Foundation for Glacier and Environmental Research
Juneau Icefield Research Program
Seattle, Washington
and
Glaciological and Arctic Sciences Institute
University of Idaho
Moscow, Idaho

JIRP Open File Survey Report—2000

GEODETIC ACTIVITIES DURING THE 2000 JUNEAU ICEFIELD RESEARCH PROGRAM FIELD SEASON

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All data contained herein were collected from 1992 to 2000 by the Foundation for Glacier and Environmental Research, Juneau Icefield Research Program with additional financial support from the University of Idaho, National Science Foundation, NASA, the Army Research Office, and the Universität der Bundeswehr, Munich, Germany. These data are available to the public at no charge for scholarly use. Researchers wishing to use the information contained herein may do so provided the author and the Foundation for Glacier and Environmental Research, Juneau Icefield Research Program are properly credited and cited as the originators of the data.

Survey reports from previous field seasons of the Juneau Icefield Research Program may be obtained from the Foundation for Glacier and Environmental Research at the above address, or on the Internet at http://crevassezone.org.

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FOUNDATION FOR GLACIER AND ENVIRONMENTAL RESEARCH,

JUNEAU ICEFIELD RESEARCH PROGRAM,

SEATTLE, WASHINGTON

SUMMARY

The JIRP 2000 field season proved to be a productive one for the survey team. GPS surveys were conducted at eleven previously established transverse movement profiles. Three longitudinal movement profiles were extended in length, and two new longitudinal movement profiles were established. Additional surveys were conducted within the wave-bulge zone of the Vaughan Lewis Glacier, and several 1995 positions on the Gilkey Glacier were resurveyed this year. The survey team also determined geospatial coordinates of three benchmarks in the vicinity of Camp 19, and also measured the location of several mass balance test pits.

As in past years, the survey work focused on determining surface movements, surface elevations and changes, strain rates, ablation data, and local surface mass balance. Additionally, evaluation of the surface velocity along the longitudinal profiles has enabled the calculation of more precise flow lag times for the Taku, Matthes, Llewellyn, Demorest, Southwest Branch, Northwest Branch, and West Branch Glaciers. Results of the surveys show that, for the second consecutive year, there was an overall increase in surface elevations on the Juneau Icefield, ranging from the Lemon Glacier to the Llewellyn Glacier at F-10 Peak. The only exception to the positive balance was in the Gilkey Trench, where comparative surveys from 1995 and 2000 reveal a mean surface elevation decrease of some 13 meters. Evaluation of the local surface mass balance changes at Profile 4 reveals a return to positive net balance after a four year period of strongly negative balance. The observed surface velocities at all locations remain consistent with that found in previous years.

1. INTRODUCTION

The 2000 JIRP field season was, once again, a resounding success in terms of survey work accomplished. The number of surveys completed in 1999 was certainly impressive, but this was easily surpassed in 2000, despite it being the wettest and snowiest summer since 1969. The surveys conducted this summer comprised 20 distinct profiles with a total of 391 points, and considering the resurvey of selected flags, a grand total of 570 points were surveyed in 2000. Figure 1 presents a graphical timeline of the surveys, while Table 1 provides additional details of the surveys completed during the 2000 field season. Refer to Figure 2 for a map showing the locations of profiles surveyed.

The survey program on the Juneau Icefield has, for the past several decades, focused primarily on determining surface movement along various transverse profiles on the Taku Glacier and its tributaries. This has provided a substantial record of temporal surface movement, the results of which indicate that the movement of the Taku Glacier and its tributaries has been relatively constant throughout the time period of the surveys. There have been no statistically significant variations of movement along the transverse profiles.

While we now have a detailed record of movement along the standard transverse profiles, we still know very little about the surface velocity field throughout a large portion of the Icefield. With transverse profiles spaced 5-8 kilometers apart, it is not possible to determine other important characteristics that collectively help to define the surface velocity field of the entire Juneau Icefield system. For example, is the increase or decrease in velocity from one profile downglacier to the next one linear? Quantitatively, what is the relationship between velocity, glacier width, ice depth, and surface slope? What is the average gradient of the glaciers? Where, and of what magnitude, are the lowest and highest gradients?

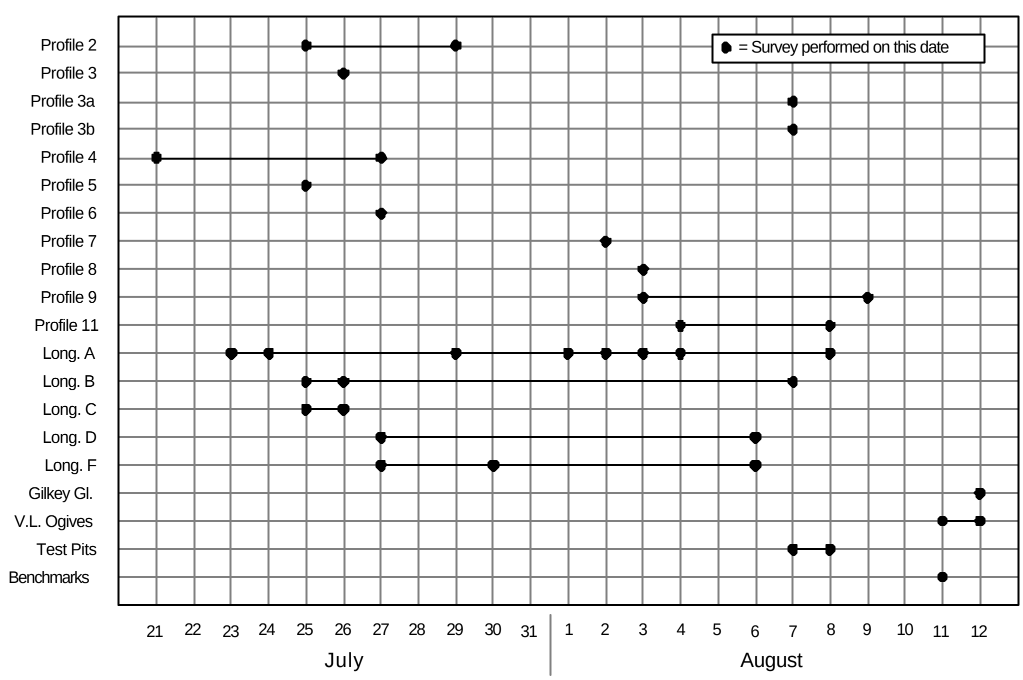

Figure 1: Timeline of surveys conducted during the 2000 JIRP field season.

With eight years of high-quality GPS survey data revealing the unchanging nature of movement at the standard transverse movement profiles, the survey program is now shifting its focus to the exploration and surveying of previously unsurveyed sectors of the Juneau Icefield. This began with the establishment of a limited longitudinal profile on the Matthes Glacier in 1995 and has included other special projects such as the Matthes/Llewellyn Divide Grid and a longitudinal profile across the divide between the Vaughan Lewis Glacier and the Matthes Glacier. Recognizing the wealth of data available from longitudinal profiles, the survey program initiated an extensive project in 1999 to determine the longitudinal surface velocities, surface elevations, and surface gradients throughout the entire Taku Glacier system with data collected at a nominal 500 meter interval. This important project was continued during the 2000 field season with the extension of Longitudinal A over the Matthes/Llewellyn divide and down the Llewellyn Glacier to near Camp 26. Additionally, Longitudinal B on the Demorest Glacier was further extended, and Longitudinals D and F were established on the Northwest and West Branches of the Taku Glacier. Together with the 1999 longitudinal surveys, we have now surveyed 93.5 kilometers of the Taku system, out of a total of some 150 kilometers. Other special projects in 2000 included a survey of the first nine wave bulges at the foot of the Vaughan Lewis Icefall, and a resurvey of several 1995 GPS points on the Gilkey Glacier. The extension of the longitudinal profiles will continue in the next several years, with the ultimate goal being a complete longitudinal survey of the entire Taku Glacier and all its major tributaries.

The survey program has now completed the transition from terrestrial theodolite and EDM methods to space-based GPS methods. As in 1999, all survey work done in 2000 was accomplished with real-time differential GPS. Of significant importance was the elimination of Selective Availability by the U.S. military in the spring of 2000, thereby enabling 2-4 meter accuracy of point determinations made even with single lightweight handheld GPS units.

A major factor in the increase in the amount of survey work accomplished was the use of fast, fuel-efficient snowmobiles. This allowed us to easily extend the survey work into areas that would have required significantly more time had they been accessed with the much slower Thiokol oversnow vehicles.

As in past years, Walter Welsch, Martin Lang, and Scott McGee headed the survey crew. The core survey group consisted of four students who dedicated their full time on the Icefield to the survey program. Four additional students elected to divide their time between the survey program and other research interests such as meteorology, hydrology, and mass balance. Overall this seemed to work well, not only for the students, but also for the survey program. A core group of four students is about the ideal number in order to carry out the required survey work. Occasionally, additional help was needed, which was readily provided by the adjunct crew of four students. The core group performed the majority of surveys during the summer and gained expertise in the use of GPS. The adjunct group, while not attaining the level of GPS proficiency of the core group, nevertheless learned enough to be quite effective, while at the same time also being able to learn and participate fully in other research areas. Although the effort needed to coordinate the core and adjunct groups is greater than with just a core group, the advantage of students learning and participating in other projects far outweighs the extra planning effort. In the future, the survey program should continue this integrative approach.

PROFILE	LOCATION	SURVEY DATES	DATA COLLECTED	SURVEY METHOD	# OF FLAGS
Profile 2	Taku Glacier	July 25, 2000 July 29, 2000	MV, AB, HC	RT-DGPS RT-DGPS	11 11
Profile 3	Demorest Glacier	July 26, 2000	HC	RT-DGPS	12
Profile 3a	Demorest Glacier	August 7, 2000	HC	RT-DGPS	15
Profile 3b	Demorest Glacier	August 7, 2000	HC	RT-DGPS	8
Profile 4	Taku Glacier	July 21, 2000 July 27, 2000	MV, AB, HC, MB, SR	RT-DGPS RT-DGPS	31 31
Profile 5	Southwest Branch	July 25, 2000	HC	RT-DGPS	12
Profile 6	Northwest Branch	July 27, 2000	HC	RT-DGPS	16
Profile 7	Matthes Glacier	August 2, 2000	HC	RT-DGPS	16
Profile 8	Matthes Glacier	August 3, 2000	HC	RT-DGPS	12
Profile 9	Vaughan Lewis Glacier	August 3, 2000 August 9, 2000	MV, AB, HC	RT-DGPS RT-DGPS	8 8
Profile 11	Llewellyn Glacier	August 4, 2000 August 8, 2000	MV, AB, HC	RT-DGPS RT-DGPS	12 12
Gilkey Trench	Gilkey Glacier	August 12, 2000	HC	RT-DGPS	9
Vaughan Lewis Ogives	Vaughan Lewis Glacier	August 11, 2000 August 12, 2000	MV, AB, SR	RT-DGPS RT-DGPS	28 28
Longitudinal A	Taku / Matthes / Llewellyn Glaciers	July 23, 2000 July 24, 2000 July 29, 2000 August 1, 2000 August 2, 2000 August 3, 2000 August 4, 2000 August 8, 2000	MV, AB, HC, GR	RT-DGPS (all dates)	16 25 11 22 27 7 13 37
Longitudinal B	Demorest Glacier	July 25, 2000 July 26, 2000 July 29, 2000 August 7, 2000	MV, AB, HC, GR	RT-DGPS (all dates)	10 9 9 15
Longitudinal C	Southwest Branch	July 25, 2000 July 26, 2000	POS, HC, GR	RT-DGPS (all dates)	7 9
Longitudinal D	Northwest Branch	July 27, 2000 August 6, 2000	MV, AB, GR	RT-DGPS (all dates)	16 16
Longitudinal F	West Branch	July 27, 2000 July 30, 2000 August 6, 2000	MV, AB, GR	RT-DGPS (all dates)	8 10 16
Benchmarks	Camp 19 area	August 11, 2000	POS	DGPS	3
Test Pits	Various locations	August 7, 2000 August 8, 2000	POS	Garmin	4

Explanation of Codes		
Data Collected:	AB = Ablation HC = Height comparison MB = Mass balance	MV = Movement POS = Position SR = Strain rates GR = Surface Gradient
Survey Method:	DGPS = Rapid static differential GPS RT-DGPS = Real time differential GPS Garmin = Garmin 45 handheld GPS	

Table 1: Detail of surveys conducted during the 2000 JIRP field season.

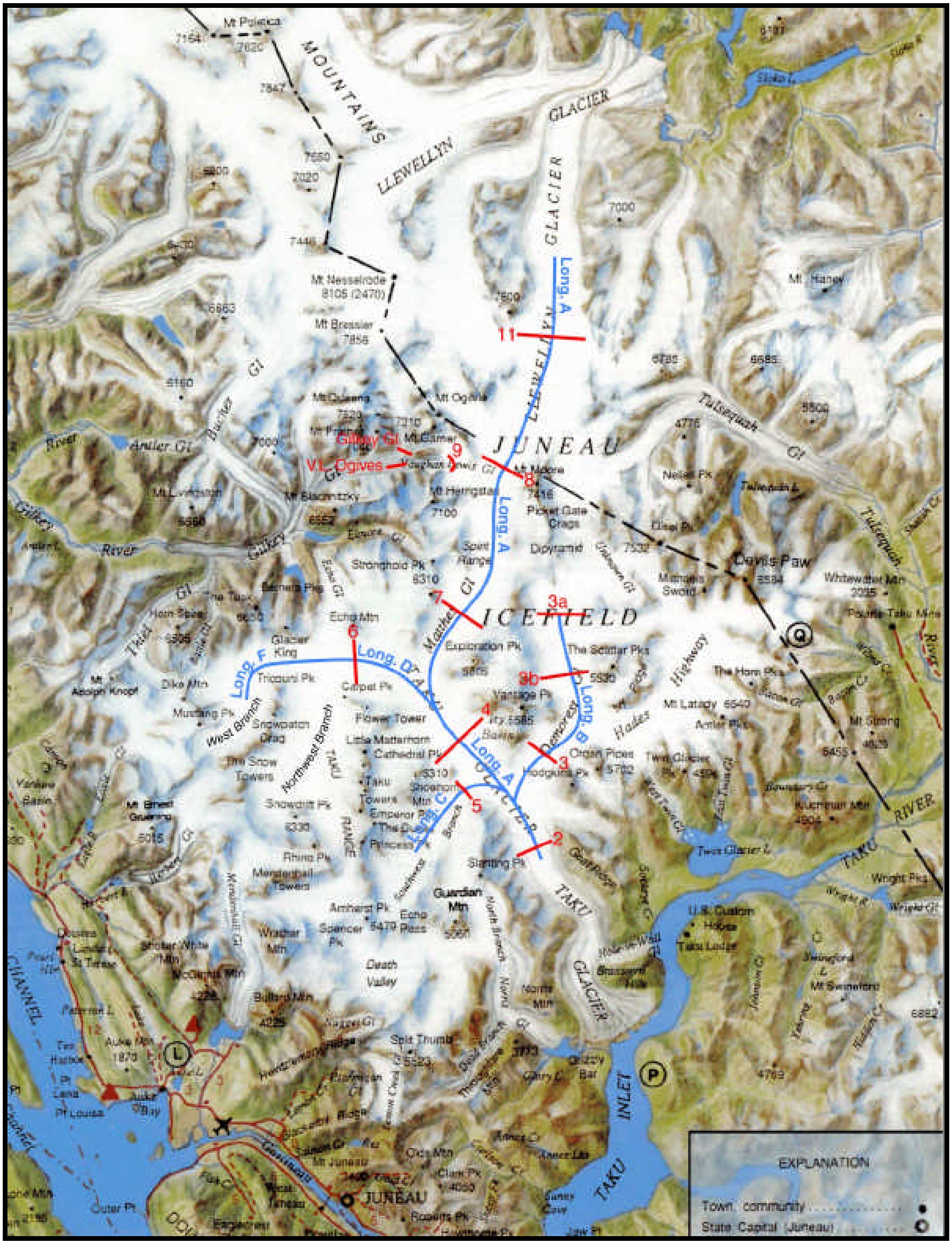

Figure 2: Location of transverse and longitudinal profiles surveyed during the 2000 JIRP field season.

2. SURVEY METHODS

As in the past several years, standard rapid static and real-time differential GPS methods were utilized for all of the 2000 surveys. For a complete description of the techniques used, refer to the discussion by Lang (1993) and McGee (1994). However, recognizing that these references may be unavailable to the reader of this report, and in order to document the procedures used and to provide evidence of the quality and validity of the data collected, a brief overview of the methodology used for the 2000 survey work will be given here.

2.1 ESTABLISHMENT OF PROFILES

One of the main goals of the surveying program is to collect data that allows quantitative comparison of surface movement and surface elevation change from year to year. In order to ensure the consistency of year-to-year movement and elevation data, all survey flags were located within one meter of the standard point coordinates as published in the JIRP Coordinate Tables (McGee, 2000). Refer to Appendix 2 for the JIRP 2000 flag placement coordinates. The placement of all flags was accomplished with a Leica 530 survey-grade GPS system operating in real-time differential mode.

2.2 GPS SURVEY METHODS

After the initial establishment of the survey profiles was completed, the points were surveyed. Because of the survey program's emphasis on extending the longitudinal network and monitoring annual surface height change, less importance was placed on surface velocity determination for several of the traditional transverse profiles and for those points of the longitudinal profiles that were surveyed in 1999. These profiles were surveyed only once in 2000 in order to determine annual height change.

Those points comprising the extension of the longitudinal profiles, and those within Profiles 2, 4, 9, 11, the Gilkey Glacier profile, and the Vaughan Lewis ogives, were surveyed two times, with the time differential between the surveys ranging from 1 day to 10 days. The survey timeline is shown in Figure 1. For all real-time surveys, a reference receiver was centered and leveled on a tripod over an appropriate bedrock benchmark (a listing of GPS benchmarks is presented in Appendix 1). Concurrently, a roving receiver was placed at each flag of a movement profile, and both the reference and roving receivers collected coincident GPS data simultaneously. The antenna of the roving receiver was mounted on an aluminum monopole, which was placed in the same hole from which the survey flag was extracted. The height of the antenna above the snow surface was measured and noted. For rapid-static work (determination of GPS coordinates of three benchmarks in the Camp 19 area) the roving receiver collected readings at 15-second intervals for 30 minutes at each benchmark. Real-time methods required only enough time at each flag sufficient to obtain a position fix from the reference receiver, typically around 5-10 seconds.

At the completion of a survey all data was downloaded from the roving and reference receivers for post-processing. Coordinates were then transformed from a geocentric coordinate system to one based on the JIRP coordinate system. This system utilizes a Transverse Mercator projection centered on the Juneau Icefield. The parameters of the JIRP coordinate system are shown in Table 2. All final horizontal coordinates are accurate to approximately 2-3 cm, with heights being accurate to some 5 cm or so. All heights in this report are with respect to the height above the WGS84 ellipsoid, in meters.

PARAMETER	VALUE	ARC/INFO PROJECTION FILE
Projection	Transverse Mercator	projection transverse units meters datum wgs84 spheroid wgs84 parameters 1 /*Scale of central meridian -134 00 00 /*Longitude of origin 00 00 00 /*Latitude of origin 500000 /*False easting 0 /*False northing
Units	Meters	
Central Meridian	134° 00' 00" West	
Latitude of Origin	0° 00' 00" North	
Zone Width	3° 00' 00"	
Central Meridian Scale	1.000000	
False Easting	500,000 meters	
False Northing	0 meters	

Table 2: Parameters of the JIRP coordinate system. The column "Projection File" lists the parameters required to transform from the JIRP system to a different projection using Arc/Info.

3. SURVEY PROJECTS

The major focus of the 2000 survey program was to determine surface velocities, surface elevations, surface gradients, and strain rates across the largest extent of the Juneau Icefield as practicable. To this end, survey work commenced on July 21 and finished on August 12, with a total of 570 points surveyed. These surveys ranged from Goat Ridge on the Taku Glacier, to the Camp 15 Peak area on the West Branch of the Taku Glacier, to Camp 26 on the Llewellyn Glacier.

As in 1999, the extension and survey of the longitudinal profiles was the main focus of the 2000 field season. Despite persistent rain and whiteout conditions in July, the survey crew succeeded in establishing an additional 44 kilometers of longitudinal profiles on the Taku, Demorest, Southwest Branch, Northwest Branch, West Branch, Matthes, and Llewellyn Glaciers. Additionally, all longitudinal points that were first established and surveyed in 1999 were again surveyed this year. Combined, the 1999 and 2000 longitudinal profiles encompass 93.5 kilometers of the Taku/Llewellyn glacier system.

Other survey work accomplished this year included ongoing surveys of the standard transverse movement profiles, with emphasis on long-term height change rather than velocity determination. This was necessary so that adequate field time could be allocated to the longitudinal surveys. Additionally, surveys were performed on the first nine wave ogives at the base of the Vaughan Lewis Icefall, and several points surveyed on the Gilkey Glacier in 1995 were resurveyed this year.

Regrettably, time constraints and weather conditions conspired to eliminate the annual surface height survey of the Lemon Glacier. This is particularly unfortunate as the retained accumulation from the winter of 1999-2000 was strongly positive. However, given the surface height increase and resultant positive mass balance observed over the main portion of the

Icefield, it is reasonable to conclude that the surface heights on the Lemon Glacier increased and that the net mass balance was also positive.

3.1 TRANSVERSE PROFILES

Surface velocity, short-term height change, and long-term height change at the transverse profiles are discussed in this section. Refer to Section 3.2 for a discussion of the survey results at the longitudinal profiles.

