 0.011	2009	224608	0.090 ± 0.011	2009
221703	0.050 ± 0.010	2009	222601	0.086 ± 0.011	2009	224609	0.049 ± 0.010	2009
221704	0.168 ± 0.011	2009	222602	0.096 ± 0.011	2009	224610	0.024 ± 0.010	2009
221705	0.071 ± 0.011	2009	222603	0.174 ± 0.011	2009	224701	0.457 ± 0.013	2006
221706	0.141 ± 0.011	2009	222701	0.093 ± 0.011	2009	224702	0.211 ± 0.012	2006
221707	0.052 ± 0.010	2009	223101	0.418 ± 0.013	2009	224703	0.765 ± 0.015	2006
221708	0.048 ± 0.010	2009	223102	0.773 ± 0.015	2009	224704	0.122 ± 0.011	2006
221709	0.108 ± 0.011	2009	223103	0.098 ± 0.011	2009	224705	0.102 ± 0.011	2006
221710	0.043 ± 0.010	2009	223104	0.070 ± 0.011	2009	224706	0.637 ± 0.014	2009
221711	0.057 ± 0.010	2009	223105	0.554 ± 0.014	2009	224707	0.032 ± 0.010	2006
221712	0.031 ± 0.010	2009	223201	0.111 ± 0.011	2009	224708	0.077 ± 0.011	2006
221713	0.041 ± 0.010	2009	223202	0.228 ± 0.012	2009	224709	0.026 ± 0.010	2006
221714	0.295 ± 0.012	2009	223203	0.362 ± 0.013	2009	224710	0.044 ± 0.010	2006
221801	0.177 ± 0.011	2009	223204	0.300 ± 0.012	2009	224711	0.046 ± 0.010	2006
221802	0.039 ± 0.010	2009	223205	1.648 ± 0.019	2009	224713	0.043 ± 0.010	2009
221803	0.036 ± 0.010	2009	223206	0.213 ± 0.012	2009	224714	0.153 ± 0.011	2006
221804	0.189 ± 0.011	2009	223207	0.864 ± 0.015	2009	224801	0.052 ± 0.010	2009
221805	0.118 ± 0.011	2009	223301	0.586 ± 0.014	2009	225101	0.050 ± 0.010	2009
221806	0.012 ± 0.010	2009	223302	2.926 ± 0.024	2009	225102	0.039 ± 0.010	2006
221807	0.059 ± 0.010	2009	223303	0.211 ± 0.012	2009	225103	0.023 ± 0.010	2009
221808	0.093 ± 0.011	2009	223304	0.192 ± 0.011	2009	225104	0.022 ± 0.010	2009
221809	0.955 ± 0.016	2009	223305	0.007 ± 0.010	2009	225105	0.107 ± 0.011	2006
221901	0.535 ± 0.014	2009	223401	0.103 ± 0.011	2009	225106	0.091 ± 0.011	2006
221902	0.103 ± 0.011	2009	223402	0.040 ± 0.010	2009	225107	0.176 ± 0.011	2006
221903	0.084 ± 0.011	2009	223403	0.040 ± 0.010	2009	225108	0.313 ± 0.012	2009
221904	0.177 ± 0.011	2009	223404	0.050 ± 0.010	2009	225109	0.754 ± 0.015	2009
222101	1.144 ± 0.017	2009	223405	0.123 ± 0.011	2009	225110	0.180 ± 0.011	2006
222102	0.010 ± 0.010	2009	223406	0.098 ± 0.011	2009	225111	0.161 ± 0.011	2006
222103	0.054 ± 0.010	2009	223407	0.496 ± 0.013	2009	225112	0.056 ± 0.010	2006
222201	0.038 ± 0.010	2009	223408	0.079 ± 0.011	2009	225113	0.187 ± 0.011	2006

BasinID	2009 Area (km²)	Source Year	BasinID	2009 Area (km²)	Source Year	BasinID	2009 Area (km²)	Source Year
225114	0.363 ± 0.013	2009	226306	0.063 ± 0.010	2006	227506	0.262 ± 0.012	2006