3.1.1 SURFACE VELOCITY

Although new emphasis was given to surveying the longitudinal profiles, the standard transverse movement profiles remain an important element in the ongoing monitoring of the Juneau Icefield. Periodic annual surveys of these profiles allow quantitative comparisons of the temporal velocity and height changes across the Icefield, at a variety of elevations. With 22 transverse profiles already established, it is not possible to survey each one every year. With this in mind, 12 profiles were selected for resurvey in 2000. Several of these profiles have not been surveyed in recent years, notably Profile 2 on the Taku Glacier, Profile 8 on the Matthes Glacier, Profile 9 on the Vaughan Lewis Glacier, Profile 11 on the Llewellyn Glacier, and the 1995 GPS points on the Gilkey Glacier.

The discussion in this section will focus on the surface velocity at the transverse profiles. Refer to Section 3.2.1 for details regarding the surface velocities along the longitudinal profiles. All surface velocity data are presented in Appendix 3.

3.1.1.1 TAKU / MATTHES / LLEWELLYN GLACIERS

The main Taku/Matthes/Llewellyn (TML) glacier system bisects the southern half of the Juneau Icefield, extending some 93 kilometers from the tidewater of Taku Inlet in Alaska to the terminal lake of the Llewellyn Glacier in British Columbia. To date, a total of ten transverse profiles have been established on the TML system (additionally, other transverse profiles have been established on other glaciers of the Juneau Icefield), with a spacing of 5 to 10 kilometers. Of these ten, five were resurveyed during the 2000 field season. Profiles 2, 4, and 11 were each surveyed twice this summer, allowing for the calculation of surface velocity vectors. These three profiles are discussed in this section. Profiles 7 and 8 were surveyed only once and therefore can be evaluated in terms of long-term height change only. Refer to Section 3.1.3.1 for details on these two profiles.

Profile 2 extends across the Taku Glacier at Goat Ridge, approximately 20 kilometers upglacier from the terminus and some 11 kilometers downglacier from Camp 10. The location of this profile is significant as it roughly coincides with the névé line. The benchmark Lupine, at Sunday Point on Taku A, was used as the real-time GPS reference point. The mean elevation of the profile at Epoch 0 in 2000 was 824.00 meters above the WGS84 ellipsoid. Its mean elevation in 1994, the only previous time it was surveyed via GPS at the same coordinates, was 824.70 meters, indicating that the net thinning of the Taku Glacier over the last six years at this location is only 0.70 meter (0.63 meter water equivalent, based on an ice density of 0.90 g/cm^3). The fastest velocities measured on the Juneau Icefield occur at this profile. This is due to three factors: 1) its location is at the névé line; 2) there is a significant decrease in the width of the valley; and 3) the profile is downglacier of the junction of all the tributaries of the Taku Glacier. The mean observed velocity in 2000 was 82.3 cm/day, with a maximum of 92.7 cm/day at Flag 6 (see Figure 3). This compares to a maximum of 93.0 cm/day at Flag 7 in 1994, indicating that there has been no statistically significant change in velocity from 1994 to 2000. This correlates well with previous findings of steady-state velocities at other profiles on the Taku Glacier during the past decade (McGee, 1996; Welsch and Lang, 1997; Lang, 1999). The relatively uniform observed velocities and lack of crevasses across the central sector of the profile seem to indicate a block-schollen mode of flow at Profile 2 (see Figure 4). However, significant shear zones and crevasses hinder the measurement of velocities at both margins of the profile. As a result, velocities within about 700 meters of the glacier edge have not been measured. Lacking this information, a complete velocity profile of Profile 2 cannot be drawn. The adjusted (4th order polynomial) velocities shown in Figure 3 must therefore be subject to some speculation where no data exist along the margins. While the overall shape of the curve seems to indicate lower energy parabolic flow, this cannot in fact be the case given the presence of the major marginal shear zones. The 2000 survey data continue to support the conclusions of Welsch and Lang (1997) that the mode of flow at Profile 2 is a transitory stage between parabolic and true block-schollen. The data and surface characteristics of the ice do suggest however, that the flow is more block-schollen than parabolic.

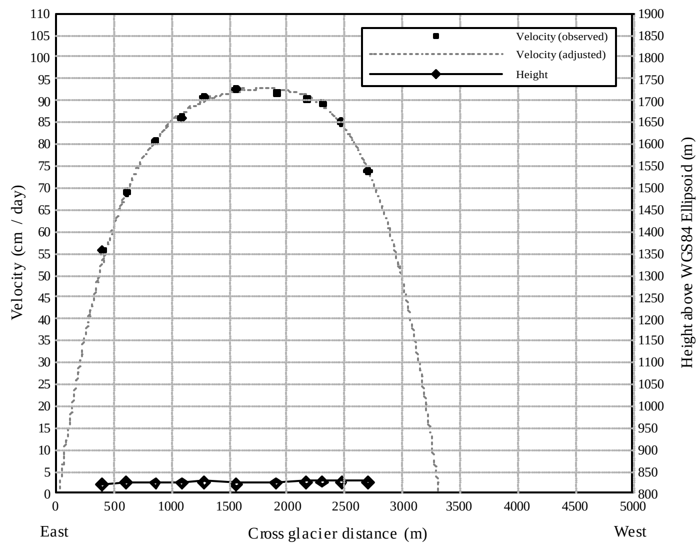

Figure 3: Surface velocity and height of Profile 2

Profile 4 is located on the main Taku Glacier at Camp 10 and extends southwesterly 4.8 kilometers from Taku B to just downglacier of Shoehorn Peak. Of the numerous cross-glacier profiles on the Juneau Icefield, this profile has the most extensive continuous survey history. Although early surveys of Profile 4 varied in the number of points and in the location of those points, this situation was rectified in 1993 with the establishment, via GPS, of standardized stake-out coordinates and with the number of points surveyed, as detailed in the JIRP movement profile stake-out coordinate tables (McGee, 2000). Profile 4 consists of 31 flags arranged in two parallel transects, placed approximately 240 meters apart, which are offset so as to form a series of 29 triangles between the 16 flags on the downglacier transect and the 15 flags on the upglacier transect. All surveys since 1993 have utilized this arrangement, which allows for the computation of strain rates, height change, and mass balance in addition to velocity, and their annual comparison. As in past years, the benchmark FFGR 19.1 (Scott) at Camp 10 was utilized as the real-time GPS reference point.

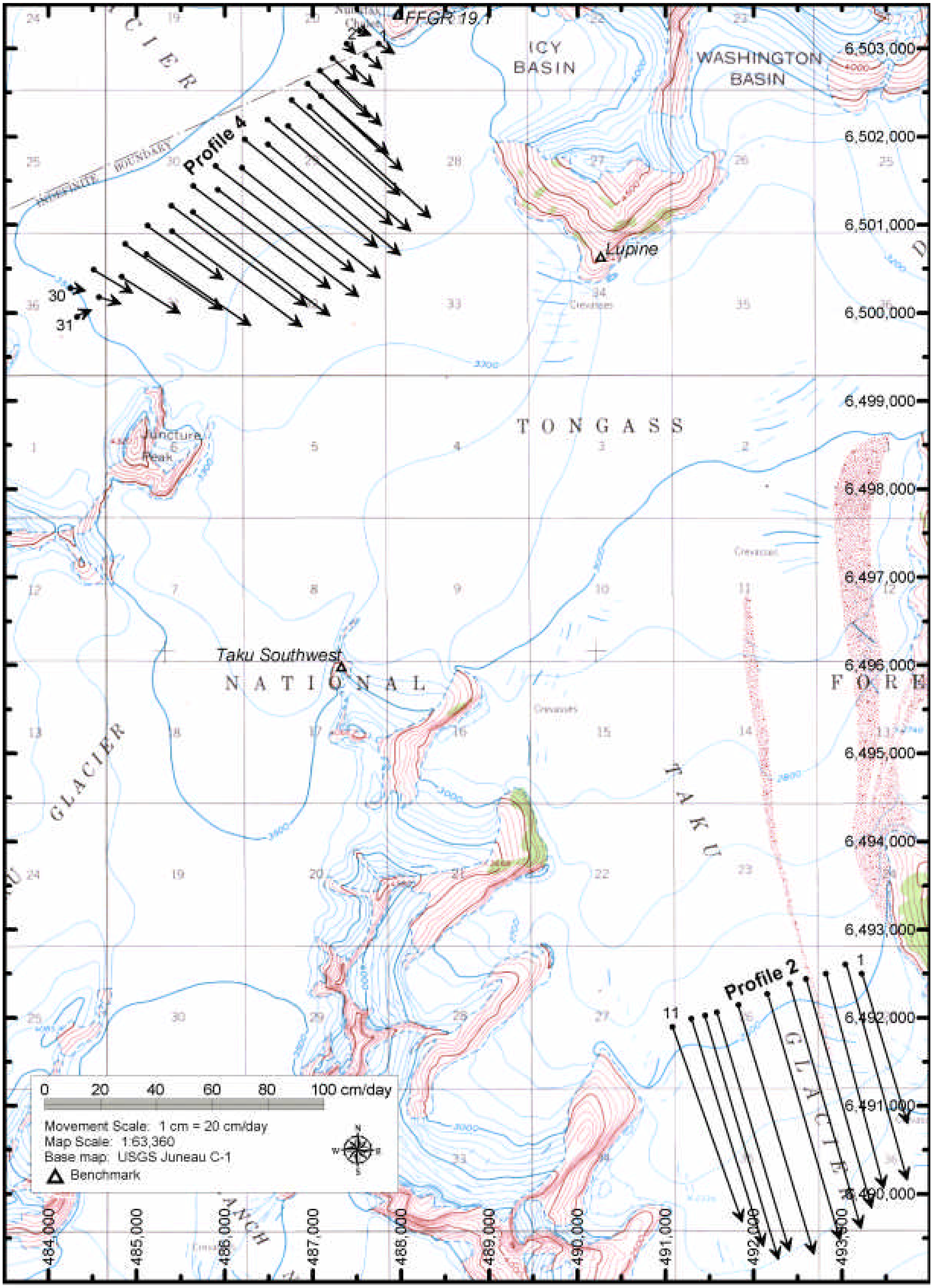

Figure 4: Surface movement vectors at Profiles 2 and 4, Taku Glacier.

The maximum measured velocity in 2000 was 62.2 cm/day at Flag 19, and the mean velocity for all 31 flags was 35 cm/day. These data show no statistically significant deviation of the measured velocities from 1993 through 1999. Therefore, a steady-state flow regime is operative. The mean elevation of all flags at Epoch 0 in 2000 was 1128.27 meters.

The cross-glacier velocity distribution curves along the downglacier line and the upglacier line are shown in Figures 5 and 6, respectively. Among the two parallel transects, the downglacier line had the highest measured velocity of 62.2 cm/day at Flag 19. The maximum velocity measured at the upglacier line was 61.4 cm/day at Flag 18. Mean velocities are 34.6 cm/day for the downglacier line and 35.5 cm/day for the upglacier line. Again, no significant velocity differences are found between the two parallel transects. This is supported by the observation of a lack of unusual crevassing or other surface strain indicators in the 240 meter lateral distance between the two transects.

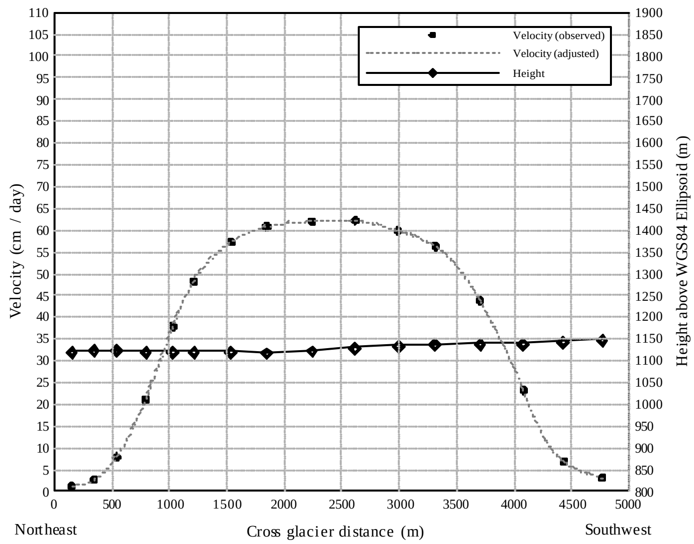

Figure 5: Surface velocity and height of Profile 4, lower line

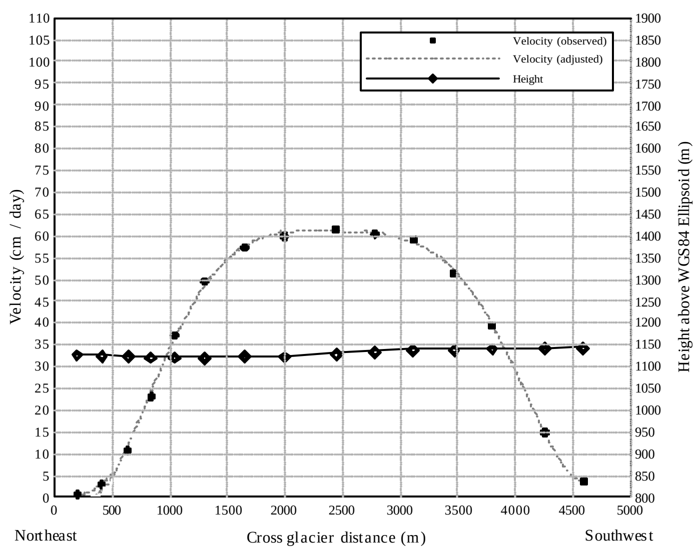

Figure 6: Surface velocity and height of Profile 4, upper line

Figures 4, 5, and 6 reveal that the mode of flow at Profile 4 is not as vigorously block-schollen as that found at Profile 2, however it is not truly parabolic either. Well-defined marginal crevasse zones give clear indication of large velocity differences along both margins of the profile, while the central portion between Flags 13 and 23 moves as a coherent block, with no evidence of crevasses. Although the marginal crevasses are numerous, the shear zones are not nearly as chaotic as those at Profile 2. The flow at this profile can be characterized as a medial transitional stage between parabolic and block-schollen.

Profile 11 is located on the Llewellyn Glacier at the north end of F-10 Peak. It is situated 10 kilometers downglacier from the Matthes/Llewellyn divide and approximately 2 km upglacier from the ELA, at a mean height of 1729.48 meters. FFGR 62, located on the north ridge of F-10, was used for the real-time GPS reference point. Figure 7 shows the velocity and height curves for this profile. The maximum velocity observed in 2000 was 29.6 cm/day at Flag 8, compared to a maximum of 27.2 cm/day in 1997, the only other time this profile was surveyed. With a horizontal error of 2-3 centimeters in the calculated flag coordinates, the difference between the 1997 and 2000 surface velocities is not significant. As with Profiles 2 and 4, a steady-state velocity regime on the Llewellyn Glacier at this location must be suggested. As can be clearly seen in Figure 8, the mode of flow at this profile is parabolic. Since Profile 11 on the Llewellyn Glacier and Profile 2 on the Taku Glacier are both within 2 kilometers of the their respective névé lines, this indicates that the flow of the Llewellyn Glacier is at a lower energy state than the flow of the Taku Glacier. This is to be expected given the differences in the accumulation area ratio between the two glaciers.

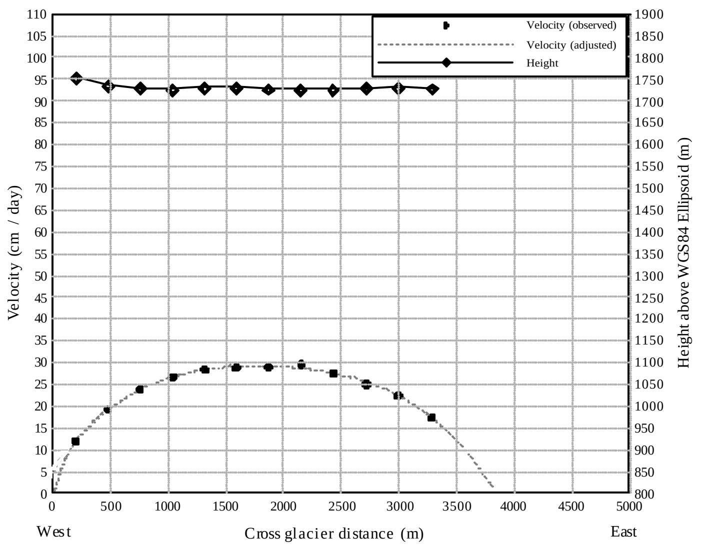

Figure 7: Surface velocity and height of Profile 11

Comparison of the adjusted velocity curves with the cross-glacier heights for Profiles 2, 4, and 11 is consistent with previous observations that velocity generally varies with respect to the terminus, ELA, and head of a valley glacier system (Sharp, 1988), with the greatest velocities occurring at the ELA, and decreasing from there both upglacier to the head of the glacier and downglacier to the terminus. A quick look at Figures 3, 5, 6, and 7 reveal that the greatest velocities observed to date on the Taku Glacier system are located at Profile 2 at a mean height of 824 meters, in the area of the ELA of the Taku Glacier. As one moves upglacier, the velocity generally decreases as the elevation increases (neglecting the local influence of steeper gradients or local changes in width and depth of the glacier). At a height of 1870 meters, near the crest of the Matthes/Llewellyn divide, the velocity is only 3.9 cm/day. Continuing down the Llewellyn Glacier from the crest, the velocity increases to 29.6 cm/day at Profile 11, at a height of 1729 meters. It should be noted however, that surveys have not been conducted downglacier from Profile 11, thus greater velocities on the Llewellyn Glacier may in fact be present.

3.1.1.2 VAUGHAN LEWIS GLACIER

Profile 9 is located in a broad cirque basin approximately 2 kilometers upglacier from the beginning of the steep descent of the Vaughan Lewis Icefall into the Gilkey Trench. This is an area of extensive extending flow, characterized by numerous large crevasses arranged in a crescentic pattern from the eastern end of the Camp 18 nunatak to the northeast ridge of Mammary Peak. Unlike all other transverse profiles on the Juneau Icefield, this profile

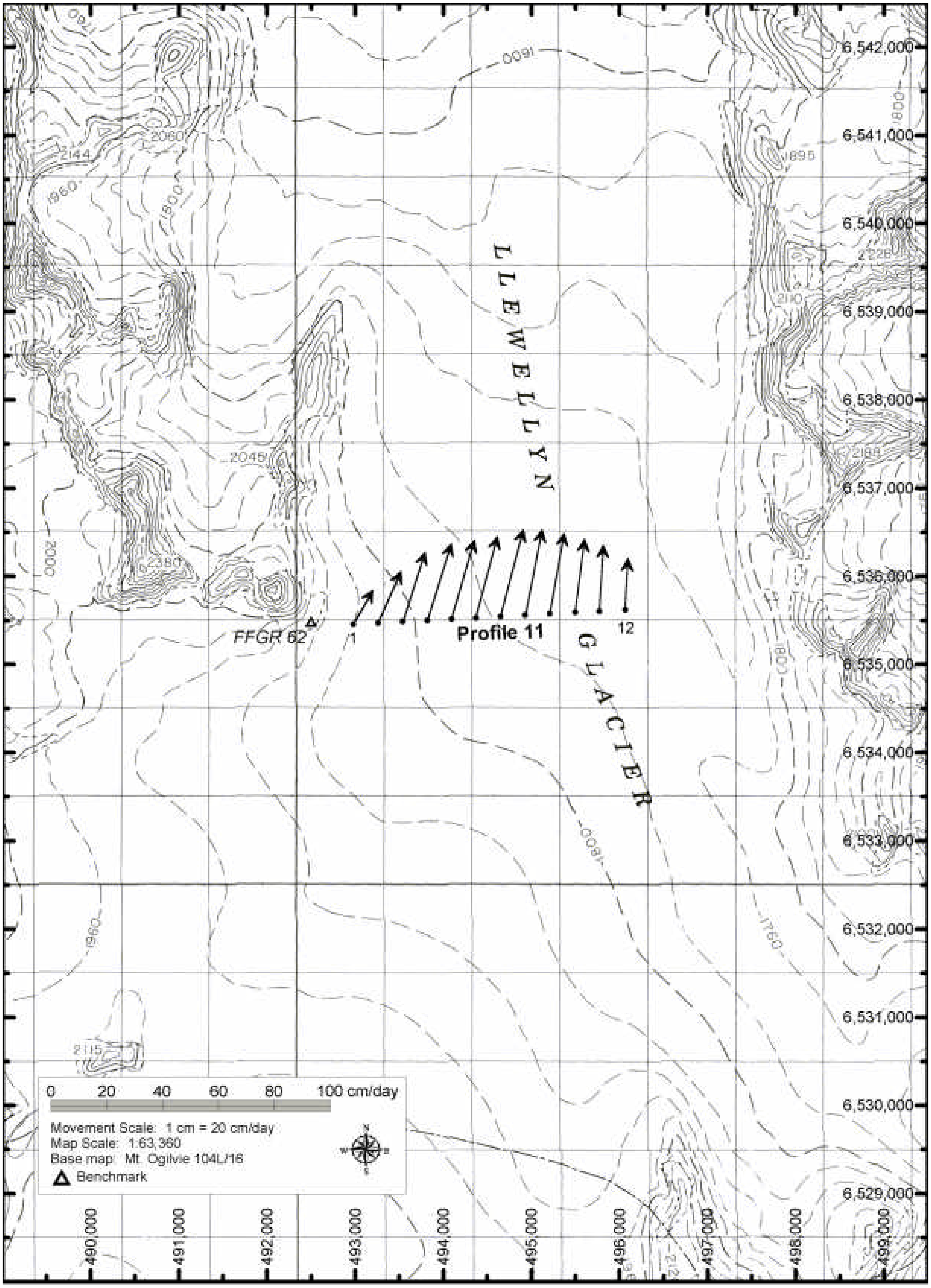

Figure 8: Surface movement vectors at Profile 11, Llewellyn Glacier.

follows a curvilinear path that coincides with the local crevasse pattern. This pattern is a manifestation of the cirque basin above the Vaughan Lewis Icefall between Mammary Peak and the Camp 18 nunatak. The profile was last surveyed in 1997. The benchmark N1, located at Camp 18, was used as the real-time GPS reference point.