225115	0.905 ± 0.016	2009	226307	0.056 ± 0.010	2006	227508	2.741 ± 0.023	2009
225201	0.064 ± 0.011	2006	226308	0.036 ± 0.010	2006	227601	0.105 ± 0.011	2009
225202	0.052 ± 0.010	2009	226401	0.047 ± 0.010	2006	227602	0.093 ± 0.011	2009
225203	0.163 ± 0.011	2006	226402	0.050 ± 0.010	2006	227603	2.674 ± 0.023	2009
225204	0.125 ± 0.011	2006	226403	0.028 ± 0.010	2009	227604	0.640 ± 0.014	2006
225205	6.100 ± 0.033	2009	226404	0.136 ± 0.011	2006	227605	1.296 ± 0.018	2006
225301	0.077 ± 0.011	2009	226405	0.056 ± 0.010	2006	227606	1.421 ± 0.018	2009
225302	0.239 ± 0.012	2009	226406	2.018 ± 0.021	2009	227607	2.247 ± 0.022	2009
225303	1.643 ± 0.019	2009	226407	0.349 ± 0.013	2006	227608	0.890 ± 0.016	2009
225304	0.125 ± 0.011	2006	226408	0.400 ± 0.013	2006	227609	1.310 ± 0.018	2006
225305	0.086 ± 0.011	2006	226410	0.025 ± 0.010	2009	227701	0.176 ± 0.011	2006
225306	4.237 ± 0.028	2006	226411	0.085 ± 0.011	2009	227702	1.287 ± 0.018	2006
225307	0.480 ± 0.013	2006	226412	0.049 ± 0.010	2009	227703	0.831 ± 0.015	2006
225308	0.090 ± 0.011	2006	226413	0.032 ± 0.010	2009	227801	0.065 ± 0.011	2006
225309	1.959 ± 0.020	2006	226501	0.052 ± 0.010	2009	227802	0.881 ± 0.016	2006
225310	1.472 ± 0.018	2006	226502	0.692 ± 0.015	2009	227803	0.038 ± 0.010	2006
225401	0.193 ± 0.011	2009	226503	0.038 ± 0.010	2006	227903	0.066 ± 0.011	2009
225402	0.283 ± 0.012	2009	226504	0.057 ± 0.010	2009	227904	0.117 ± 0.011	2009
225403	0.144 ± 0.011	2006	226505	0.097 ± 0.011	2009	228101	1.474 ± 0.018	2006
225501	0.927 ± 0.016	2009	226602	0.945 ± 0.016	2009	228102	0.742 ± 0.015	2006
225502	0.046 ± 0.010	2009	226603	0.090 ± 0.011	2009	228103	0.062 ± 0.010	2006
225503	0.058 ± 0.010	2009	226604	0.039 ± 0.010	2006	228104	0.374 ± 0.013	2006
225504	0.383 ± 0.013	2006	226701	0.254 ± 0.012	2009	228105	0.429 ± 0.013	2006
225505	0.146 ± 0.011	2006	226702	0.693 ± 0.015	2009	228201	0.295 ± 0.012	2006
225506	0.142 ± 0.011	2006	226801	0.033 ± 0.010	2009	228202	0.135 ± 0.011	2006
225507	0.039 ± 0.010	2006	226802	0.033 ± 0.010	2009	228203	1.375 ± 0.018	2006
225508	0.080 ± 0.011	2006	226803	0.097 ± 0.011	2009	228204	0.141 ± 0.011	2006
225509	4.792 ± 0.030	2009	226804	0.052 ± 0.010	2009	228307	0.049 ± 0.010	2009
225510	0.267 ± 0.012	2006	226905	0.018 ± 0.010	2006	228401	0.632 ± 0.014	2009
225511	0.078 ± 0.011	2006	227103	0.079 ± 0.011	2009	228402	0.104 ± 0.011	2009
225512	0.681 ± 0.015	2006	227104	0.156 ± 0.011	2009	228404	0.369 ± 0.013	2009
225513	0.111 ± 0.011	2006	227105	0.112 ± 0.011	2009	228406	0.372 ± 0.013	2009
225514	0.203 ± 0.012	2009	227106	0.022 ± 0.010	2009	228407	0.086 ± 0.011	2006
225601	0.182 ± 0.011	2009	227107	0.028 ± 0.010	2009	228503	0.078 ± 0.011	2009
225602	3.682 ± 0.026	2009	227201	0.018 ± 0.010	2006	228504	0.026 ± 0.010	2009
225701	0.768 ± 0.015	2009	227202	0.056 ± 0.010	2009	228505	0.096 ± 0.011	2009
225702	0.192 ± 0.011	2009	227203	0.192 ± 0.011	2009	228506	0.282 ± 0.012	2009
226101	0.057 ± 0.010	2006	227204	0.598 ± 0.014	2009	228507	0.081 ± 0.011	2009
226102	0.068 ± 0.011	2006	227205	0.054 ± 0.010	2006	228601	0.055 ± 0.010	2009
226103	0.701 ± 0.015	2006	227206	0.023 ± 0.010	2006	228602	0.060 ± 0.010	2009
226104	0.137 ± 0.011	2009	227207	0.057 ± 0.010	2006	228603	0.158 ± 0.011	2009
226105	0.341 ± 0.012	2009	227208	0.033 ± 0.010	2006	228604	0.207 ± 0.012	2009
226106	0.179 ± 0.011	2009	227209	0.062 ± 0.010	2009	231101	0.286 ± 0.012	2009
226107	0.089 ± 0.011	2006	227210	0.794 ± 0.015	2009	231102	0.027 ± 0.010	2009
226108	0.269 ± 0.012	2009	227211	0.078 ± 0.011	2006	231104	0.125 ± 0.011	2009
226109	0.226 ± 0.012	2009	227212	0.026 ± 0.010	2009	231105	0.565 ± 0.014	2009
226110	0.320 ± 0.012	2009	227301	0.075 ± 0.011	2006	233101	0.169 ± 0.011	2009
226201	0.087 ± 0.011	2006	227302	0.075 ± 0.011	2006	233201	0.037 ± 0.010	2009
226203	1.858 ± 0.020	2006	227303	0.033 ± 0.010	2006	233202	0.039 ± 0.010	2009
226205	0.033 ± 0.010	2006	227304	0.100 ± 0.011	2006	233203	0.072 ± 0.011	2009
226206	0.042 ± 0.010	2006	227305	0.026 ± 0.010	2006	233204	0.742 ± 0.015	2009
226207	0.255 ± 0.012	2006	227306	1.008 ± 0.016	2009	233205	0.090 ± 0.011	2009
226208	0.132 ± 0.011	2006	227307	0.117 ± 0.011	2009	233206	0.081 ± 0.011	2009
226209	0.775 ± 0.015	2006	227308	0.164 ± 0.011	2006	233207	0.026 ± 0.010	2009
226210	0.050 ± 0.010	2006	227309	0.106 ± 0.011	2006	233208	0.118 ± 0.011	2009
226211	0.050 ± 0.010	2006	227310	0.335 ± 0.012	2006	233209	0.028 ± 0.010	2009
226212	0.118 ± 0.011	2009	227311	0.071 ± 0.011	2006	233401	0.095 ± 0.011	2006
226213	0.259 ± 0.012	2009	227312	0.268 ± 0.012	2006	233402	0.525 ± 0.014	2006
226301	0.042 ± 0.010	2009	227313	0.227 ± 0.012	2006	233403	0.113 ± 0.011	2006
226302	0.074 ± 0.011	2006	227402	0.171 ± 0.011	2006	233404	0.200 ± 0.012	2006
226303	0.870 ± 0.016	2009	224703	0.765 ± 0.015	2006	233405	0.714 ± 0.015	2006
226304	0.277 ± 0.012	2009	227501	0.105 ± 0.011	2006	233406	0.116 ± 0.011	2006
226305	0.066 ± 0.011	2006	227505	0.332 ± 0.012	2006	233407	0.611 ± 0.014	2006

BasinID	2009 Area (km^2)	Source Year
233409	0.054 ± 0.010	2006
234201	0.051 ± 0.010	2006
234202	0.056 ± 0.010	2006