The maximum velocity measured during the 2000 field season was 12 cm/day at Flag 3 and the mean height at Epoch 0 was 1745.39 meters. Figure 9 shows the velocity/elevation graph for Profile 9. It must be noted however, that the velocity curve does not represent a straight, cross-glacier traverse, as is the case with Profiles 2, 4, and 11. The velocity curve shown here actually represents the converging radial flow from the perimeters of the cirque basin toward the center. As such, caution must be exercised when determining the mode of flow at this location. Although the shape of the velocity graph for Profile 9 is similar to the graph for Profile 11 (see Figure 7), the mode of flow at this profile is in fact extensional rather than parabolic, as evidenced by the strongly crescentic crevasse pattern in the vicinity of Profile 9. Figure 10 shows the movement vectors for Profile 9 and for the profiles surveyed in the Gilkey Trench during the summer of 2000.

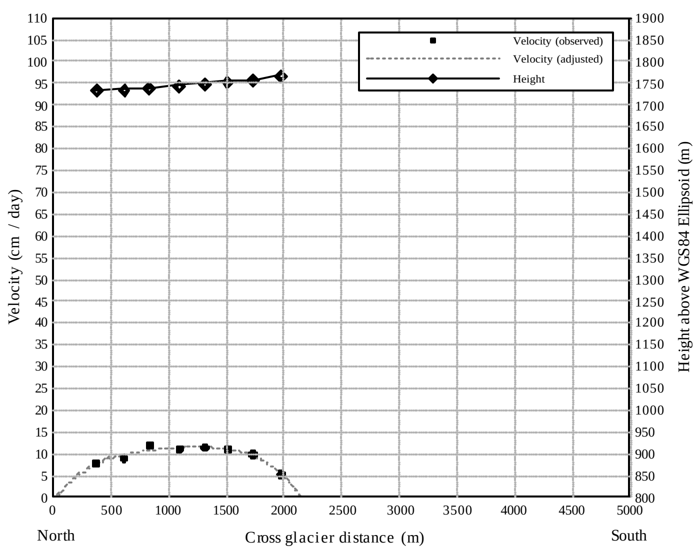

Figure 9: Surface velocity and height of Profile 9

While the 2000 velocities are similar to the velocities observed in 1996 and 1997 (McGee 1996; Lang, 1997) the direction of the movement shows greater variation at this profile than at any other profile (see Figure 11). This is probably due to the location of the profile in the extension zone above the Vaughan Lewis Icefall, and to the placement of the flags around the perimeter of the basin. Steep slopes on the southern end of the profile descend the north face of Mammary Peak. Slopes on the northern end of the profile are somewhat gentler. Analysis of the movement vectors from 1996, 1997, and 2000 reveals no significant difference in the magnitude of the movement, however the direction of the movement varies by as much as 39 gon[1] from one year to the next. The mean directional deviation is 13.8 gon from year to year. These year-to-year differences in the direction of the vectors are to be expected given the highly dynamic nature of the Vaughan Lewis Glacier at the location of this profile.

[1] A metric unit of angular measure whereby a complete revolution equals 400 gon, or 360 degrees. To convert gon to degrees: degrees = gon x 0.9

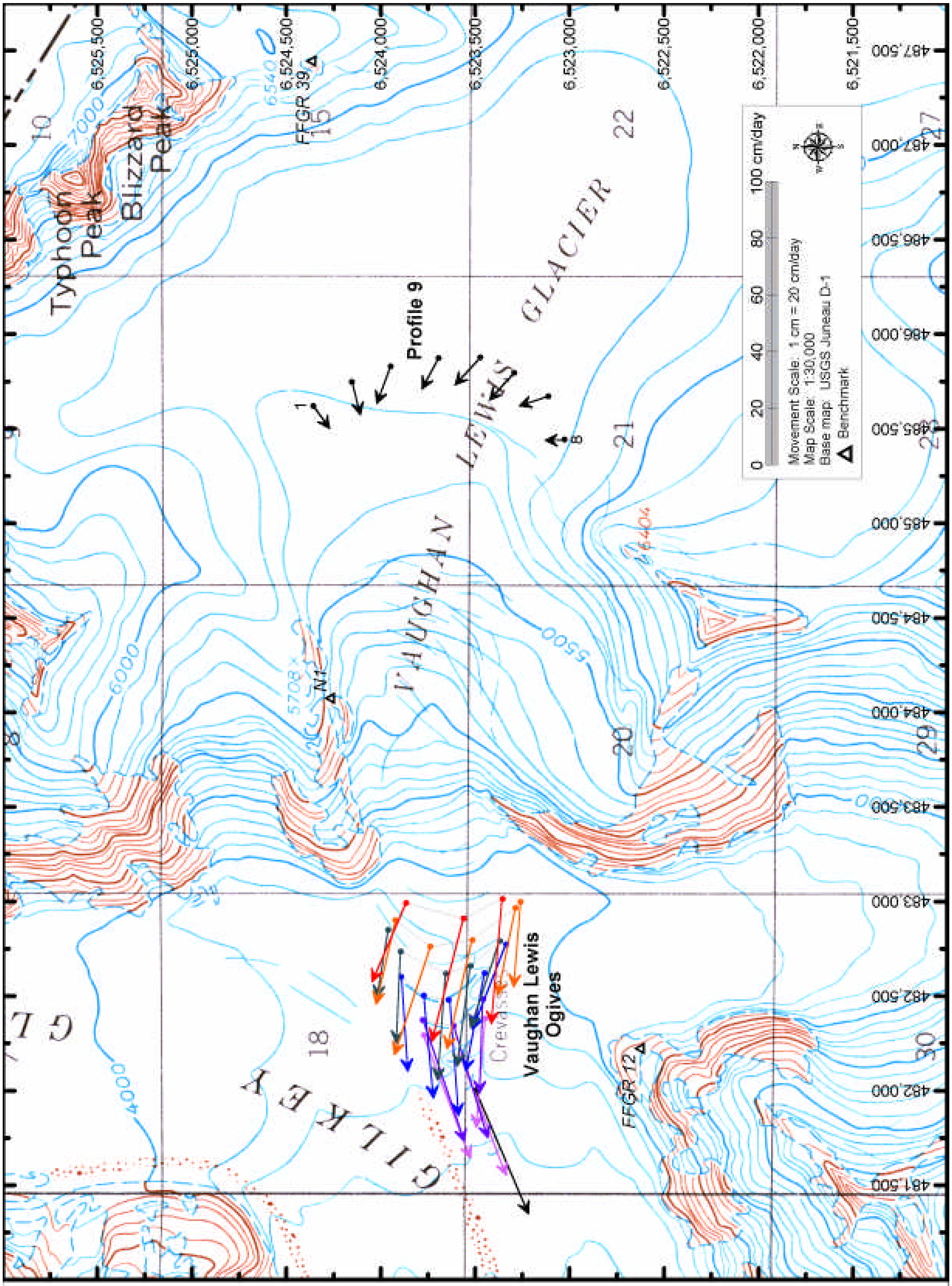

Figure 10: Surface movement vectors at Profile 9 and ogives, Vaughan Lewis Glacier.

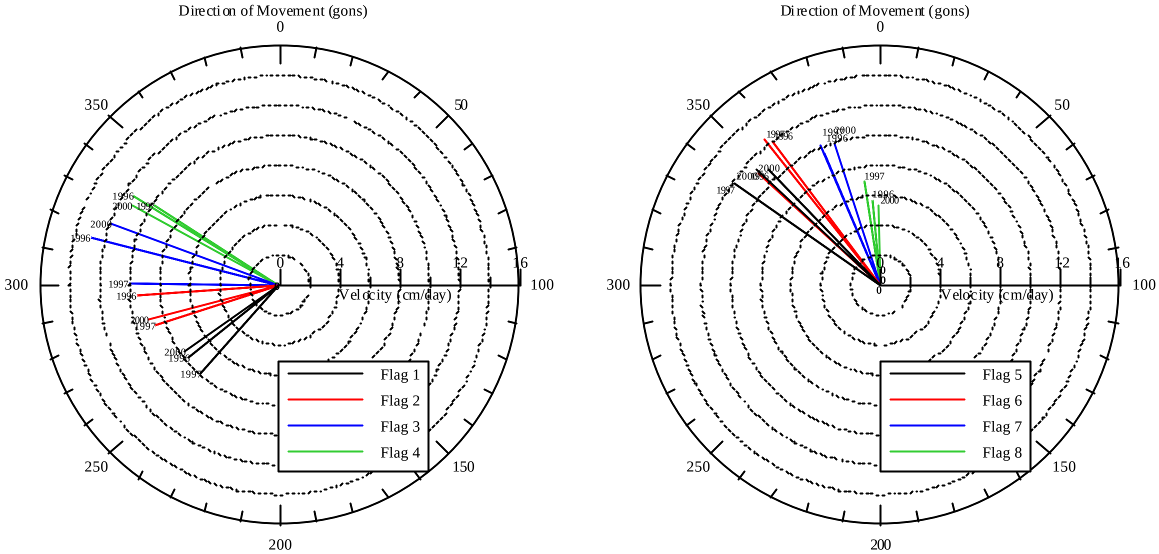

Figure 11: Comparison of movement vectors for Flags 1-8 of Profile 9, for the years 1996, 1997, and 2000.

3.1.2 SHORT-TERM HEIGHT CHANGE

For the purposes of this report, short-term height change is defined as the change in height of the glacier surface between the summer Epoch 0 and Epoch 1 surveys, typically covering a time span of 7 to 14 days. Ablation, downslope movement, and firn compaction are the main contributors to short-term height change. The accuracy to which this change can be detected on a glacier with GPS is roughly 1-5 cm, depending on the magnitude of suncup-induced surface roughness. A smooth surface devoid of suncups allows for more precise measurement of the GPS antenna above the well-defined snow surface. The presence of large suncups mandates estimation of the mean surface between the crest and the troughs. With a smooth, suncup-free surface (typical at the higher elevations of the Matthes and Llewellyn Glaciers), surface heights relative to a known benchmark can be determined within about ±0.5-1 cm. As the surface becomes rougher, the height determination may degrade to ±5-6 cm. Nevertheless, with an elapsed time between Epoch 0 and Epoch 1 surveys of 7 to 14 days, and daily ablation rates of roughly 5-8 cm/day, it is possible to determine significant short-term height changes during the time period of the surveys. It is important to note that the short-term height changes reported here include the component of downslope movement of the surveyed flags. Surface height changes due to the downslope movement of the flags between Epoch 0 and Epoch 1 have not been extensively investigated on the Juneau Icefield. However, with surface gradients ranging from 1-2 degrees, the contribution to short-term height change due to downslope movement amounts to roughly 20% of the total observed short-term height change. The remaining 80% can be attributed to actual ablation of the surface.

Theoretically, an inverse relationship should exist between ablation and elevation; the higher the elevation, the lower the ablation. This is not conclusively evident in the survey data. Table 3 presents total short-term height-change with respect to increasing elevation for the transverse profiles that were surveyed twice in 2000. There is no clear pattern linking height change and elevation, and in fact the range between the minimum and maximum height change is rather large, not only when comparing one profile to another, but also within individual profiles as well. Differing weather conditions among the profiles during the survey periods may contribute to this unexpected result. Survey data from previous years support this conclusion (Lang, 1995; McGee, 1996; Lang, 1997; Welsch, et al, 1998; Lang, 1999). As a result, only rough approximations of short-term height change due to ablation can be derived from GPS measurements on the Juneau Icefield. Refer to Appendix 4 for detailed graphs of short-term height change at the transverse and longitudinal profiles. Appendix 2 lists the surveyed height of the flags at all profiles for both the Epoch 0 and Epoch 1 surveys.

PROFILE	MEAN SURFACE HEIGHT OF PROFILE (HAE M)	SHORT-TERM HEIGHT CHANGE (CM/DAY)		
		MINIMUM	MAXIMUM	MEAN
2	824.01	-4.3	-12.5	-8.5
V.L. Ogives	1087.85	-2.3	-13.1	-6.3
4	1128.27	-3.5	-7.7	-5.1
11	1729.48	-3.1	-6.4	-5.0
9	1745.39	-6.6	-10.3	-7.7

Table 3: Short-term height change as a function of mean profile height for the transverse profiles that were measured twice during the summer of 2000. An obvious elevation versus short-term height change relationship cannot be definitively established at this time.

3.1.3 LONG-TERM HEIGHT CHANGE

Long-term height change analysis is important in determining the relationship between surface height changes, the elevation of ablation and accumulation zones, and the accumulation area ratio (AAR) of a glacier system. This is particularly important when assessing the likely response of a glacier to climate change because the zones of net increase or decrease in elevation of the surface with respect to the elevation of the accumulation and ablation zones determine whether the glacier will ultimately advance, retreat, or remain stable. This is because changes in surface height have a direct correlation with mass balance. For example, suppose a glacier has an AAR of 0.67. In this case, the accumulation area is twice the size of the ablation area. If the surface height increases 2 meters water equivalent in the accumulation area, then the glacier will likely increase its mass (assuming that the accumulation is not offset by extreme ablation lower on the glacier). In addition, since the accumulation area is twice the size of the ablation area, the surface height of the glacier in the ablation zone (and/or retreat of the terminus) would have to decrease 4 meters water equivalent to nullify the 2 meter surface height increase in the accumulation area.

Recognizing the critical importance of surface height changes and the elevations at which they occur, and the ability of GPS to consistently measure heights over time, transverse and longitudinal profiles on the Juneau Icefield are monitored to determine long-term height changes. As used in this report, long-term height change refers to the change in height of the glacier surface from one year to another. This is determined by taking GPS height readings in subsequent years at the standard flag coordinates as published in the JIRP Coordinate Tables (McGee, 2000). Because the measurements are taken within a 10-50 cm radius of the location of measurements in previous years, the contribution of downslope movement to height change is eliminated. Thus, long-term height change reflects a true measure of the increase or decrease of mass on an annual basis.

This section presents the long-term height change data for the transverse profiles (refer to Section 3.2.2 for a discussion of long-term height change along the longitudinal profiles). The analysis here focuses on change primarily between 1999 and 2000, although in some cases the lack of data for 1999 forces comparison between greater time spans. Additionally, the data presented in this section reflect the surface height change at the profiles only between 2000 and the previous most recent survey; a multi-year comparison of cumulative height change at each profile is beyond the scope of this annual report. Refer to previous JIRP survey reports for data concerning the surveyed heights of profiles in years not covered in this section.

All long-term height change data presented in this section are based on the actual dates of survey, without any interpolation or adjustment. Long-term height change data are reported here as either positive or negative; positive height change indicates a net increase in mass during the survey period, whereas negative height change results in a net decrease in mass.

3.1.3.1 TAKU / MATTHES / LLEWELLYN GLACIERS

Five transverse profiles on the Taku, Matthes, and Llewellyn Glaciers were surveyed in 2000. These ranged from Profile 2 at an elevation of 824 meters on the Taku Glacier to Profile 8 near the crest of the Matthes Glacier, at an elevation of 1,810 meters, to Profile 11 on the north side of the crestal divide on the Llewellyn Glacier at an elevation of 1,730 meters. Unfortunately, Profiles 2, 8, and 11 were not surveyed in 1999, so a comparison of height change between 1999 and 2000 is not possible for these profiles. The only other survey at Profile 2 was conducted in 1994, while the previous most recent survey of Profiles 8 and 11 was in 1997. The previous most recent survey of Profiles 4 and 7 was in 1999.

In general, retained accumulation on the Taku Glacier resulted in a net increase in the surface height of some 1.6 meters between July 24, 1999 and July 21, 2000 at Profile 4. The mean 1999 to 2000 surface height increase at Profile 7 was 1.4 meters. Profiles 2, 8, and 11 were not surveyed in 1999, so a direct comparison of their surface height between 1999 and 2000 is not possible. However, Table 4 shows the magnitude of surface height change between 2000 and the previous most recent surveys for these profiles. Overall, there was a net increase in retained accumulation on the Taku, Matthes, and Llewellyn Glaciers in 2000, resulting in a region-wide increase of the surface elevation from Goat Ridge on the Taku Glacier to F-10 Peak on the Llewellyn Glacier. The maximum surface height change of 1.60 meters was observed at the upper line of Profile 4, at an elevation of 1129 meters.

PROFILE	TIME PERIOD		MEAN SURFACE HEIGHT IN 2000 (HAE M)	LONG-TERM HEIGHT CHANGE (M)		
	FROM	TO		MINIMUM	MAXIMUM	MEAN
2	8/3/1994	7/29/2000	823.67	-3.10	-0.38	-1.03
4 (lower)	7/24/1999	7/21/2000	1127.52	0.97	1.83	1.55
4 (upper)	7/24/1999	7/21/2000	1129.07	1.39	1.83	1.61
7	7/31/1999	8/2/2000	1425.19	0.77	1.72	1.39
8	8/5/1997	8/3/2000	1810.23	0.04	1.54	0.46
11	8/6/1997	8/4/2000	1729.48	-1.80	-0.87	-1.39

Table 4: Long-term height change at the transverse profiles on the Taku, Matthes, and Llewellyn Glaciers.

3.1.3.2 DEMOREST GLACIER

Three transverse profiles on the Demorest Glacier were surveyed in 1999 and 2000. Profile 3, with a mean elevation of 1035 meters, was located on the lower sector of the glacier approximately 1.5 kilometers upglacier from its confluence with the main stem of the Taku Glacier. Profile 3b was situated between Floprock Peak and the Scatter Peaks some 8 kilometers upglacier from Profile 3 at an elevation of 1242 meters. Continuing upglacier, Profile 3a was located between the southeast ridge of Spider Peak and an unnamed peak due east of it. The mean elevation at Profile 3a was 1357 meters.

The elapsed time between the 1999 and 2000 surveys for Profiles 3 and 3b was exactly one year, while Profile 3a had an elapsed time of 371 days. The annual surface height change at Profile 3 was 1.50 meters, increasing to 1.75 meters at Profile 3b. Upglacier from Profile 3b, the data show a decrease in the magnitude of surface height change at Profile 3a (see Table 5 below). Thus the maximum observed long-term height change on the middle Demorest Glacier was at Profile 3b, at an elevation of 1242 meters.

PROFILE	TIME PERIOD		MEAN SURFACE HEIGHT IN 2000 (HAE M)	LONG-TERM HEIGHT CHANGE (M)		
	FROM	TO		MINIMUM	MAXIMUM	MEAN
3	7/26/1999	7/26/2000	1034.599	1.24	1.83	1.50
3b	8/7/1999	8/7/2000	1242.307	1.46	1.96	1.75
3a	8/1/1999	8/7/2000	1356.890	-0.59	1.79	1.19

Table 5: Long-term height change at the transverse profiles on the Demorest Glacier, 1999 to 2000.

3.1.3.3 SOUTHWEST BRANCH OF THE TAKU GLACIER

To date, only one transverse profile has been established on the Southwest Branch of the Taku Glacier. Profile 5 is located on the lower Southwest Branch approximately 1.5 kilometers upglacier from its confluence with the Taku Glacier. The mean elevation of the profile is 1072 meters. The mean long-term height change of Profile 5 between 1999 and 2000 increased 1.48 meters, which is comparable to that found at Profile 3. Table 6 presents the data for Profile 5.

Profile	Time Period		Mean Surface Height in 2000 (HAE m)	Long-term Height Change (m)		
	From	To		Minimum	Maximum	Mean
5	7/25/1999	7/25/2000	1071.54	1.31	1.87	1.48

Table 6: Long-term height change for the Southwest Branch of the Taku Glacier at transverse Profile 5, 1999 to 2000.

3.1.3.4 Northwest Branch of the Taku Glacier

Profile 6 is located on the lower Northwest Branch of the Taku Glacier between Echo Mountain and a small, unnamed nunatak directly to the south. The Northwest Branch is an extensive névé area comprised of a southern branch on the west side of the Taku Towers, and a western branch that trends west from Profile 6 to the crestal divide between the Taku system and the Herbert and Eagle Glaciers. All flow from the two branches of the Northwest Branch passes through Profile 6.

The mean elevation of Profile 6 in 2000 was 1331 meters. The mean surface height increased 1.68 meters between 1999 and 2000. While this is only 26 meters lower than the elevation of Profile 3a on the Demorest Glacier.

Profile	Time Period		Mean Surface Height in 2000 (HAE m)	Long-term Height Change (m)		
	From	To		Minimum	Maximum	Mean
6	7/29/1999	7/27/2000	1330.74	1.47	2.05	1.68

Table 7: Long-term height change for the Northwest Branch of the Taku Glacier at transverse Profile 6, 1999 to 2000.

3.1.3.5 Vaughan Lewis Glacier

Profile 9 is located on the Vaughan Lewis Glacier approximately 2 kilometers upglacier from the point where the glacier begins its steep descent through the icefall. The mean elevation of the profile in 2000 was 1745 meters. This was, on average, 1.18 meters higher than it was in 1997, the previous most recent survey.