234203	0.116 ± 0.011	2006
234204	0.325 ± 0.012	2006
241302	0.122 ± 0.011	2006
241303	0.178 ± 0.011	2006
241304	0.045 ± 0.010	2006
241305	0.402 ± 0.013	2006
241306	0.002 ± 0.010	2009
241307	0.213 ± 0.012	2009
241308	0.068 ± 0.011	2006
241401	0.081 ± 0.011	2006
241501	0.137 ± 0.011	2006
241502	0.028 ± 0.010	2006
241503	0.028 ± 0.010	2006
241504	0.345 ± 0.012	2006
242201	0.052 ± 0.010	2006
242204	0.032 ± 0.010	2006
242205	0.035 ± 0.010	2006
242206	0.025 ± 0.010	2006
242207	0.129 ± 0.011	2006
242209	0.067 ± 0.011	2006
242210	0.020 ± 0.010	2006
242211	0.105 ± 0.011	2006
242213	0.081 ± 0.011	2006
242601	0.067 ± 0.011	2006
242602	0.038 ± 0.010	2006
242604	0.037 ± 0.010	2006
242605	0.050 ± 0.010	2006
242606	0.051 ± 0.010	2009
242607	0.095 ± 0.011	2006
242608	0.164 ± 0.011	2006
242609	0.062 ± 0.010	2006
242610	1.040 ± 0.016	2006
242611	0.114 ± 0.011	2009
242612	0.250 ± 0.012	2006
242701	1.441 ± 0.018	2006
242702	0.068 ± 0.011	2006
242703	0.801 ± 0.015	2006
242704	0.049 ± 0.010	2006
242705	0.046 ± 0.010	2006
242706	0.901 ± 0.016	2006
242707	1.210 ± 0.017	2006
242708	0.334 ± 0.012	2006
242709	0.120 ± 0.011	2006
242802	0.343 ± 0.012	2006
242803	0.092 ± 0.011	2006
242804	0.107 ± 0.011	2006
242805	0.000 ± 0.010	2006
243101	0.020 ± 0.010	2006
243102	0.109 ± 0.011	2006
243103	0.098 ± 0.011	2006
243104	0.057 ± 0.010	2006
243105	0.085 ± 0.011	2006
243106	0.058 ± 0.010	2006
243201	0.076 ± 0.011	2006
243202	0.074 ± 0.011	2006
243203	0.545 ± 0.014	2006
243204	0.243 ± 0.012	2006
243205	0.105 ± 0.011	2006
244201	0.144 ± 0.011	2006
244202	0.132 ± 0.011	2006
244203	0.036 ± 0.010	2006
244204	0.140 ± 0.011	2006
244205	0.163 ± 0.011	2006
244206	0.035 ± 0.010	2006
244207	0.155 ± 0.011	2006
244209	0.041 ± 0.010	2006
244210	0.082 ± 0.011	2006
244211	0.036 ± 0.010	2006
244212	0.049 ± 0.010	2006
244213	0.305 ± 0.012	2006
244215	0.093 ± 0.011	2006
244217	0.386 ± 0.013	2006
244219	0.085 ± 0.011	2006
244220	0.034 ± 0.010	2006
244221	1.110 ± 0.017	2006
244222	0.184 ± 0.011	2006
244223	0.017 ± 0.010	2006
244301	0.004 ± 0.010	2006
244302	0.599 ± 0.014	2006
244303	0.291 ± 0.012	2006
244305	0.076 ± 0.011	2006
244306	0.053 ± 0.010	2006
244307	0.241 ± 0.012	2006
244308	0.231 ± 0.012	2006
244401	0.113 ± 0.011	2006
244402	0.082 ± 0.011	2006
244403	0.257 ± 0.012	2006
244404	0.030 ± 0.010	2006
244405	0.014 ± 0.010	2006
244406	0.071 ± 0.011	2006
244407	4.487 ± 0.029	2009
244408	1.409 ± 0.018	2009
244409	0.787 ± 0.015	2009
244410	0.039 ± 0.010	2009
244411	0.054 ± 0.010	2009
244412	0.031 ± 0.010	2006
244413	0.028 ± 0.010	2006
244414	0.061 ± 0.010	2006
244415	0.118 ± 0.011	2006
244416	0.098 ± 0.011	2006
244417	0.222 ± 0.012	2006
244501	0.016 ± 0.010	2006
244502	0.019 ± 0.010	2006
244503	0.151 ± 0.011	2006
244504	1.524 ± 0.019	2006
244505	0.250 ± 0.012	2006
244506	0.029 ± 0.010	2009
244507	0.130 ± 0.011	2006
244508	0.136 ± 0.011	2006
244509	0.020 ± 0.010	2006
244510	0.049 ± 0.010	2006
244511	0.214 ± 0.012	2006
244512	0.248 ± 0.012	2006
244513	0.034 ± 0.010	2006
244514	0.051 ± 0.010	2006
244515	0.099 ± 0.011	2006
244516	0.068 ± 0.011	2006
244517	0.038 ± 0.010	2006
244518	0.020 ± 0.010	2009
244519	0.021 ± 0.010	2006
244601	0.092 ± 0.011	2006
244602	0.258 ± 0.012	2006
244603	0.117 ± 0.011	2009
244604	0.068 ± 0.011	2006
244605	0.025 ± 0.010	2006
244606	0.030 ± 0.010	2006
244607	0.152 ± 0.011	2006
244608	0.059 ± 0.010	2006
244609	0.274 ± 0.012	2009
244610	0.158 ± 0.011	2006
244612	0.033 ± 0.010	2006
244613	0.123 ± 0.011	2006
244615	0.040 ± 0.010	2006
244616	0.052 ± 0.010	2006
244617	0.041 ± 0.010	2006
244618	0.015 ± 0.010	2006
244620	0.304 ± 0.012	2006
244621	0.291 ± 0.012	2006
244622	0.240 ± 0.012	2006
244623	0.057 ± 0.010	2006
244624	0.016 ± 0.010	2006
244625	0.012 ± 0.010	2006
244701	0.020 ± 0.010	2006
244702	0.057 ± 0.010	2006
244703	0.587 ± 0.014	2006
244704	0.191 ± 0.011	2006
244705	0.037 ± 0.010	2006
244706	0.090 ± 0.011	2006
244707	0.036 ± 0.010	2006
244708	0.817 ± 0.015	2006
244709	0.098 ± 0.011	2006
244710	0.251 ± 0.012	2009
244711	0.040 ± 0.010	2006
244712	0.222 ± 0.012	2009
244713	0.027 ± 0.010	2006
244801	0.013 ± 0.010	2006
244802	0.020 ± 0.010	2006
244803	0.129 ± 0.011	2006
244804	0.016 ± 0.010	2006
244805	0.125 ± 0.011	2006
244806	0.055 ± 0.010	2006
244807	0.100 ± 0.011	2006
244808	0.192 ± 0.011	2006
244809	0.079 ± 0.011	2006
244810	0.113 ± 0.011	2006
244811	0.018 ± 0.010	2006
245303	0.052 ± 0.010	2006
245304	0.107 ± 0.011	2006
245305	0.136 ± 0.011	2006
245306	0.019 ± 0.010	2006
245307	0.015 ± 0.010	2006
245401	0.013 ± 0.010	2006
245402	0.042 ± 0.010	2006
245403	0.023 ± 0.010	2006
245404	0.007 ± 0.010	2006
245405	0.033 ± 0.010	2006
246501	0.040 ± 0.010	2006
246502	0.033 ± 0.010	2006
245509	0.027 ± 0.010	2006
246301	0.007 ± 0.010	2006
246302	0.043 ± 0.010	2006
246303	0.039 ± 0.010	2006
246304	0.014 ± 0.010	2006
246305	0.014 ± 0.010	2006
246306	0.017 ± 0.010	2006
246307	0.032 ± 0.010	2006
224712	0.084 ± 0.011	2006

Appendix C – Climate Data

Average PRISM data for the grid cells where glaciers are located. Mean emperature is reported in ° Celsius and mean precipitation is in cm.