Profile	Time Period		Mean Surface Height in 2000 (HAE m)	Long-term Height Change (m)		
	From	To		Minimum	Maximum	Mean
7	8/7/1997	8/3/2000	1745.39	0.30	1.82	1.18

Table 8: Long-term height change for the Upper Vaughan Lewis Glacier at transverse Profile 9, 1997 to 2000.

3.1.3.6 Gilkey Glacier

During the 1990 summer field season, 45 points were established throughout the convergence zone of the Gilkey, Vaughan Lewis, and Unnamed Glaciers in the Gilkey Trench below Camp 18. Survey flags were placed at each of the 45 points. The objective was to determine, using theodolite and EDM techniques, the flow regime in the convergence zone and to relocate and resurvey the flags in successive years in order to determine actual annual velocity. Annual surveys were conducted up to 1995, at which time all the flags had moved through the convergence zone, effectively concluding the project. The results of this project are described by Lang and Welsch (1997, pp. 109-113).

The 1995 GPS survey work in the Gilkey Trench included the relocation and resurvey of 7 of the 9 flags of Profile D across the Gilkey Glacier just upglacier from the convergence zone. Two of the 3 flags of Profile E on the Little Vaughan Lewis Glacier were also surveyed. The purpose of the 1995 GPS survey was to establish baseline surface heights for subsequent future comparison. Unlike all other established profiles on the Juneau Icefield, the points surveyed on the Gilkey Glacier are well within the ablation zone.

In 2000, all 9 of the 1995 baseline points were again surveyed via real-time GPS. Comparison of the 1995 and 2000 surface elevations reveals significant downwasting of the glacier surface (see Table 9). Refer to Appendix 2 for the survey observations. Results show that, in only five years, the mean elevation decrease was 13.11 meters (11.8 meters water equivalent) at Profiles D and E. This equates to a surface height decrease of approximately 2.6 meters per year, or a mass loss of 2.36 meters water equivalent per year. These quantitative data are corroborated by various qualitative observations such as the thinning and catastrophic collapse of the lower third of the Little Vaughan Lewis Icefall in 1998, and the near total disappearance of firn on the lower slopes of the Camp 18 nunatak. Clearly, it is evident that the greatest magnitude of long-term height change, of those areas surveyed on the Juneau Icefield, occurs in the convergence area of the Gilkey and Vaughan Lewis Glaciers. Although surveys have not been conducted downglacier from the convergence zone, it can be postulated that an even greater rate of mass loss than that observed in the convergence zone may occur nearer the terminus of the Gilkey Glacier.

FLAG	SURFACE HEIGHT ON AUG. 12, 1995 (M)	SURFACE HEIGHT ON AUG. 12, 2000 (M)	HEIGHT CHANGE (M)
D1	1097.91	1085.72	-12.18
D2	1104.78	1092.37	-12.41
D5	1097.57	1085.11	-12.46
D6	1100.47	1087.73	-12.75
D7	1079.32	1066.06	-13.26
D8	1094.57	1079.86	-14.71
D9	1077.08	1063.18	-13.90
E2	1106.68	1094.11	-12.57
E3	1105.83	1092.05	-13.79
MEAN	**1096.02**	**1082.91**	**-13.11**

Table 9: Long-term height change for the Gilkey Glacier at transverse Profiles D and E, 1995 to 2000.

3.1.3.7 Summary of Height Change at Transverse Profiles

The relationship between surface height changes, the elevation of the ablation and accumulation zones, and the accumulation area ratio of a glacier determines how the system will respond to climate changes. It is therefore important to identify the elevation zones at which the surface height increases or decreases. An examination of all transverse profiles that were surveyed in both 1999 and 2000 reveals that the maximum surface height increase was at an elevation of 1242 meters at Profile 3b on the Demorest Glacier. Figure 12 summarizes the long-term height change at eight transverse profiles with respect to the mean elevation of the profiles. The general trend is one of increasing positive height change with increasing elevation, with the maximum positive height change at an elevation of 1242 meters. Above 1242 meters, the magnitude of positive height change decreases. Table 10 presents the Figure 12 data in a tabular format.

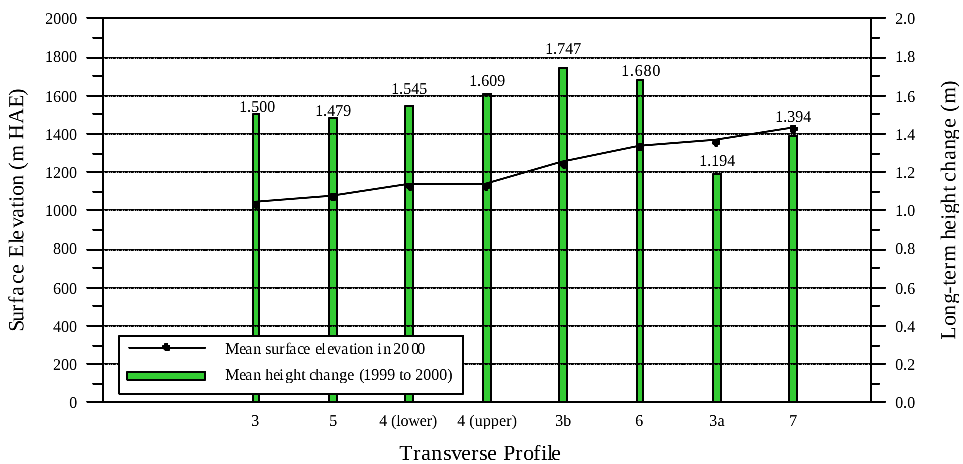

Figure 12: Long-term height change for all transverse profiles that were surveyed in 1999 and 2000, showing magnitude of height change with respect to mean profile elevation. The maximum surface elevation increase occurred at an elevation of 1242 meters at Profile 3b on the Demorest Glacier.

Profile	Time Period		Mean Surface Height in 2000 (HAE m)	Long-term Height Change (m)		
	From	To		Minimum	Maximum	Mean
3	7/26/1999	7/26/2000	1034.60	1.24	1.83	1.50
5	7/25/1999	7/25/2000	1071.54	1.31	1.87	1.48
4 (lower)	7/24/1999	7/21/2000	1127.52	0.97	1.83	1.55
4 (upper)	7/24/1999	7/21/2000	1129.07	1.39	1.83	1.61
3b	8/7/1999	8/7/2000	1242.31	1.46	1.96	1.75
6	7/29/1999	7/27/2000	1330.74	1.47	2.05	1.68
3a	8/1/1999	8/7/2000	1356.89	-0.59	1.79	1.19
7	7/31/1999	8/2/2000	1425.19	0.77	1.72	1.39

Table 10: Summary of long-term height change as a function of mean profile height for all transverse profiles surveyed in 1999 and 2000.

3.2 LONGITUDINAL PROFILES

While the transverse profiles have provided invaluable data relating to the flow regime of the Taku Glacier and its tributaries, they have not allowed a comprehensive examination of the surface morphology and flow patterns across the entire extent of the Juneau Icefield. Recognizing this shortcoming, a comprehensive network of longitudinal profiles was first established in 1999. These longitudinal profiles are designed to ultimately extend along the centerlines of the main Taku/Matthes/Llewellyn Glaciers and the major tributaries to them. Initially, the glaciers of the Taku system have been given first priority. Thereafter, it is hoped that the longitudinal network can be further extended to include the main Llewellyn Glacier system and possibly the Norris Glacier.

Unlike the transverse profiles, the longitudinals provide detailed data regarding the flow regime along the entire length of the surveyed glaciers, at a nominal flag spacing of 500 meters. Data collected includes surface velocity, surface height, surface gradient, and both short-term (1-2 weeks) and long-term (annual) height change. The height change data, in particular, may provide important insights into accumulation and ablation patterns across the Icefield with respect to elevation.

The continued monitoring and extension of the longitudinal profiles on the Taku Glacier system was the major focus of the survey program in 2000. Of the initial 150 kilometers of longitudinal profiles first planned during the winter of 1998, 49.5 kilometers were established and surveyed during the 1999 JIRP field season. This network was further extended during the summer of 2000 with the survey of an additional 44 kilometers. At the same time, the 49.5 kilometers first surveyed in 1999 were again resurveyed in 2000 to allow for the determination of annual height change.

Longitudinal A, on the Taku/Matthes/Llewellyn system, was extended down the Taku Glacier from Point 24 to Point 13. It was also extended across the Matthes/Llewellyn divide from Point 85 down the Llewellyn Glacier to Point 122. Weather and field logistics during 1999 prevented the observation of a 5-kilometer gap on the Demorest Glacier along Longitudinal B. This gap was closed in 2000 with the addition of Points 10 to 19. On the Southwest Branch, two new points (15 and 16) were added in 2000. Also established this summer were two new longitudinal profiles on the Northwest and West Branches of the Taku Glacier; Longitudinal D extended from the center of the Taku Glacier west toward Glacier King with Points 1-16. Longitudinal F continued westward from Longitudinal D toward the divide between the Herbert Glacier and the West Branch of the Taku Glacier. Points 1-18 were surveyed along Longitudinal F. Refer to Figure 2 for a map showing the locations and extent of all longitudinal profiles surveyed to date.

3.2.1 SURFACE VELOCITY AND GRADIENT

Perhaps one of the most interesting applications of longitudinal velocity is the evaluation of the velocity as it relates to elevation, gradient, and the locations of glacio-morphological features such as the terminus, ELA, and glacial divides. As with the transverse profiles, surveys of the longitudinal profiles in 1999 and 2000 have shown no significant difference in the surface velocities from one year to the next.

3.2.1.1 TAKU/MATTHES/LLEWELLYN GLACIERS

The Taku, Matthes, and Llewellyn glacier system extends from Taku Inlet, Alaska to near Atlin Lake, British Columbia, a distance of 93 kilometers. The broad divide between the Matthes and Llewellyn Glaciers is located 58 kilometers from the Taku Glacier terminus (in 2000, the terminus was approximately 1.5 kilometers north of the bedrock on the south side of the Taku River at Taku Point). Beginning approximately 18 kilometers upglacier from the Taku Glacier terminus (Point 13) and extending nearly to Camp 26 (Point 122), 54 kilometers have now been surveyed at a nominal observation interval of 500 meters. See Table 11 for a list of GPS reference points used for the surveys. The survey data confirm the general trend of increasing velocity with increasing distance from the Matthes/Llewellyn divide (see Figure 13). This is true on both the Taku/Matthes Glaciers and the Llewellyn Glacier.

LONGITUDINAL A	REFERENCE POINT USED	EASTING (LONGITUDE)	NORTHING (LATITUDE)
Points 13 to 35	Lupine (Taku A)	490,263.717 (134° 10' 3.247" W)	6,500,621.560 (58° 37' 20.701" N)
Points 36 to 53	Scott (Camp 10)	487,963.303 (134° 12' 26.303" W)	6,503,372.111 (58° 38' 49.388" N)
Points 54 to 75	C-9 Bolt	489,442.431 (134° 10' 55.823" W)	6,510,665.042 (58° 42' 45.226" N)
Points 76 to 95	FFGR 39 (Blizzard)	487,443.145 (134° 13' 2.776" W)	6,524,360.975 (58° 50' 7.663" N)
Points 96 to 122	FFGR 62 (F-10)	492,497.562 (134° 7' 49.040" W)	6,535,469.195 (58° 56' 7.081" N)

Table 11: GPS reference points used for the survey of Longitudinal A. Easting and northing coordinates are with respect to the JIRP coordinate system (see Table 2). Latitude and longitude are with respect to the WGS84 datum and spheroid.

Significant retained accumulation from the winter of 1999-2000 allowed for the extension of Longitudinal A downglacier from Taku Point 24 (first surveyed in 1999) to Point 13, approximately 1 kilometer downglacier from the transverse Profile 2. This is in the general area of the ELA of the Taku Glacier, and at a point where the valley width decreases to 3.2 kilometers. Not surprisingly, the highest velocities thus far recorded on the Taku Glacier occur here. The velocity at Point 13 was 93.7 cm/day, while the velocity at Flag 6 of Profile 2 (1 kilometer further upglacier, and in the center of the glacier) was 1 cm/day slower. This indicates that the velocity of the Taku Glacier most likely continues to increase to a point approximately 6 kilometers downglacier from Profile 2, where the valley width decreases 2.4 kilometers (see Figure 2). It is possible that a maximum velocity in excess of 1 m/day will be found in this area. Downglacier from this point, the velocity decreases as evidenced by a maximum observed velocity of 86 cm/day at Profile 1 in 1994.

Figure 13 graphs the velocity versus the surface height and the centerline distance from the terminus of the Taku Glacier for Longitudinal A. Relative velocities are indicated by the size of the circles; the larger the circle, the higher the velocity. Refer to Appendix 3 for a tabular listing of the velocities at Points 13-23 and 86-122. The surface gradient between adjacent surveyed points (13 to 14, 14 to 15, etc.) is indicated by the vertical bars, the magnitude of which is shown on the right-hand Y-axis. All points surveyed to date are shown; Points 24-85 were surveyed in 1999 (shown in green), and Points 13-23 and Points 86-122 were surveyed in 2000 (shown in red). In general, all comments by Welsch (1999) regarding Points 24-85 remain valid, therefore this discussion will focus mainly on the new points surveyed in 2000.

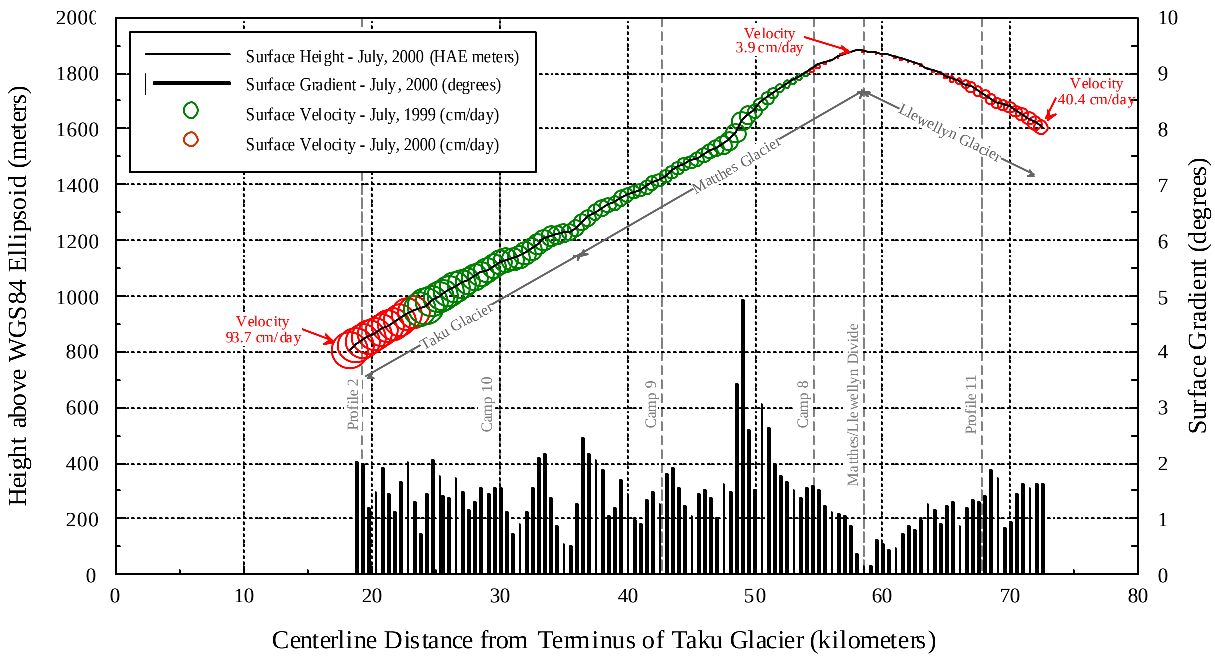

Figure13: Gradient and relative surface velocity as a function of elevation and distance from the terminus of the Taku Glacier along Longitudinal A. The magnitude of velocity is indicated by the size of the circles. Velocity and height were observed at 500 meter intervals along the longitudinal centerline of the Taku, Matthes, and Llewellyn Glaciers. The effect of valley width on velocity is not considered here. Refer to Welsch, et al (1999, Fig. 13) for additional details.

Points From-To	Gradient (degrees)	Mean Velocity (cm/day)	Points From-To	Gradient (degrees)	Mean Velocity (cm/day)	Points From-To	Gradient (degrees)	Mean Velocity (cm/day)
13-14	2.03	92.9	90-91	1.05	6.3	106-107	1.25	13.0
14-15	1.99	91.8	91-92	0.87	4.6	107-108	1.31	15.5
15-16	1.18	91.1	92-93	0.37	4.5	108-109	0.88	19.2
16-17	1.47	89.6	93-94	0.14	5.9	109-110	1.19	23.2
17-18	1.93	88.0	94-95	0.16	7.3	110-111	1.33	26.5
18-19	1.45	86.9	95-96	0.63	7.6	111-112	1.29	28.8
19-20	1.12	86.3	96-97	0.54	7.3	112-113	1.43	29.3
20-21	1.66	85.8	97-98	0.42	7.0	113-114	1.89	29.0
21-22	2.01	85.2	98-99	0.47	7.2	114-115	1.75	29.3
22-23	1.31	85.0	99-100	0.72	7.5	115-116	0.85	30.5
23-24	0.72	83.1	100-101	0.86	7.8	116-117	0.96	31.9
85-86	1.60	14.6	101-102	0.79	8.3	117-118	1.46	33.4
86-87	1.53	13.4	102-103	0.98	8.6	118-119	1.64	34.6
87-88	1.24	11.2	103-104	1.28	9.2	119-120	1.54	35.7
88-89	1.13	9.4	104-105	1.17	10.0	120-121	1.64	37.2
89-90	1.07	8.1	105-106	0.92	11.2	121-122	1.63	39.2

Table 12: Surface gradient and velocity for those points of Longitudinal A surveyed in 2000. Refer to Lang (1999) for the gradient and velocity between Points 24 and 85.

Beginning at Point 13 (the point closest to the Taku terminus) at a height of 800.9 meters, the velocity was observed to be 93.7 cm/day. The Taku Glacier slopes at about 2 degrees at this point. Continuing upglacier to Point 23, the velocity decreases to 85.1 cm/day at a height of 942 meters. The surface slope varies from 1 to 2 degrees between Points 13 and 23. Referring to Figure 13, it can be seen that the centerline velocity of the Taku and Matthes Glaciers gradually decreases with increasing distance from the terminus. A notable exception occurs some 48.5 kilometers from the Taku terminus, where increased velocities (~51 cm/day) occur over a 1-kilometer distance. As noted by Welsch (1999), this is due to the significant gradient increase of the Matthes Glacier (~5 degrees) in conjunction with local narrowing of the constraining valley walls. Velocities measured in 1999 upglacier from the steep slope gradually decrease from 43.6 cm/day at Point 76, to 3.9 cm/day at Point 92 in the vicinity of the Matthes/Llewellyn divide. From the divide, velocities increase to 40.4 cm/day at Point 122 on the Llewellyn Glacier. Refer to Figures 16, 18, and 19 for plots of the surface velocities along Longitudinal A.

A vertical cross-section along Longitudinal A reveals a bench and step morphology on the surface of the Taku and Matthes Glaciers. This is clearly seen by the vertical bars in Figure 13, where surface gradients vary intermittently between 1 and 2 degrees. Upglacier from the steep 5 degree slope of the Matthes Glacier at kilometer 48.5, surface gradients consistently decrease to 0.1 degree at the divide. The gradient then increases from the divide to Point 114 on the Llewellyn Glacier, where it was observed to be 1.9 degrees. From Point 114 to 122, the surface gradient is similar to the bench and step morphology of the Taku and Matthes Glaciers.

3.2.1.2 DEMOREST GLACIER

The Demorest Glacier and its various source areas comprise the main accumulation area on the eastern side of the Juneau Icefield. The glacier trends northerly some 26 kilometers from the center of the Taku Glacier to a divide between the Demorest and Tulsequah Glaciers in British Columbia, directly east of Mount Moore. Currently, Longitudinal B follows the centerline of the glacier from its junction with the center of the Taku Glacier to a point east of the Camp 9 nunatak. The profile will ultimately be extended an additional 13 kilometers to the divide between the Demorest and Tulsequah Glaciers. Points 1 through 9 and 20 through 34 were first established and surveyed in 1999, leaving a 5.5 kilometer gap in the middle. This gap was closed in 2000 with the establishment of Points 10 through 19. Approximately 63%, or 16.5 kilometers, of the Demorest Glacier (excluding the Hades Highway sector) have now been surveyed with a nominal flag spacing of 500 meters. Table 13 lists the GPS reference points used for the survey of Longitudinal B.

LONGITUDINAL B	REFERENCE POINT USED	EASTING (LONGITUDE)	NORTHING (LATITUDE)
Points 1 to 19	Lupine (Taku A)	490,263.717 (134° 10' 3.247" W)	6,500,621.560 (58° 37' 20.701" N)
Points 20 to 34	Vista (C-9)	489,873.478 (134° 10' 28.988" W)	6,510,298.945 (58° 42' 33.431" N)

Table 13: GPS reference points used for the survey of Longitudinal B. Easting and northing coordinates are with respect to the JIRP coordinate system (see Table 2). Latitude and longitude are with respect to the WGS84 datum and spheroid.

Because Longitudinal B extends to the center of the Taku Glacier, it is possible to determine the point at which the movement of the Taku Glacier affects the Demorest Glacier. As can clearly been seen in Figures 14 and 17, Points 1 through 3 of Longitudinal B show a marked increase in velocity with significant redirection of the movement vectors to the southeast, in alignment with the flow of the Taku Glacier. Lang (1999) found the transition zone between the Demorest and Taku Glaciers to be between Points 3 and 6, which correlates well with an extensive crevasse zone at the junction of the two glaciers.