Year	Annual Max Temp	Annual Mean Precip	Summer Max Temp	Summer Mean Precip	Spring Max Temp	Spring Mean Precip	Winter Max Temp	Winter Mean Precip	Fall Max Temp	Fall Mean Precip
1900	7.38	199	14.56	80	10.31	130	0.98	308	2.92	290
1901	7.56	183	15.04	62	8.92	128	-0.66	271	7.65	308
1902	6.87	212	15.36	70	8.70	137	-1.26	349	4.31	298
1903	6.26	213	14.02	107	8.25	95	-1.38	321	4.07	330
1904	7.26	201	15.72	53	10.10	100	-1.82	372	5.68	259
1905	7.04	182	15.52	92	10.07	103	-0.70	261	2.52	283
1906	7.58	210	16.45	95	9.55	119	-0.33	281	3.69	384
1907	6.93	187	15.11	73	9.43	98	-2.26	322	6.42	233
1908	7.48	197	16.62	53	8.51	136	-1.22	337	5.55	268
1909	6.33	206	15.97	63	7.80	88	-2.48	306	3.18	413
1910	7.35	232	15.81	58	11.44	130	-1.06	350	3.14	446
1911	6.44	181	15.15	81	7.52	134	-1.26	259	3.32	272
1912	6.86	204	14.78	90	8.81	110	-0.26	314	3.27	308
1913	6.25	189	15.39	90	8.52	117	-2.28	261	2.72	318
1914	7.76	191	15.93	78	11.00	112	-0.80	275	5.29	326
1915	8.23	211	17.39	52	10.41	148	0.59	322	3.03	370
1916	6.09	201	15.64	75	8.36	122	-3.21	353	3.33	229
1917	7.14	229	16.95	67	6.90	148	-1.91	459	5.89	172
1918	7.77	208	16.98	60	9.18	84	-0.55	346	4.58	353
1919	7.01	210	16.56	63	9.05	151	-1.11	378	2.08	226
1920	7.01	208	15.87	119	6.37	115	0.27	279	3.41	336
1921	6.72	246	14.81	88	8.41	125	-1.03	378	4.34	420
1922	6.31	172	16.73	64	7.25	96	-3.54	286	4.25	236
1923	7.60	194	16.71	74	8.96	116	-1.33	342	5.89	214
1924	7.26	186	15.87	64	10.04	89	-0.62	298	3.02	302
1925	8.23	187	17.00	45	10.49	102	0.55	355	3.79	222
1926	8.84	188	16.95	70	11.24	116	1.21	280	5.50	310
1927	6.67	240	16.42	93	7.26	167	-1.82	339	3.58	412
1928	7.86	189	16.81	57	9.95	144	-0.24	298	4.09	281
1929	7.16	144	16.77	55	8.00	135	-2.01	256	5.46	106
1930	7.04	163	16.31	58	9.34	138	-1.50	254	3.27	216
1931	8.17	231	16.81	110	11.02	131	0.20	388	4.01	259
1932	7.29	248	16.72	67	9.13	120	-1.82	385	4.83	466
1933	7.37	249	16.40	103	7.90	85	-1.37	454	6.25	297
1934	9.68	243	16.91	68	12.97	122	2.70	363	5.91	471
1935	7.64	174	16.87	86	9.47	68	-0.56	315	3.74	176
1936	7.91	188	17.26	88	11.04	115	-2.27	381	6.47	77
1937	7.19	229	16.82	94	7.65	192	-2.26	295	6.38	403
1938	9.17	171	18.95	36	10.98	109	0.20	299	5.75	248
1939	8.83	185	16.96	59	10.98	102	0.99	327	6.08	237
1940	8.91	192	17.91	52	10.93	132	1.38	294	3.96	330
1941	8.77	189	16.23	106	11.08	135	1.99	238	5.09	314
1942	8.15	174	17.92	73	9.14	116	-0.06	229	4.03	321
1943	7.95	172	17.26	67	9.08	156	-0.85	278	5.80	188
1944	8.36	157	17.13	86	9.91	121	-0.06	212	6.13	226
1945	7.75	217	16.58	66	8.65	141	0.04	332	4.58	365
1946	7.55	220	16.38	72	9.83	119	-0.19	365	3.08	326
1947	8.15	207	16.23	82	11.21	97	0.50	328	4.23	326
1948	6.37	246	15.33	122	6.69	209	-1.69	334	4.27	355
1949	7.05	217	15.66	88	10.35	98	-2.47	331	5.58	365
1950	6.34	253	16.98	78	6.71	151	-2.88	404	3.14	402
1951	7.13	216	17.38	63	10.16	87	-2.73	374	3.31	333
1952	8.00	141	16.85	66	9.29	101	-1.22	256	7.44	99
1953	8.34	244	16.28	92	8.46	124	1.46	432	6.13	292
1954	6.69	220	14.11	100	7.64	137	-0.51	326	5.31	330