Surface velocities along Longitudinal B show no surprising qualities. The velocities measured between Points 5 and 34 range from 34.5 cm/day at Point 17 to 18.8 cm/day at Point 34, with a mean of 26.7 cm/day. Velocities and surface gradients between Points 1-9 and 20-34 were measured in 1999. All remarks by Lang (1999) pertaining to these points remained valid in 2000. Therefore, this discussion will focus primarily on the portion of the Demorest Glacier between Points 9 and 20 that was surveyed in 2000.

Ten new points (10 through 19) were established and surveyed in 2000. These points were located in the area where the Demorest Glacier makes a turn from a primarily north/south trend to a southwest bearing. Unfortunately, the flag marking location of Point 12 was mistakenly removed only hours before it was to be surveyed a second time, making it impossible to compute a velocity at this point.

In general, the gradient of the Demorest Glacier between Points 9 and 20 varies between approximately 1 and 2 degrees. An exception is a small rise between Points 18 and 19 with a gradient of 2.9 degrees. The velocity increases from 25.6 cm/day between Points 9 and 10 to 33.9 cm/day between Points 17 to 19. This increase in velocity is due to the steeper gradient between Points 17 to 19, and to the fact that these points are located between the East Ridge of Vantage Peak and Icy Ridge where the glacier width decreases slightly. Upglacier from Point 19, both the gradient and velocity decrease. Table 14 lists the gradient and velocity between Points 9 and 20. Figure 14 presents the surface elevation, velocity, and gradient in relation to the centerline distance from the middle of the Taku Glacier. Refer to Figure 17 for a plot of the movement vectors along Longitudinal B.

POINTS FROM-TO	GRADIENT (DEGREES)	MEAN VELOCITY (CM/DAY)
9-10	1.33	25.6
10-11	0.94	27.2
11-12	1.10	—
12-13	0.92	—
13-14	1.26	28.8
14-15	1.78	29.7
15-16	1.80	31.2
16-17	1.01	32.4
17-18	1.87	33.9
18-19	2.90	33.9
19-20	1.28	33.4

Table 14: Surface gradient and velocity for those points of Longitudinal B surveyed in 2000. Velocity was not obtained at Point 12. Refer to Lang (1999) for the gradient and velocity between Points 1 to 9 and 20 to 34.

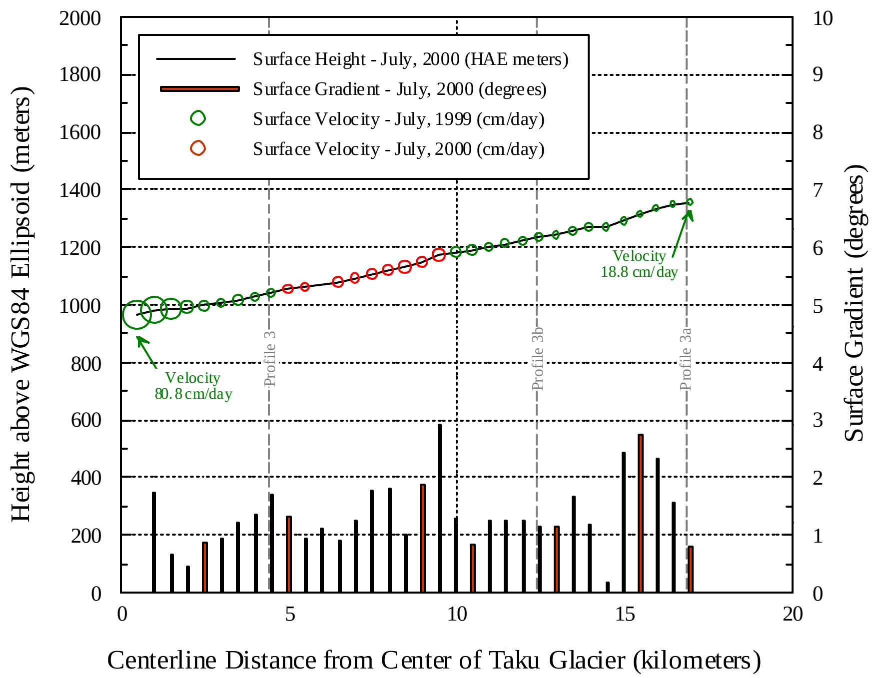

Figure 14: Gradient and relative surface velocity as a function of elevation and distance from the centerline of the Taku Glacier along Longitudinal B. The magnitude of velocity is indicated by the size of the circles. Velocity and height were observed at 500 meter intervals along the longitudinal centerline of the Demorest Glacier.

3.2.1.3 NORTHWEST AND WEST BRANCHES OF THE TAKU GLACIER

Two new longitudinal profiles were established on the Northwest and West Branches of the Taku Glacier in 2000. Longitudinal D begins at the centerline of the Taku Glacier between Taku Northwest Point and Taku C Peak, and trends in a northwest and westerly direction to a point midway between Knowl Peak and Tricouni Peak. It then turns south and follows the centerline of the tributary branch on the west side of Flower Tower, Little Matterhorn, Cathedral Peak, and the Taku Towers (see Figure 2). Point numbering begins with Point 1 on the Taku Glacier and ends with Point 50 west of the Taku Towers, giving a total length of 25 kilometers for the profile. Longitudinal F begins with Point 1 at the location where Longitudinal D makes the turn to the south. The profile proceeds west along the centerline of the West Branch to a point north of Tricouni Peak where it makes a gradual turn to the south-southwest, terminating with Point 27 at the divide between the West Branch and the Eagle Glacier (see Figure 2). The total distance of Longitudinal F is approximately 13.5 kilometers.

During the 2000 field season, Points 1 through 16 (32%) of Longitudinal D were established and surveyed, while Points 1 through 18 (67%) of Longitudinal F were completed. All points, with the exception of Longitudinal F Points 17 and 18, were surveyed twice. The resurvey of these two points was not possible due to their location at the extreme range of the radio link between the reference and roving receivers and by marginal weather conditions at the time of the resurvey. The time interval between surveys ranged from 8 to 11 days. The benchmark at Taku Northwest Point was utilized for the reference station (see Table 16). Future extension of Longitudinals D and F will require the establishment of additional benchmarks. One possible location is the south ridge of Snowpatch Craig. This location would provide complete GPS reference/rover coverage of the upper Northwest and West Branches of the Taku Glacier.

The movement characteristics along Longitudinals “D” and “F” are rather unremarkable. Velocities gradually and consistently decrease from Longitudinal D Point 1 (50.5 cm/day) to Longitudinal F Point 16 (9.7 cm/day). Unlike the junction of the Demorest and Taku Glaciers, the junction of the Northwest Branch and Taku Glaciers is less well defined. Only slight changes in velocities and movement vectors are seen at Longitudinal D Points 1 through 4; velocities vary from 51.3 cm/day to 46.0 cm/day with vector changes from 176.3 gon to 173.6 gon. A larger velocity and vector deviation is seen between Points 4 and 5, with Point 5 having a velocity of 41.8 cm/day and a movement vector of 166.8 gon. Thus the area between Points 4 and 5 of Longitudinal D may delineate the boundary of the movement regimes of the Northwest Branch and Taku Glaciers, although this zone is not as well-defined as that found between the Taku Glacier and the Demorest and Southwest Branch. Figures 18 and 19 show plots of the movement vectors for Longitudinals D and F.

The gradient of the Northwest and West Branches is remarkably consistent at around 1° (see Figure 15). The one notable exception is between Longitudinal F Points 5 and 6, located midway between transverse Profiles 6 and 6c. The maximum gradient here is 2.84°.

Long. D From-To	Gradient (degrees)	Mean Velocity (cm/day)
1-2	0.57	50.5
2-3	0.83	49.2
3-4	1.25	47.3
4-5	1.21	43.9
5-6	1.04	38.9
6-7	0.67	34.5
7-8	1.28	32.7
8-9	1.38	32.0
9-10	1.06	31.4
10-11	1.06	30.8
11-12	1.24	30.3
12-13	1.40	29.9
13-14	1.14	29.4
14-15	0.86	29.1
15-16	1.10	28.7

Long. F From-To	Gradient (degrees)	Mean Velocity (cm/day)
1-2	0.91	26.9
2-3	0.93	25.2
3-4	0.69	23.1
4-5	1.28	20.1
5-6	2.84	17.9
6-7	1.78	15.9
7-8	0.98	13.8
8-9	0.69	13.1
9-10	1.01	12.9
10-11	0.98	12.4
11-12	1.14	12.7
12-13	1.19	12.2
13-14	0.97	10.9
14-15	0.94	10.4
15-16	1.12	9.7
16-17	0.73	—
17-18	0.25	—

Table 15: Surface gradient and velocity for those points of Longitudinal D and Longitudinal F surveyed in 2000. Velocity was not obtained at Longitudinal F Points 17 and 18.

PROFILE (POINTS)	REFERENCE POINT USED	EASTING (LONGITUDE)	NORTHING (LATITUDE)
Long. D (1 to 16)	Taku NW (UniBm)	479,188.345 (134° 21' 30.949" W)	6,505,144.633 (58° 39' 45.478" N)
Long. F (1 to 18)	Taku NW (UniBm)	479,188.345 (134° 21' 30.949" W)	6,505,144.633 (58° 39' 45.478" N)

Table 16: GPS reference points used for the survey of Longitudinal D and Longitudinal F. Easting and northing coordinates are with respect to the JIRP coordinate system (see Table 2). Latitude and longitude are with respect to the WGS84 datum and spheroid.

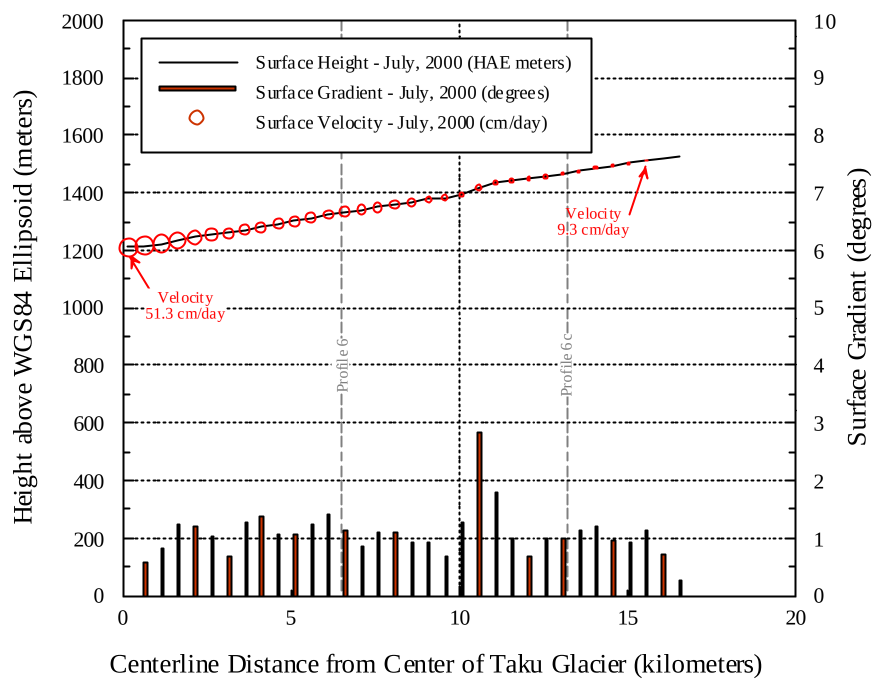

Figure 15: Gradient and relative surface velocity as a function of elevation and distance from the centerline of the Taku Glacier along Longitudinals D and F. The magnitude of velocity is indicated by the size of the circles. Velocity and height were observed at 500 meter intervals along the longitudinal centerline of the Northwest and West Branches of the Taku Glacier.

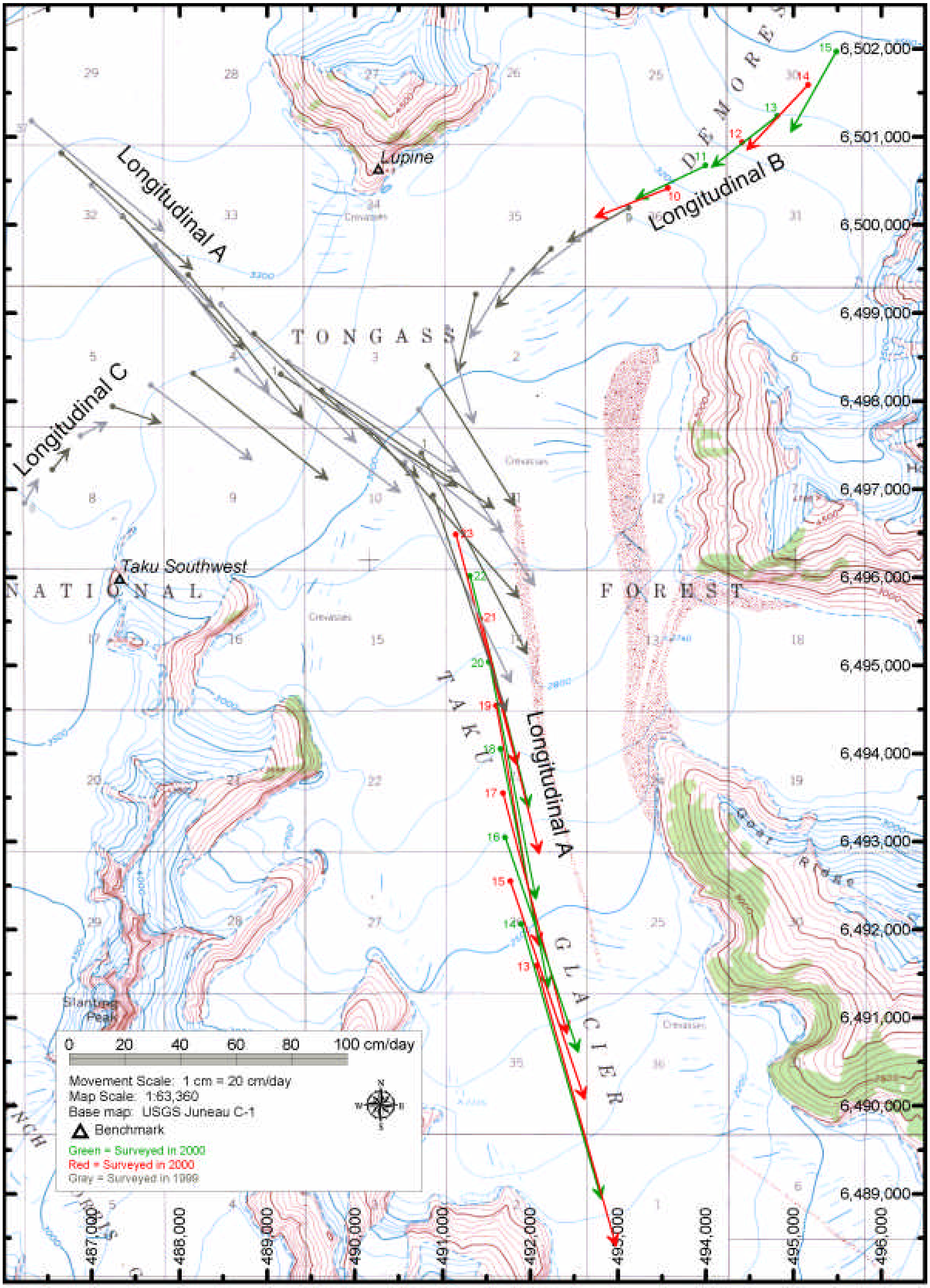

Figure 16: Movement vectors along Longitudinal Profiles A (Taku Glacier), B (Demorest Glacier), and C (Southwest Branch).

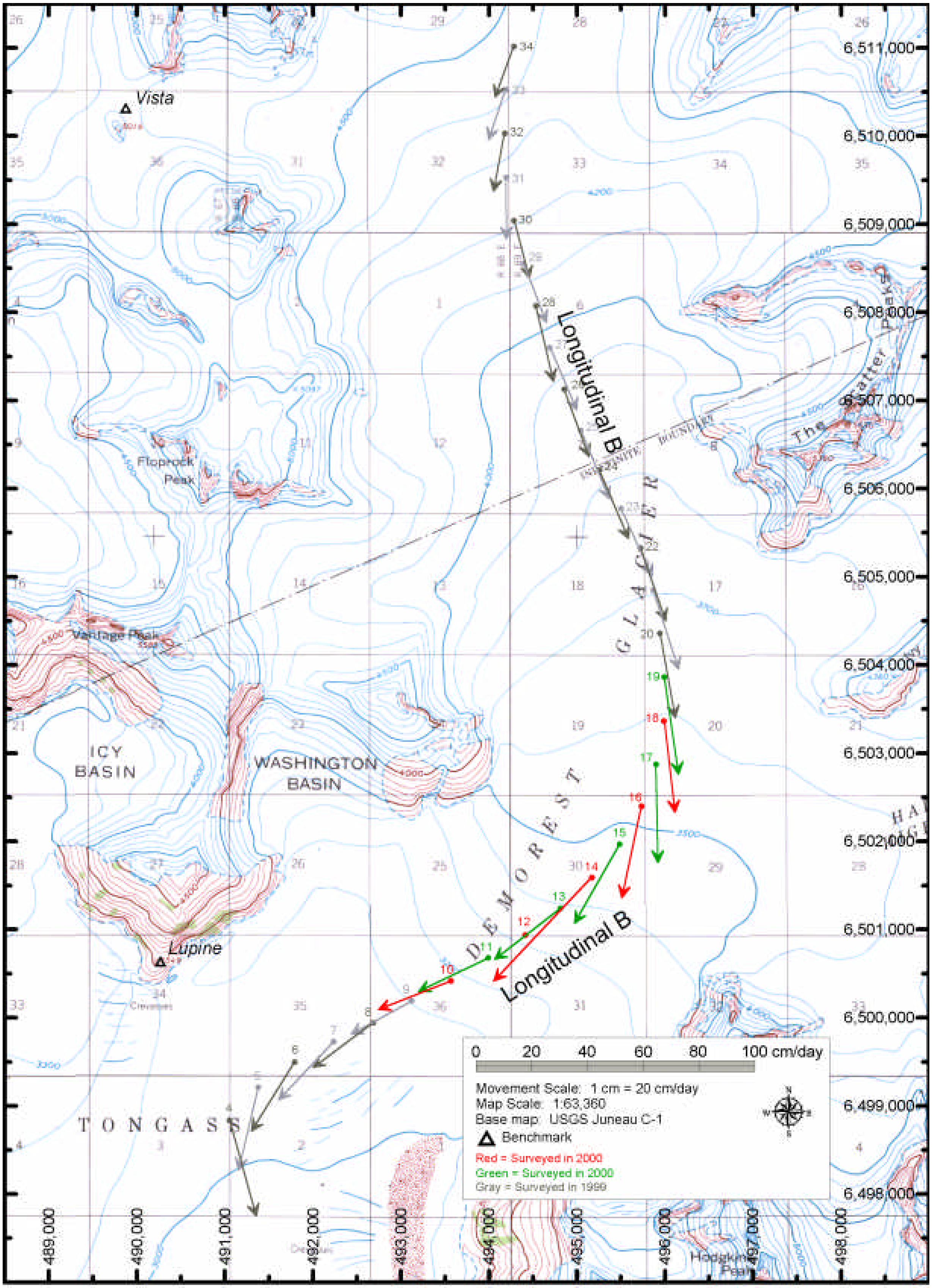

Figure 17: Movement vectors along Longitudinal B on the Demorest Glacier.

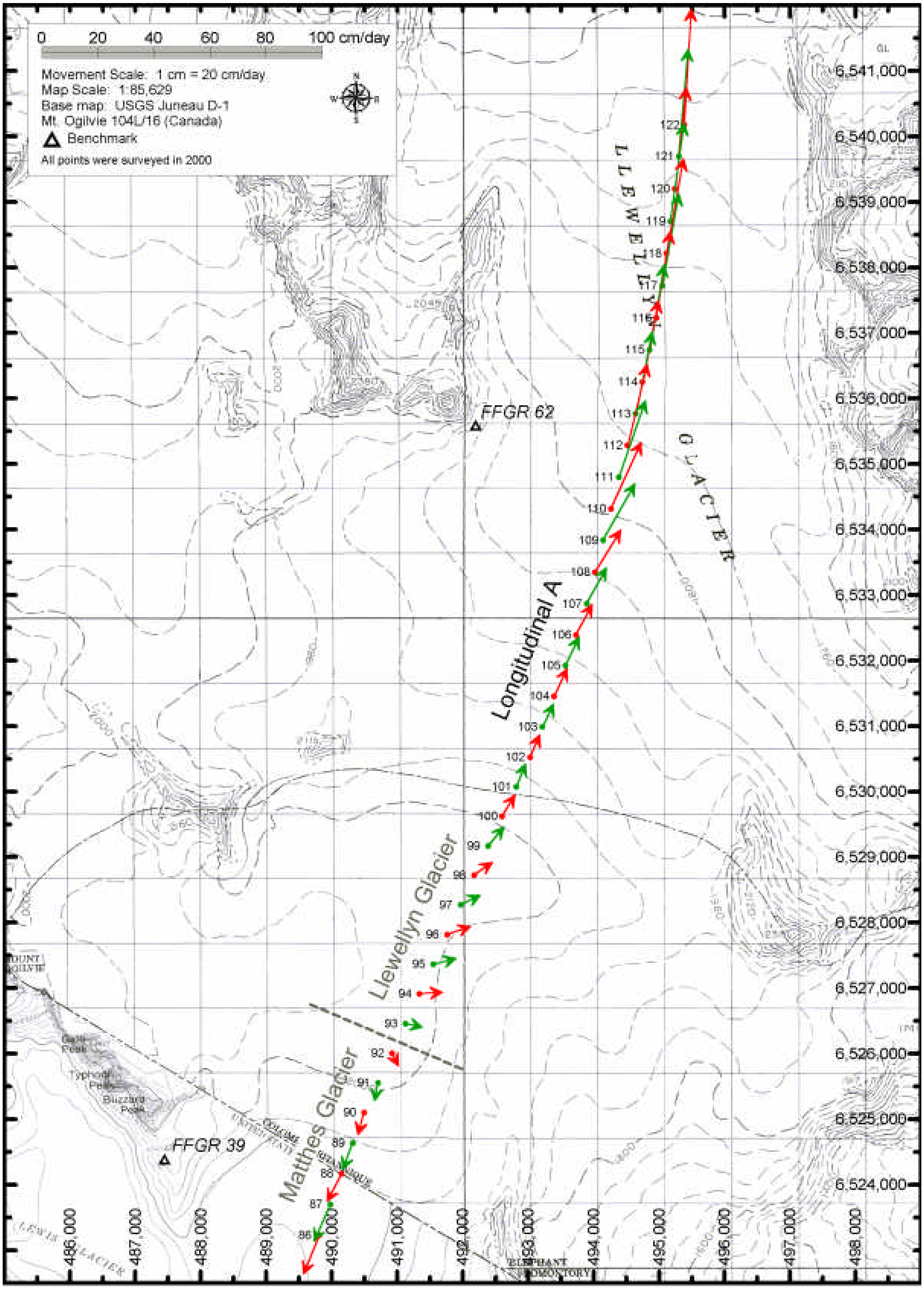

Figure 18: Movement vectors along Longitudinal A on the Matthes and Llewellyn Glaciers.

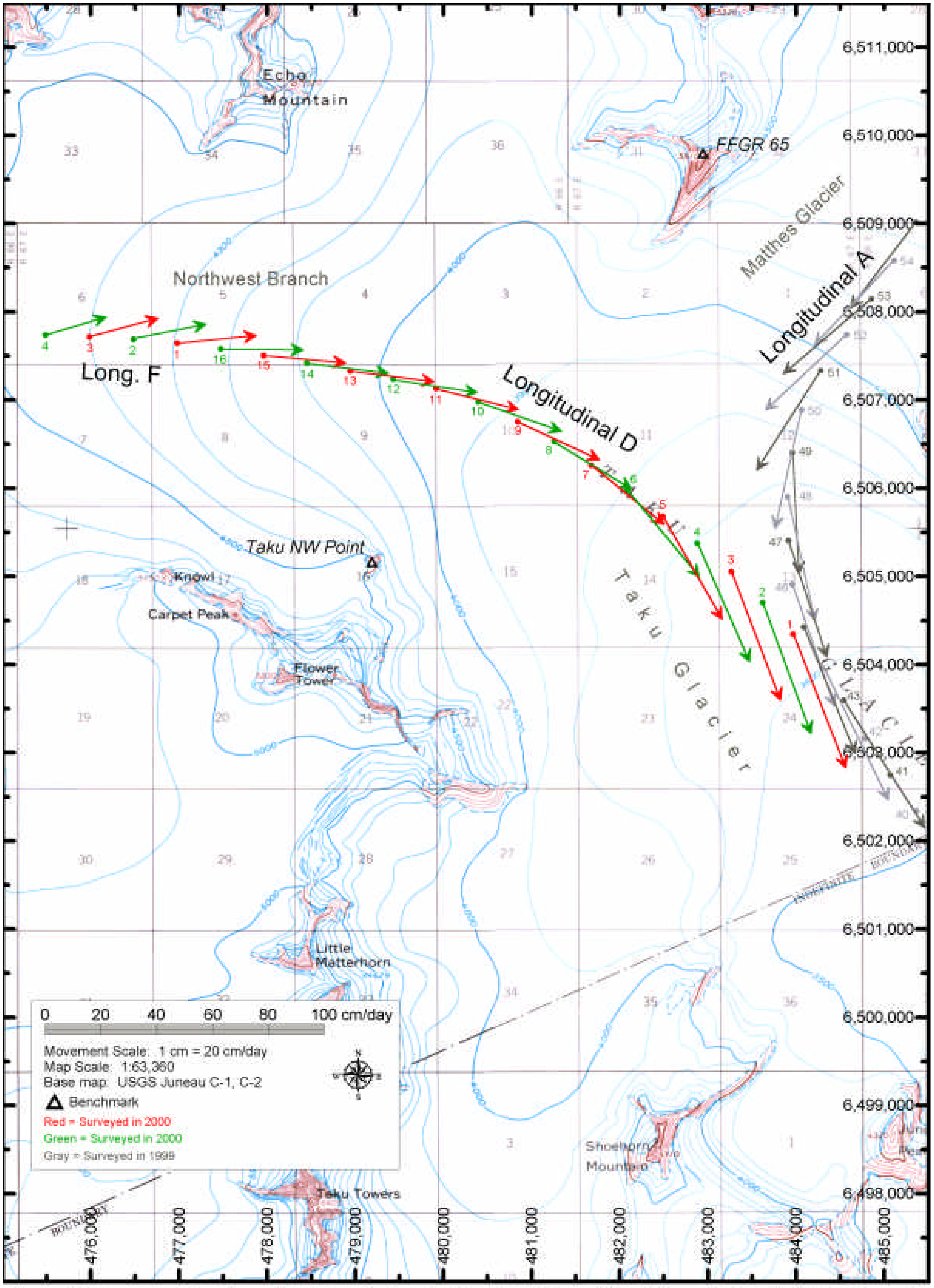

Figure 19: Movement vectors along Longitudinal D (Northwest Branch) and Longitudinal F (West Branch), Taku Glacier.

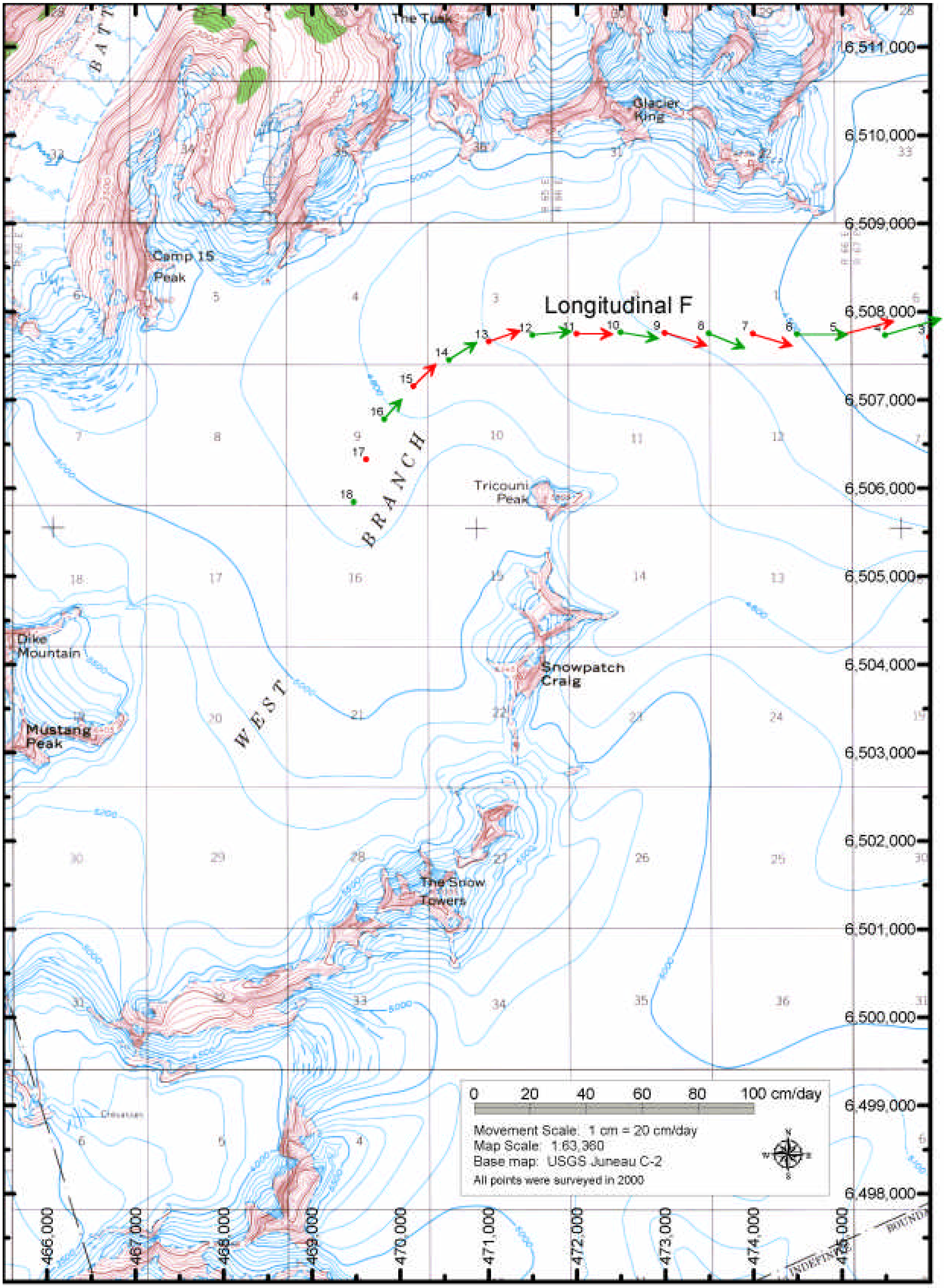

Figure 20: Movement vectors along Longitudinal F on the West Branch of the Taku Glacier.

3.2.2 LONG-TERM HEIGHT CHANGE

The longitudinal profiles contribute to a greater understanding of the velocity fields and mass balance of the Juneau Icefield. This network of profiles, across the entire extent of the Icefield, enables a close examination of the relationship between surface elevation and year-to-year height change. By determining the elevation at which the least and greatest height change occurs, it is possible to make more precise predictions of glacier advance, retreat, or stability.

This year, the surface elevation of 61 points along Longitudinal A and 24 points along Longitudinal B were determined and compared with the elevations from the 1999 surveys. In both cases, there was an increase in surface elevation of the points, indicating a positive mass balance for the 1999-2000 time period. This correlates well with the height change data found at the transverse profiles (see Section 3.1.3).

Weather conditions and field logistics from year-to-year conspire to produce time intervals between annual surveys of slightly less or slightly more than one year. For example, Points 63-75 of Longitudinal A were surveyed on August 3, 1999 and August 1, 2000, giving a time interval of 363 days. This makes it necessary to adjust the data to a 365 day time period by adjusting the surveyed heights either up or down, based on the average daily summer ablation rate times the number of days that must be either subtracted or added to the dates of the Epoch 0 and Epoch 1 surveys that will result in a time period of exactly 365 days. This adjustment was done for all points of Longitudinals A and B. Thus the height change data reported in this section reflects the height change over a full one year time period. These data are reported in terms of the change in surface elevation above the WGS84 ellipsoid rather than in terms of water equivalent.

3.2.2.1 TAKU / MATTHES / LLEWELLYN GLACIERS

The Taku/Matthes/Llewellyn system provides a unique opportunity to examine mass balance trends along a 100 kilometer north-south transect from the maritime conditions of Taku Inlet to the interior continental climate of the Atlin Lake area. All 61 points of Longitudinal A first established and surveyed in 1999 were resurveyed in 2000. The surface elevations of these points in 2000 ranged from 948.37 meters at Point 24 to 1794.72 meters at Point 85, for an elevation range of 846.35 meters over a distance of some 30 kilometers.

For Longitudinal A, the survey data do not reveal a clear and obvious relationship between elevation and surface height change (see Figure 21). All points experienced an increase in surface elevation from 1999 to 2000. The least magnitude of increase was 0.76 meter at an elevation of 978.86 meters (Point 26), while the greatest height change was 2.02 meters at an elevation of 1027.56 meters (Point 30). The mean height change for all points was 1.36 meters. Referring to Figure 21, there appears to be an undulating pattern of height change, however this may be an artificial effect of the varying time periods being compared. Table 17 details the adjusted survey dates, elevation ranges, and mean height change for Points 24 to 85. A histogram of the data (see Figure 22) reveals an approximately normal distribution of height change values.

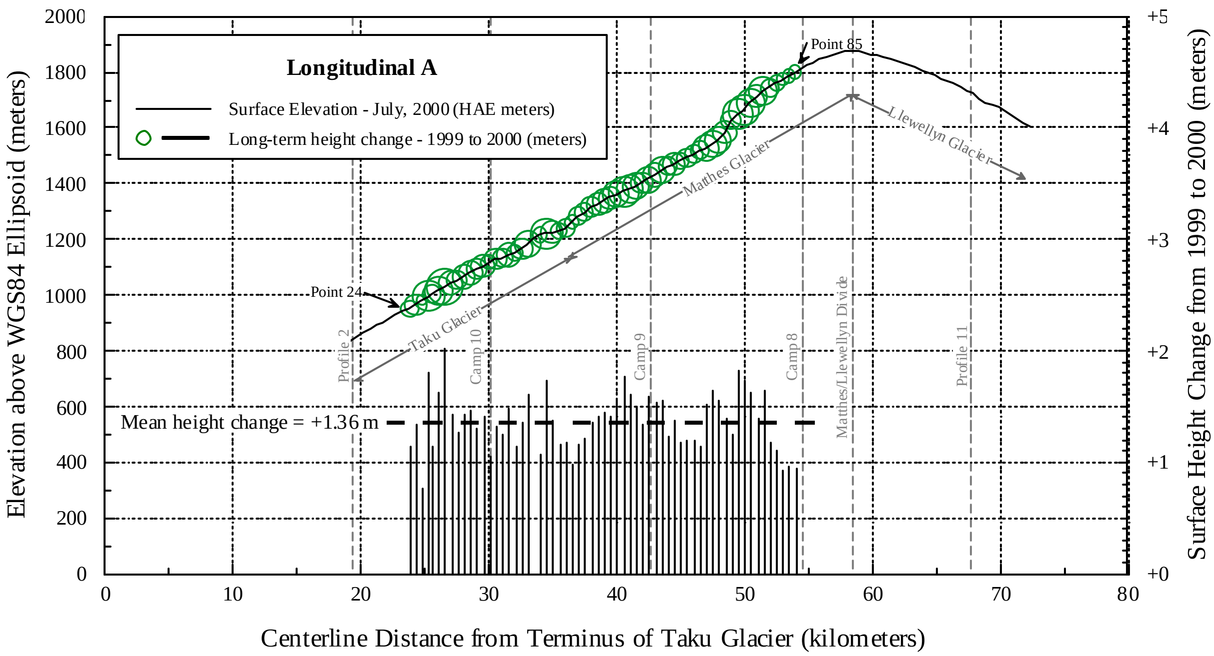

Figure 21: Long-term surface height change as a function of elevation and distance from the terminus of the Taku Glacier along Longitudinal A. The magnitude of height change is indicated by the size of the circles and the length of the vertical bars. Height change was measured at 500 meter intervals along 30 kilometers of the Taku and Matthes Glaciers from Point 24 to Point 85.

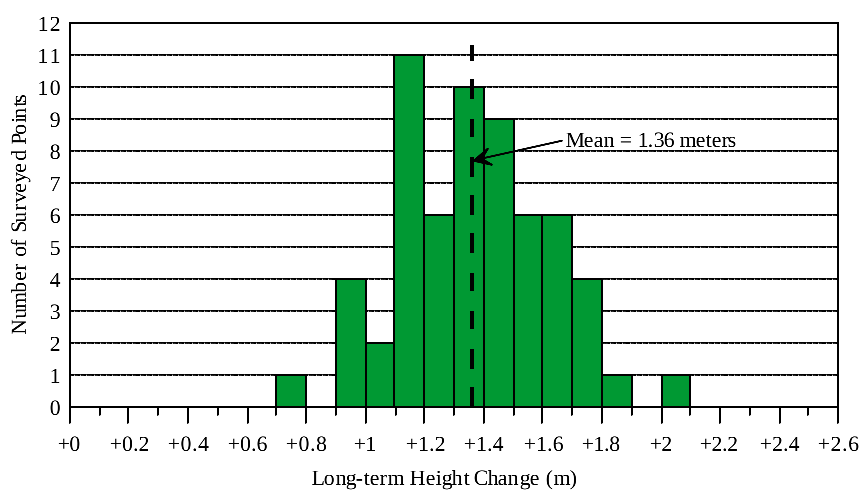

Figure 22: Histogram of long-term height change for Longitudinal "A".

Points	Epoch 0 Date	Epoch 1 Date	Elevation Range (m)	Height Change (m)
24 to 37	7/24/1999	7/24/2000	948 to 1115	+1.37
38 to 53	7/23/1999	7/23/2000	1125 to 1313	+1.29
54 to 75	8/1/1999	8/1/2000	1322 to 1624	+1.43
76 to 85	8/2/1999	8/2/2000	1647 to 1796	+1.33

Table 17: Adjusted survey dates, elevation ranges, and long-term height change for Points 24-85 of Longitudinal A. Future survey dates for the points listed should be adjusted to match those shown here.

3.2.2.2 Demorest Glacier

All 24 points along Longitudinal B, first established and surveyed in 1999, were resurveyed in 2000. These points ranged in elevation from 962.01 meters at Point 1 to 1352.16 meters at Point 34 in 2000. Because of the absence of survey data for Points 10-19 in 1999, long-term height change for this 5.5 kilometer segment cannot be determined.

Unlike Longitudinal A on the Taku/Matthes/Llewellyn glaciers, Longitudinal B on the Demorest Glacier does appear to exhibit a relationship between elevation and height change. As shown in Figure 23, the general height change trend is one of increasing change with increasing elevation. The overall mean height change was +1.53 meters for all points, compared to the mean of +1.36 meters along Longitudinal A. The minimum height change was +1.03 meters at Point 5 (994.38 meters elevation), while the maximum height change was +1.89 meters at Point 33 (1345.16 meters elevation). Point 34, with a height change of +0.58 meter, is an outlier and is ignored in this analysis. The adjusted survey dates, point numbers with associated elevation ranges, and height change are shown in Table 18. A histogram showing the distribution of height change for the points of Longitudinal B is shown in Figure 24. The histogram reveals a negatively skewed distribution, suggesting a positive relationship between elevation and height change. A correlation coefficient (r) of 0.84 provides further corroboration of the relationship.

Points	Epoch 0 Date	Epoch 1 Date	Elevation Range (m)	Height Change (m)
1 to 9	7/26/1999	7/26/2000	962 to 1039	+1.31
20 to 34	8/7/1999	8/7/2000	1181 to 1352	+1.68

Table 18: Adjusted survey dates, elevation ranges, and long-term height change for Points 1-9 and 20-34 of Longitudinal B. Future survey dates for the points listed should be adjusted to match those shown here.

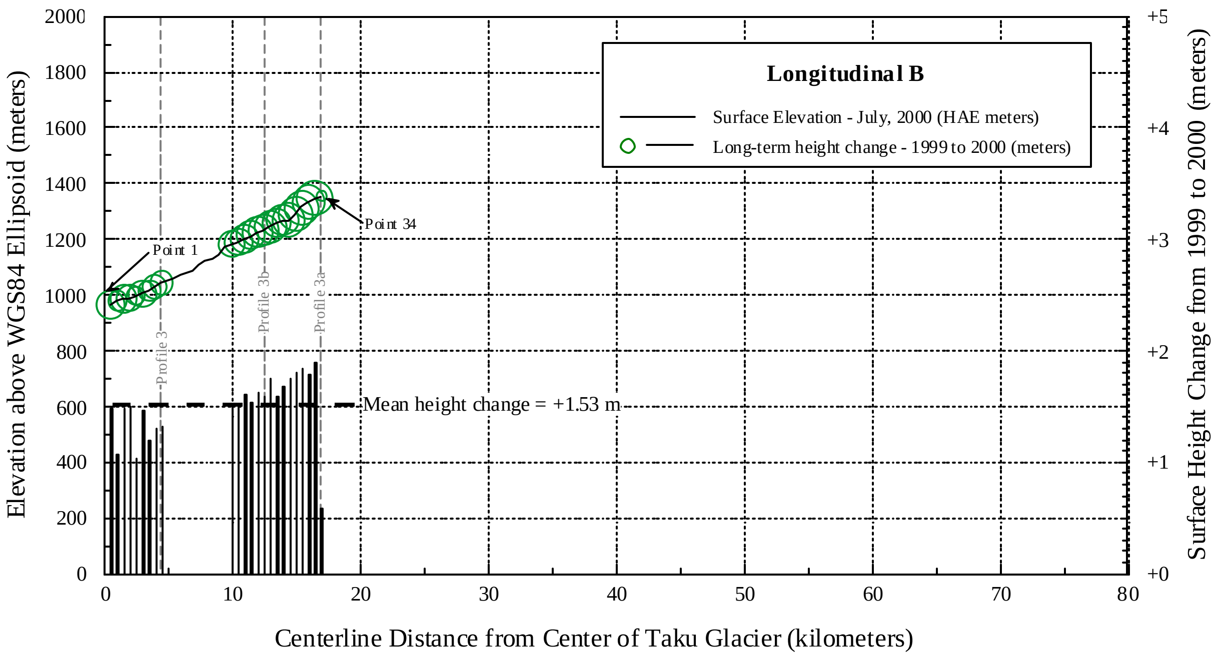

Figure 23: Long-term surface height change as a function of elevation and distance from the centerline of the Taku Glacier along Longitudinal B. The magnitude of height change is indicated by the size of the circles and the length of the vertical bars. Height change was measured at 500 meter intervals along 12 kilometers of the Demorest Glacier between Points 1-9 and 20-34.