1955	5.75	240	15.38	67	6.06	177	-1.95	326	1.59	476
1956	7.27	209	16.40	108	11.20	51	-1.62	351	2.87	284

1957	7.69	173	16.60	64	10.82	100	-1.18	311	4.46	188
1958	9.37	212	18.80	71	11.52	133	1.38	298	4.34	404
1959	7.16	246	15.70	126	8.64	190	-0.47	333	3.89	367
1960	7.41	202	16.66	61	8.14	203	-0.78	263	4.58	364
1961	7.95	232	18.19	72	7.74	146	0.46	410	2.63	283
1962	7.35	197	15.85	87	7.50	159	-0.06	257	5.01	333
1963	7.59	194	16.24	83	8.55	138	0.09	244	4.32	372
1964	6.56	214	14.71	104	7.89	136	-1.27	336	4.61	271
1965	7.80	186	16.22	57	9.37	149	-0.50	306	5.97	241
1966	7.41	204	15.74	82	9.34	98	-0.31	326	4.23	310
1967	8.34	233	18.82	56	7.47	95	0.11	393	4.74	404
1968	6.92	236	15.69	123	7.95	127	-0.52	360	3.24	325
1969	7.35	178	16.99	94	9.60	149	-2.04	276	4.58	181
1970	7.44	196	17.25	70	7.81	157	-0.72	306	3.75	265
1971	6.54	230	15.78	82	8.90	112	-1.90	396	2.56	315
1972	6.60	251	15.36	128	7.90	172	-1.79	462	4.55	153
1973	7.32	181	16.34	58	9.70	111	-0.25	259	2.03	342
1974	7.76	237	17.31	63	7.58	150	-0.65	442	5.68	263
1975	6.69	246	15.94	63	7.90	115	-1.56	388	3.48	458
1976	6.98	179	14.95	79	8.80	121	-1.01	320	5.20	159
1977	7.50	210	16.48	87	9.60	115	-0.57	310	3.55	352
1978	7.24	164	16.13	107	8.47	127	-0.75	225	4.21	193
1979	7.88	184	17.44	73	9.82	118	-1.29	342	5.16	159
1980	7.01	212	14.93	95	9.98	137	-1.63	319	5.49	306
1981	7.82	204	16.08	112	8.56	200	0.78	267	4.69	263
1982	6.87	227	16.38	96	8.33	130	-1.22	387	2.57	265
1983	7.50	228	15.33	132	11.06	122	-0.57	311	4.39	362
1984	6.85	228	16.20	79	7.43	192	-0.53	322	2.32	375
1985	6.84	165	17.33	79	9.84	145	-1.80	156	0.12	375
1986	8.18	206	17.15	74	8.64	136	0.19	304	5.77	348
1987	9.25	169	18.08	54	11.57	159	0.01	305	7.75	136
1988	7.93	211	16.22	86	9.96	176	-0.01	272	5.20	373
1989	7.71	188	16.43	56	10.59	153	-1.02	264	4.86	339
1990	7.82	261	17.79	81	10.15	112	-0.95	362	3.10	568
1991	8.02	200	16.72	69	9.03	177	0.34	303	5.01	280
1992	9.10	180	17.60	104	12.26	116	1.37	255	4.41	250
1993	7.46	161	15.44	100	10.67	162	-0.97	214	5.15	179
1994	8.68	204	18.37	67	11.53	101	0.36	315	3.09	357
1995	8.31	229	17.22	84	11.35	96	0.11	303	3.84	505
1996	7.33	227	17.81	60	8.03	192	-1.34	358	3.01	335
1997	9.53	279	19.22	141	11.30	173	0.80	433	5.82	357
1998	9.55	209	19.84	39	10.53	96	0.71	357	5.66	363
1999	8.44	245	17.17	69	8.66	100	0.65	434	6.32	362
2000	8.12	152	16.63	82	10.37	139	0.63	228	3.82	151
2001	8.79	174	18.38	64	9.32	133	2.10	211	2.45	358
2002	9.13	183	18.67	54	9.65	178	0.17	344	7.47	122
2003	10.01	224	20.45	36	10.11	109	1.80	325	5.44	512
2004	10.31	179	19.20	115	12.63	95	2.21	245	6.39	261
2005	9.97	164	18.38	75	12.30	125	2.55	229	5.67	251
2006	8.40	215	17.61	48	9.20	90	0.72	325	4.54	454
2007	8.03	178	15.85	56	9.34	84	1.43	330	4.30	213
2008	7.45	167	15.52	67	7.55	87	0.05	259	6.01	264
2009	8.06	174	17.44	51	8.78	137	0.28	207	4.15	389

Supplemental CD

Name: NOCA_GlacierInventory.gdb
File Type: File geodatabase
Size: 14.1 MB
Required Application Software: ArcGIS 10.1