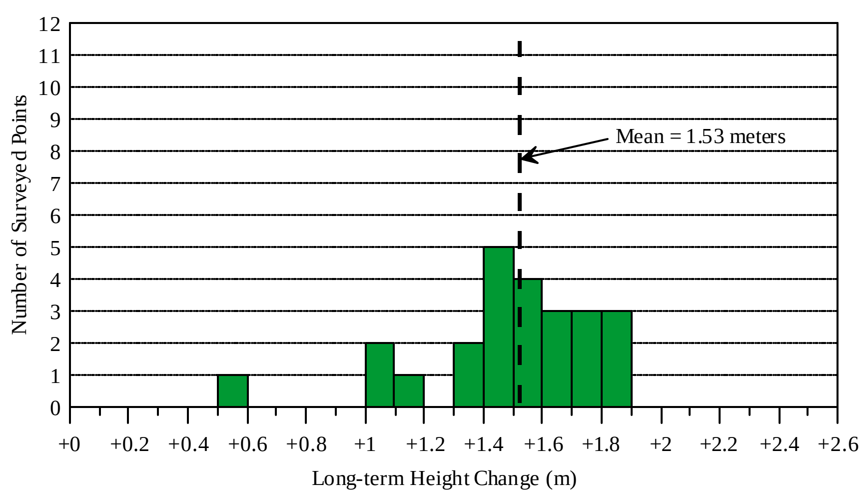

Figure 24: Histogram of long-term height change for Longitudinal "B".

3.2.3 LONGITUDINAL FLOW LAG TIMES

With the establishment of the longitudinal profiles, it is now possible to quantitatively determine the longitudinal flow, or lag, times with a much higher degree of accuracy than has been possible in the past. Previously, estimates of the lag time were based on the observed surface velocity at widely spaced (8-12 km apart) transverse profiles, with no data for the intervening 8-12 km gaps. The current longitudinal profiles provide much higher resolution data due to the nominal flag spacing of 500 meters.

Miller (1997) estimated the lag time of the Taku Glacier, from Névé Zone B (roughly, the current location of Profile 4, 30 km upglacier from the terminus) to the terminus to be approximately 78 years. Results of the longitudinal surveys reveal a lag time of 44 years from Longitudinal A Point 38 (at Profile 4) to Point 13, over a longitudinal slope distance of 12.3 kilometers. With the exception of Profile 1, surface velocities have not been measured from the terminus to Longitudinal A, Point 13. Given a velocity of 93.7 cm/day at Point 13 and a similar velocity at Profile 1 in 1994, a flow lag estimate of 54 years is postulated for the 17.7 kilometer distance from Point 13 to the terminus (based on an average velocity estimate of 90 cm/day, recognizing that the velocity downglacier from Profile 1 will be less than that found at the profile). Adding the flow lag from Point 38 to Point 13, and from Point 13 to the terminus gives a total flow lag of 98 years, 20 years greater than Miller's estimate.

Flow lag times for the extent of the longitudinal profiles surveyed to date are shown in Appendix 5. When considering the Matthes and Taku Glaciers collectively, it takes approximately 335 years for a particle of ice to move from the Matthes/Llewellyn divide to Point 13 on the Taku Glacier (17.7 kilometers upglacier from the terminus). Adding the estimated 54 years from Point 13 to the terminus gives a total flow lag of 389 years from the Matthes/Llewellyn divide to the terminus, for a mean velocity of 146.3 meters per year over a distance of 56.9 kilometers.

Unfortunately, surveys have not been conducted downglacier from the north end of F-10 Peak on the Llewellyn Glacier, making it impossible to determine the flow lag time from the Matthes/Llewellyn divide to the terminus of the Llewellyn. The 2000 surveys of Longitudinal A on the Llewellyn Glacier extended from the divide (Point 93) to the north end of F-10 Peak (Point 122). As seen in Appendix 5, the flow lag time for this segment of the Llewellyn Glacier is 309.5 years, for a mean velocity of 46.7 meters per year over a distance of 14.5 kilometers. This is roughly 68% slower than the flow of the Taku/Matthes system.

Longitudinal B, on the Demorest Glacier, has a flow lag time of 151.6 years from Point 34 (directly east of Camp 9) to Point 5 (at the confluence of the Demorest and Taku Glaciers), over a total slope distance of 14.5 kilometers, for a mean velocity of 95.6 meters per year. The movement between Point 5 and Point 1 is not considered because this area reflects the flow of the Taku Glacier.

The flow lag time for Longitudinal C, on the Southwest Branch of the Taku Glacier, is 124.6 years. This is for the segment of the glacier from Point 14 (midway between the Norris/Southwest Branch divide) to Point 6 (at the confluence of the SW Branch and Taku Glaciers), a total slope distance of 4 kilometers. The mean velocity for this portion of the Southwest Branch is 32.1 meters per year. The area from Point 6 to Point 1 is not included in these figures as this area reflects the flow of the Taku Glacier rather than the Southwest Branch.

Longitudinals D and F traverse the Northwest and West Branches of the Taku Glacier, respectively. Points 1-16 of Longitudinal D are actually an extension of Longitudinal F, and so are included in this analysis together with Longitudinal F. Taken together, the total slope distance is 12.9 kilometers and the flow lag time is 192.1 years over this distance, for a mean velocity of 67.2 meters per year. As with the other tributaries of the Taku Glacier, the area between Longitudinal D Points 1 and 6 is not included in these figures. This area reflects the flow of the Taku Glacier instead of the true flow along Longitudinals D and F.

3.3 PROFILE 4

Profile 4, located on the main Taku Glacier some 30 kilometers upglacier from the terminus, has historically been the focus of much research. Miller (1951) conducted glacier borehole research to investigate ice fabric structures and firn stratigraphy, and to determine englacial temperatures and the vertical flow profile. Long-term mass balance studies (Pelto and Miller, 1990) have documented the dynamic response of the Taku Glacier to decadal climate cycles, and seismic reflection studies by Poulter (1950), Sprenke, et al (1993), and Echelmeyer, et al (1995) have investigated the ice thickness of the Taku Glacier at this location. Surface velocity, strain-rate, and volume change studies by Kersting (1986), Welsch and Daellenbach (1993), Lang (1993, 1995, 1997, 1999), and McGee (1988, 1994, 1996, 1997) have provided detailed information relating to the flow regime of the Taku Glacier at this profile.

3.3.1 HEIGHT CHANGE AND LOCAL SURFACE MASS BALANCE

GPS, coupled with computer-aided surface modeling, provides a unique opportunity to monitor the volume change of a glacier through time. Recent efforts by Hock and Jensen (1999) and Hagen, et al (1999) have demonstrated the effectiveness and utility of this technique. With the advent of the use of GPS on the Juneau Icefield in 1992, the Juneau Icefield Research Program initiated a long-term monitoring program in 1993 to determine the temporal and spatial distribution changes of mass at Profile 4. This is accomplished by the annual GPS survey of two parallel, transverse profiles comprised of 31 stakes stretching across the Taku Glacier from Camp 10 to Shoehorn Peak (see Figure 2). The annual placement of the stakes is accomplished with the aid of real-time differential GPS and is in accordance with the stakeout coordinates published by McGee (2000).

The mean annual surface height change at Profile 4 is calculated by taking the mean of three calculation methods — the interpolated grids method, the trihedral method, and the normalized heights method. The interpolated grid method relies on the use of three-dimensional surface modeling software to create surface models of the profile based on the surveyed surface heights (adjusted to conform to an annual survey date of July 25). The volume of each surface model above a baseline elevation, in conjunction with the surface area, allows for the calculation of mean height change across the extent of the profile. The trihedral method is non-interpolative, instead obtaining the mean volume and height change of the profile by simply determining the volume of each trihedron within the profile (a trihedron is created by three flags of the profile which define a surface triangle with an associated baseline elevation, e.g., Flags 1, 2, and 3, and a baseline elevation of 1100 meters; there are 29 trihedrals at Profile 4). Summation of the volumes and surface areas of all the trihedrals within the profile gives the mean volume and height change. The third method, normalized heights (e.g., the direct method) calculates the height change at each of the 31 flags by simply comparing the July 25 adjusted heights from one year to the next. It is a direct method in that the height change is calculated directly from surveyed heights, rather than deriving the height change from the change in volume, as the interpolated heights and trihedral methods do. The final volume and height change is determined by taking the mean of all three methods. Refer to McGee (1993, 1997, 2000a) for complete details on the survey and data analysis procedures used for this project.

With a now seven-year record of height change at Profile 4, a pattern revealing the record-breaking climate of the mid-to-late 1990's is seen. During the first year of the project, the mean height of the Taku Glacier at Profile 4 increased a modest 9 cm. The surface elevation then decreased each year from 1994 to 1998. The 1999 and 2000 surveys reveal a return to positive mass balance as evidenced by increases in the mean surface height. Table 19 presents the data for each of the three calculation methods on an annual basis. The cumulative height change is shown in Table 20. Figure 25 presents the annual and cumulative height change data in a graphic format. The normalized, July 25 elevations of all 31 flags of Profile 4, from 1993 to 2000, are shown in Appendix 6.

TIME PERIOD	ANNUAL HEIGHT CHANGE BY CALCULATION METHOD			MEAN (M)
	INTERPOLATED GRIDS (M)	TRIHEDRAL METHOD (M)	NORMALIZED HEIGHTS (M)	
1993 baseline	—	—	—	0
1993 to 1994	+0.890	+0.880	+0.096	+0.091
1994 to 1995	-1.360	-1.343	-1.294	-1.332
1995 to 1996	-0.657	-0.654	-0.687	-0.666
1996 to 1997	-0.441	-0.438	-0.493	-0.457
1997 to 1998	-1.087	-1.068	-1.043	-1.066
1998 to 1999	+0.602	+0.594	+0.571	+0.589
1999 to 2000	+1.330	+1.308	+1.318	+1.319

Table 19: Annual height change at Profile 4 based on three methods for calculating height change. Annual mass balance was positive from 1993 to 1994, negative from 1994 to 1998, and again positive from 1998 to 2000.

Time Period	Cumulative Height Change by Calculation Method			Mean (m)
	Interpolated Grids (m)	Trihedral Method (m)	Normalized Heights (m)	
1993 baseline	—	—	—	0
1993 to 1994	+0.089	+0.088	+0.096	+0.091
1993 to 1995	-1.270	-1.256	-1.198	-1.241
1993 to 1996	-1.928	-1.910	-1.885	-1.907
1993 to 1997	-2.369	-2.348	-2.378	-2.365
1993 to 1998	-3.456	-3.416	-3.421	-3.431
1993 to 1999	-2.854	-2.823	-2.850	-2.842
1993 to 2000	-1.523	-1.514	-1.532	-1.523

Table 20: Cumulative height change at Profile 4 based on three methods for calculating height change. Despite positive mass balance from 1998 to 1999 and from 1999 to 2000, the mean surface height at Profile 4 remains some 1.52 meters lower than it was during the 1993 baseline year.

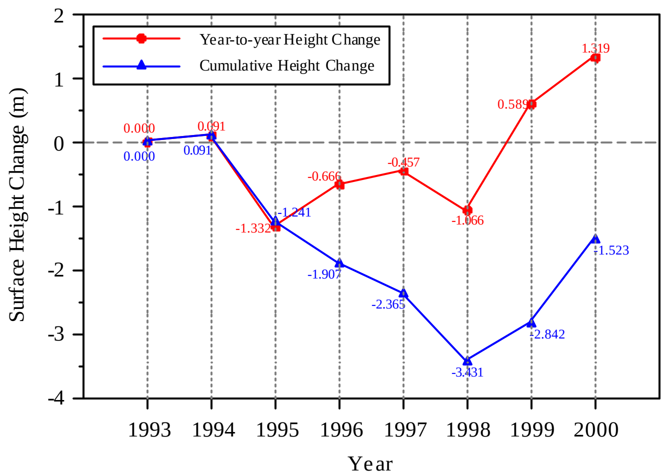

Figure 25: Mean year-to-year and cumulative surface height change of the Taku Glacier at Profile 4.

Annual three-dimensional modeling of the glacier surface at Profile 4 provides a means to determine not only the surface height change, and hence mass balance, but also to determine the spatial distribution of mass as it varies from year to year, and cumulatively. Figures 26-33 show the year-to-year spatial distribution changes at Profile 4, along with the cumulative effects from 1993 to 2000. In all figures, yellow, orange, and red represent a decrease in surface height and mass balance. Green, blue, and violet indicate an increase in surface height and mass balance. As seen in Figure 26, the mass increased for approximately 75% of the profile from 1993 to 1994. The mean surface height increase was 9.1 cm (5 cm water equivalent, based on a surface firn density of 0.55 g/cm^3). The decrease in surface height from 1993 to 1994 occurred primarily at the southwest end of Profile 4, with decreases also evident near the center and northeast end of the profile. 1994 marked the beginning of a four-year negative balance trend as seen in Figures 27-30. From 1994 to 1995, the mean surface height decrease was 1.332 meters (0.733 meter w.e.). The mean surface height decreased 0.666 meter (0.366 meter w.e.) from 1995 to 1996. The mean decrease was slightly less from 1996 to 1997 at 0.457 meter (0.251 meter w.e.), but then more than doubled between 1997 and 1998, with a mean surface height decrease of 1.066 meters (0.586 meter w.e.). The spatial distribution of the height and mass decrease from 1994 to 1998 was relatively uniform across the extent of the profile. After 4 consecutive years of negative mass balance, there was a mean surface height increase of 0.589 meter (0.324 meter w.e.) from 1998 to 1999. Figure 31 shows the spatial distribution pattern between 1998 and 1999, with the maximum increase occurring near the center of the profile. As can be seen, the magnitude of height change varied considerably among the 31 flags of the profile. The positive mass balance trend continued from 1999 to 2000, with a mean surface height increase of 1.319 meters (0.725 meter w.e.). The spatial distribution pattern was remarkably consistent from 1999 to 2000, as shown in Figure 32. Figure 33 presents the cumulative surface height change from 1993 to 2000. The mean decrease in height over this 7 year time period was 1.523 meters (0.838 meter w.e).

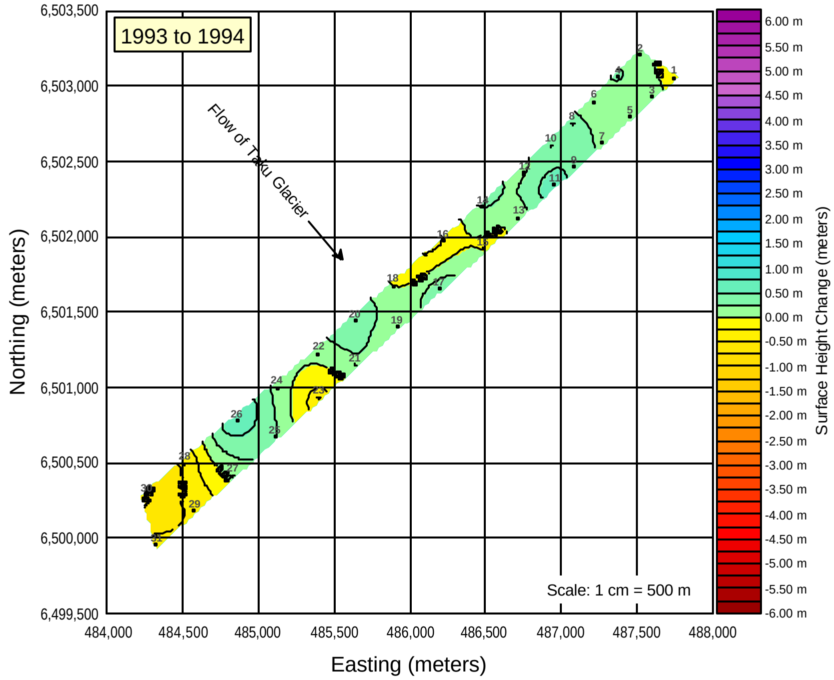

Figure 26: Surface height change at Profile 4 from July 25, 1993 to July 25, 1994.

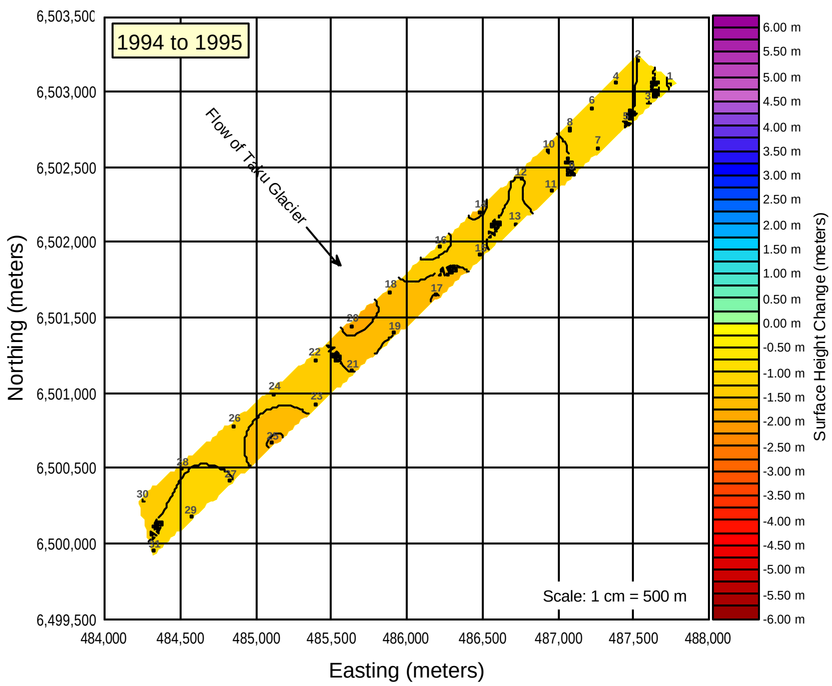

Figure 27: Surface height change at Profile 4 from July 25, 1994 to July 25, 1995.

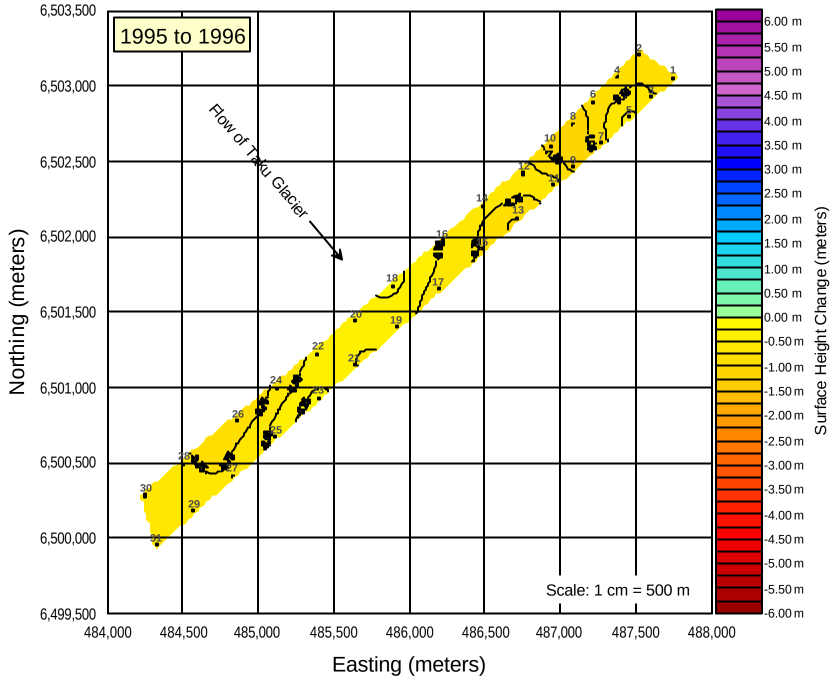

Figure 28: Surface height change at Profile 4 from July 25, 1995 to July 25, 1996.

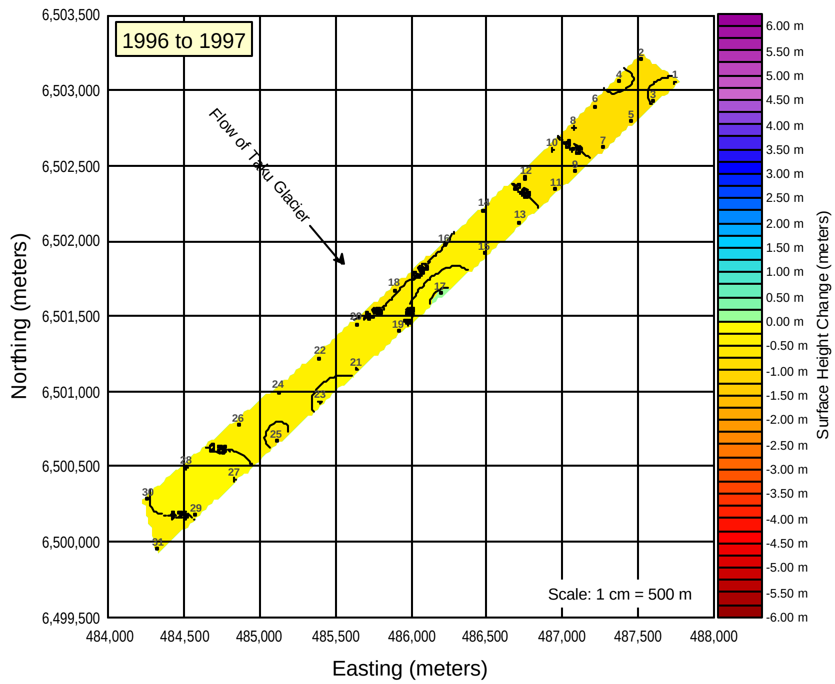

Figure 29: Surface height change at Profile 4 from July 25, 1996 to July 25, 1997.

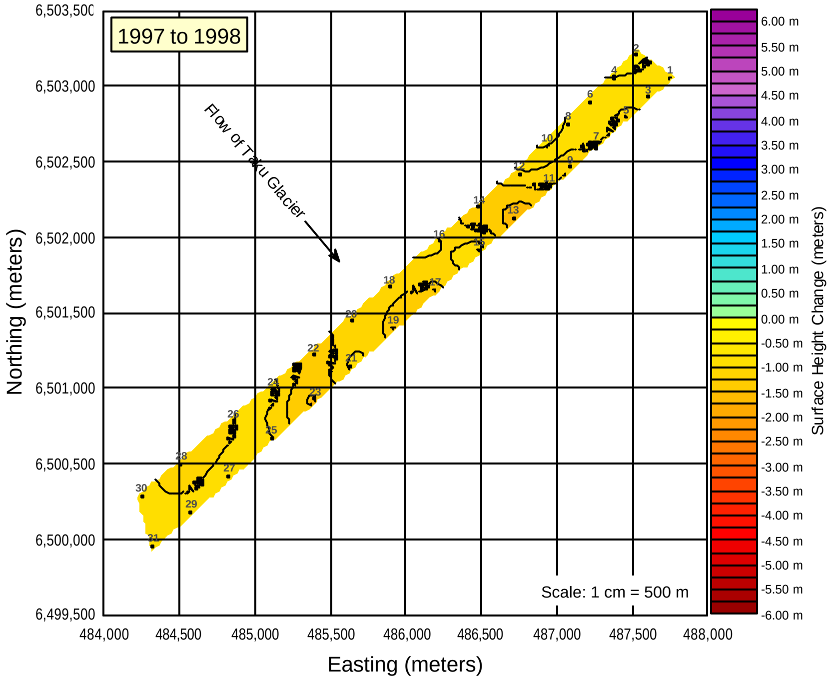

Figure 30: Surface height change at Profile 4 from July 25, 1997 to July 25, 1998.

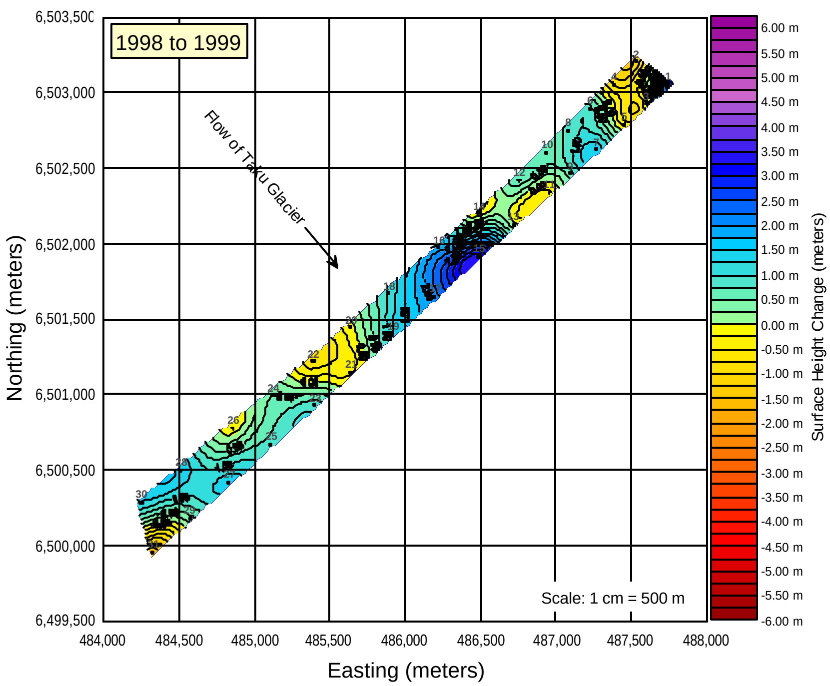

Figure 31: Surface height change at Profile 4 from July 25, 1998 to July 25, 1999.

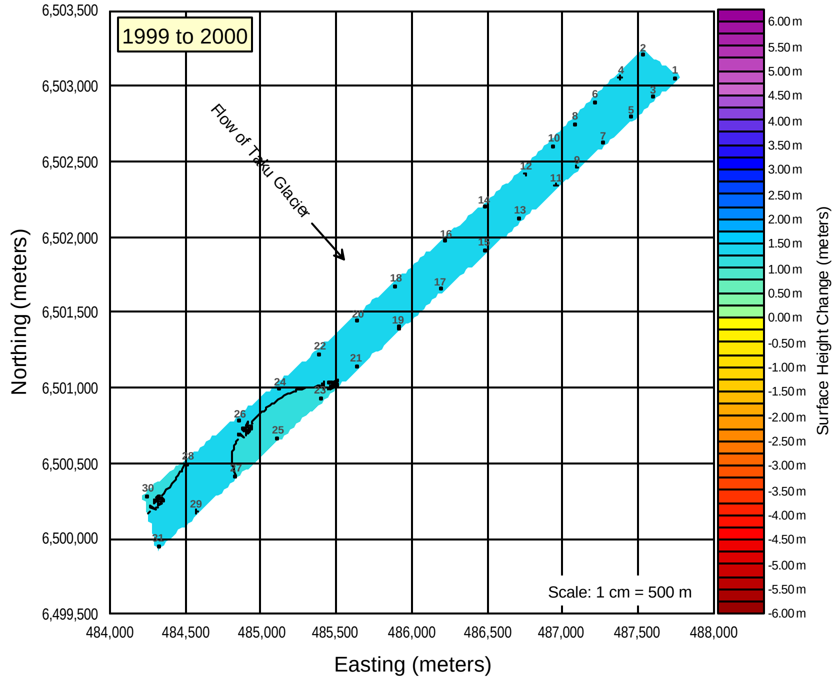

Figure 32: Surface height change at Profile 4 from July 25, 1999 to July 25, 2000.

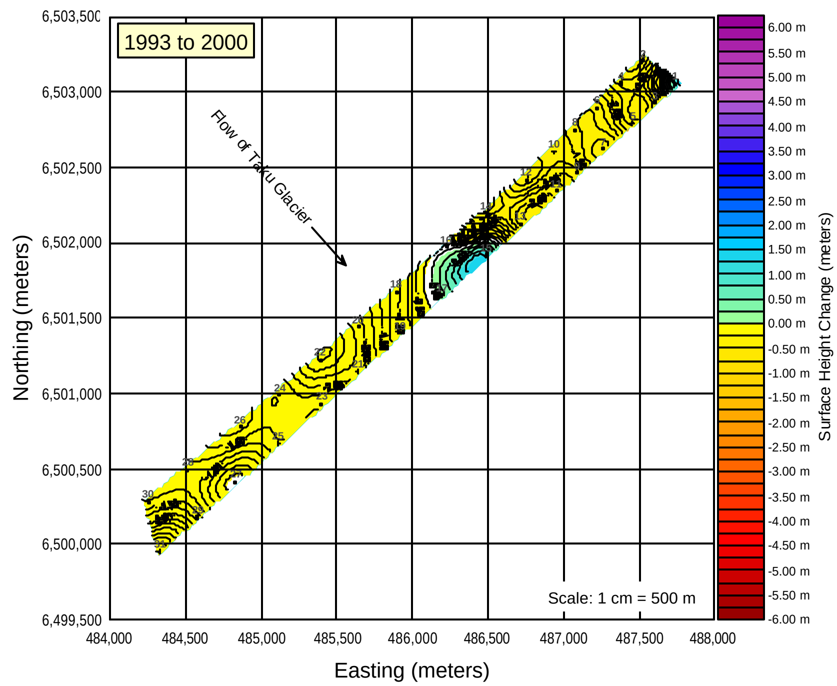

Figure 33: Surface height change at Profile 4 from July 25, 1993 to July 25, 2000.

3.3.2 STRAIN

In conjunction with the monitoring of surface height and mass balance change at Profile 4, strain rates have been analyzed annually. This is accomplished by determining the change in the geometry of the triangles formed by the dual line setup of Profile 4. Calculation of strain rates is based on the method described by Welsch (1987), which evaluates the changes in the elements (interior angles and the length of sides) of a triangle. The result, strain, is expressed in terms of a strain ellipse, with the maximum strain ($e1$) representing extension and the minimum strain ($e2$) representing compression. Vertical strain ($e3$) is derived from the equation $e1 + e2 + e3 = 0$. Additionally, the orientation of the strain ellipse is given by the value ?.

The strain regime at Profile 4 has been relatively consistent since 1993. Figure 34 presents the results of the 2000 strain analysis of the profile. Refer to Lang (1999) for the strain results from 1993 to 1999. As seen in Figure 34, both extensional and compressional strains are greatest along the northeast and southwest margins of the profile. Strains in the center of the profile are relatively small. As expected, this is consistent with the flow and crevasse patterns of the Taku Glacier. As seen in Figures 5 and 6, the rate of increase in the surface flow is greatest along the margins, with the rate of increase lessening to zero in the center of the glacier. This reflects the normal flow and strain regime, and resultant crevassing, of a glacier exhibiting a mode of flow somewhere between parabolic and rectilinear. The computed strain data is presented in Appendix 7.

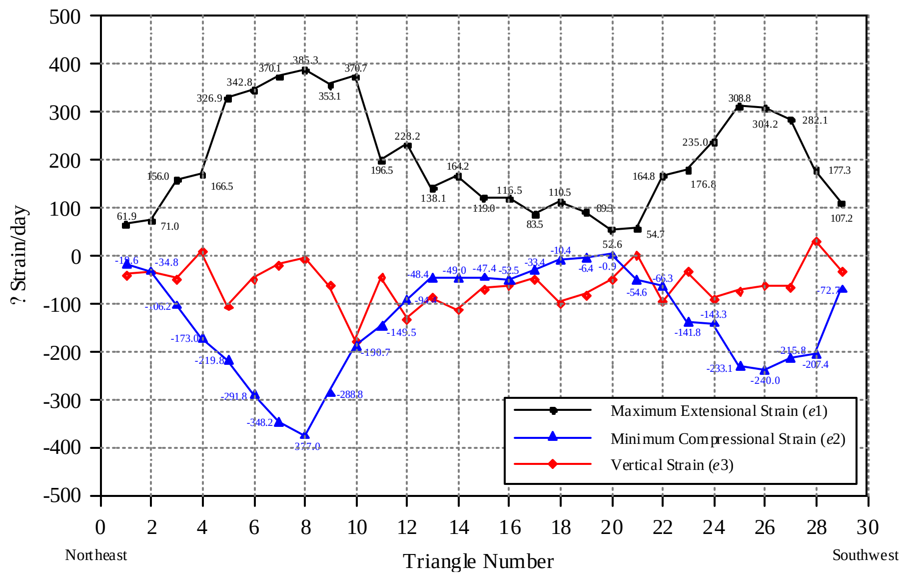

Figure 34: Observed surface strains at Profile 4 between July 21 and July 27, 2000. Maximum strain is extensional and minimum strain is compressional. A positive vertical strain indicates an increase in surface elevation, while a negative vertical strain results in a lowering of the surface.

3.4 GILKEY GLACIER SURVEYS

Surveys in the Gilkey Trench in 2000 focused on determining the surface height change on the Gilkey Glacier since 1995 (see the discussion in Section 3.1.3.6) and on determining the surface velocity and heights of the first nine ogives at the base of the Vaughan Lewis Icefall.

3.4.1 VAUGHAN LEWIS OGIVES

In addition to the surveys on the Gilkey Glacier, 28 points on the first nine ogives at the base of the Vaughan Lewis Icefall were also surveyed in August, 2000. Twenty-four of these points were arranged in a transverse configuration along the crests of Ogives 0 through 5, while the remaining four points were on located on the crests of Ogives 6 through 9 at the longitudinal centerline of the Vaughan Lewis Glacier. The objective of the survey was to determine the surface velocities and surface elevations. Refer to Figure 10 for a plot of the movement vectors. The surface velocities and heights are summarized in Table 21. The survey observations are presented in Appendix 2, and the calculated velocities are shown in Appendix 3.

POINT	SURFACE HEIGHT (M)	VELOCITY (CM/DAY)	DIRECTION (GON)
Ogive 0 #1	1105.548	39.1	325.8335
Ogive 0 #2	1121.163	44.1	316.0976
Ogive 0 #3	1123.544	42.5	305.6296
Ogive 1 #1	1094.141	29.0	314.4210
Ogive 1 #2	1093.510	39.0	320.5651
Ogive 1 #3	1108.358	38.4	314.4168
Ogive 1 #4	1110.160	29.6	312.6314
Ogive 1 #5	1111.710	26.7	305.1349
Ogive 2 #1	1085.846	23.3	310.3892
Ogive 2 #2	1089.278	30.9	302.8169
Ogive 2 #3	1087.287	37.3	304.8414
Ogive 2 #4	1095.171	33.7	308.3497
Ogive 2 #5	1102.752	31.3	320.1829
Ogive 3 #1	1089.517	31.6	295.8787
Ogive 3 #2	1087.680	35.4	294.0491
Ogive 3 #3	1078.482	39.5	295.0965
Ogive 3 #4	1097.722	33.7	312.0245
Ogive 3 #5	1101.229	30.7	324.0384
Ogive 4 #1	1084.375	43.8	279.0819
Ogive 4 #2	1070.829	40.1	281.0339
Ogive 4 #3	1091.073	31.9	302.2356
Ogive 5 #1	1081.258	45.6	276.6413
Ogive 5 #2	1060.894	44.4	276.6354
Ogive 5 #3	1086.368	36.5	305.3002
Ogive 6	1047.555	46.7	274.2689
Ogive 7	1036.533	83.5*	224.5807
Ogive 8	1029.829	85.8*	225.4121
Ogive 9	1023.270	71.6*	227.1930

*Data unreliable

Table 21: Summary of surface heights and movement vectors on Ogives 1-9, Vaughan Lewis Glacier in August, 2000.

4. FUTURE WORK

Steady progress has been made on determining the overall velocity field and vertical elevation profiles of the main portion of the Juneau Icefield. Future survey work should focus on extending the existing longitudinal profiles to the head of the respective glaciers. To do so, new benchmarks must be established on the Demorest Glacier east of Camp 8 and west of the Taku Towers on the south ridge of Snowpatch Craig between the West and Northwest Branches of the Taku Glacier. A resurvey of the four profiles on the Lemon Glacier should be done in 2001, as the last survey here was done in 1999. Continued monitoring of the longitudinal profiles will provide detailed annual information relating to the mass balance regime.

5. ACKNOWLEDGEMENTS

As usual, the survey work detailed in this report could not have been accomplished without the financial, logistical, and field support of the Foundation for Glacier and Environmental Research, Juneau Icefield Research Program. Financial support from NASA enabled several students to assist with the survey projects. Significant personnel and equipment support was provided by the Universität der Bundeswehr in Munich, Germany. As always, many thanks are extended to Dr. Maynard Miller and Joan Miller for their countless efforts in organizing and carrying out the summer field season. The tireless efforts of Annette Erickson and other staff in providing the necessary logistical support in Juneau during the summer are greatly appreciated.

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APPENDICES

APPENDIX 1
GPS BENCHMARK COORDINATES

GPS BENCHMARKS (JIRP COORDINATE SYSTEM)			
BENCHMARK	EASTING (M)	NORTHING (M)	HEIGHT[1] (M)
FFGR 1[2] (C-17)	478,573.838	6,472,234.227	1,301.709
FFGR 6 (Cleaver)	483,309.746	6,524,118.094	1,388.753
FFGR 12 (C-19)	482,221.820	6,522,621.728	1,292.865
FFGR 18 (C-19)	482,304.622	6,522,507.563	1,285.892
FFGR 19 (C-10)	488,001.820	6,503,290.614	1,180.836
FFGR 19C (C-10)	487,983.651	6,503,410.033	1,198.000
FFGR 24 (C-18 Hill)	484,189.635	6,524,371.872	1,733.416
FFGR 31 (C-8)	492,136.624	6,521,147.773	2,051.576
FFGR 31 (Cleaver)	483,705.534	6,524,279.606	1,623.548
FFGR 34 (C-18 Hill)	484,554.464	6,524,402.905	1,734.890
FFGR 39 (Blizzard)	487,443.145	6,524,360.975	1,984.385
FFGR 43 (Cleaver)	483,990.101	6,524,352.738	1,703.762
FFGR 44 (Cleaver)	483,834.598	6,524,280.382	1,669.527
FFGR 45 (C-18 Hill)	484,309.150	6,524,412.394	1,746.191
FFGR 53 (C-19)	482,195.157	6,522,670.922	1,277.773
FFGR 62 (F10)	492,497.562	6,535,469.195	1,860.563
FFGR 63 (C-18 Hill)	484,315.335	6,524,309.996	1,723.699
FFGR 64 (C-18 Hill)	484,219.214	6,524,334.390	1,727.783
FFGR 65 (Taku D)	482,942.072	6,509,779.956	1,774.109
FFGR 68 (C-18 Hill)	484,425.554	6,524,412.335	1,751.611
C-9 Bolt	489,442.431	6,510,665.042	1,554.938
C-10A	489,181.351	6,501,882.011	1,105.758
Lupine (Taku A)	490,263.717	6,500,621.560	1,080.574
N1 (C-18)	484,073.444	6,524,262.764	1,698.457
N2 (Cleaver)	483,956.314	6,524,239.526	1,682.217
Scott (C-10)	487,963.303	6,503,372.111	1,189.740
SW Taku Pt.	487,320.590	6,495,968.917	1,133.488
Taku D Lower	482,601.539	6,509,092.743	1,399.213
Taku NW Pt (USGS)	479,186.763	6,505,147.716	1,402.060
Taku NW (UniBm)	479,188.345	6,505,144.633	1,402.149
Vista (C-9 East)	489,873.478	6,510,298.945	1,564.057

[1] Height above WGS84 ellipsoid, in meters.
[2] Coordinates were obtained by single-point positioning.

GPS BENCHMARKS (GEOGRAPHIC COORDINATES — WGS84 DATUM)			
BENCHMARK	WEST LONGITUDE	NORTH LATITUDE	HEIGHT[1] (M)
FFGR 1[2] (C-17)	134° 21’ 57.942684”	58° 22’ 01.732978”	1,301.709
FFGR 6 (Cleaver)	134° 17’ 20.377172”	58° 49’ 59.308553”	1,388.753
FFGR 12 (C-19)	134° 18’ 27.762700”	58° 49’ 10.792606”	1,292.865
FFGR 18 (C-19)	134° 18’ 29.436030”	58° 49’ 12.377740”	1,285.892
FFGR 19 (C-10)	134° 12’ 23.899681”	58° 38’ 46.758278”	1,180.836
FFGR 19C (C-10)	134° 12’ 25.049008”	58° 38’ 50.615966”	1,198.000
FFGR 24 (C-18 Hill)	134° 16’ 25.595230”	58° 50’ 07.629607”	1,733.416
FFGR 31 (C-8)	134° 08’ 09.785576”	58° 48’ 24.218727”	2,051.576
FFGR 31 (Cleaver)	134° 16’ 55.748732”	58° 50’ 04.582822”	1,623.548
FFGR 34 (C-18 Hill)	134° 16’ 02.860336”	58° 50’ 08.680180”	1,734.890
FFGR 39 (Blizzard)	134° 13’ 02.775834”	58° 50’ 07.663122”	1,984.385
FFGR 43 (Cleaver)	134° 16’ 38.028785”	58° 50’ 06.984705”	1,703.762
FFGR 44 (Cleaver)	134° 16’ 47.703578”	58° 50’ 04.625407”	1,669.527
FFGR 45 (C-18 Hill)	134° 16’ 18.155186”	58° 50’ 08.954924”	1,746.191
FFGR 53 (C-19)	134° 18’ 29.438155”	58° 49’ 12.378488”	1,277.773
FFGR 62 (F10)	134° 07’ 49.040300”	58° 56’ 07.080992”	1,860.563
FFGR 63 (C-18 Hill)	134° 16’ 17.743731”	58° 50’ 05.646451”	1,723.699
FFGR 64 (C-18 Hill)	134° 16’ 23.741807”	58° 50’ 06.422174”	1,727.783
FFGR 65 (Taku D)	134° 17’ 39.370491”	58° 42’ 15.874914”	1,774.109
FFGR 68 (C-18 Hill)	134° 16’ 10.898731”	58° 50’ 08.968227”	1,751.611
C-9 Bolt	134° 10’ 55.822743”	58° 42’ 45.226060”	1,554.938
C-10A	134° 11’ 10.525565”	58° 38’ 01.345224”	1,105.758
Lupine (Taku A)	134° 10’ 03.247227”	58° 37’ 20.700786”	1,080.574
N1 (C-18)	134° 16’ 32.810299”	58° 50’ 04.088062”	1,698.457
N2 (Cleaver)	134° 16’ 40.105698”	58° 50’ 03.321412”	1,682.217
Scott (C-10)	134° 12’ 26.303369”	58° 38’ 49.388336”	1,189.740
SW Taku Pt.	134° 13’ 04.662101”	58° 34’ 50.057832”	1,133.488
Taku D Lower	134° 18’ 00.327718”	58° 41’ 53.616470”	1,399.213
Taku NW Pt (USGS)	134° 21’ 31.048187”	58° 39’ 45.577275”	1,402.060
Taku NW (UniBm)	134° 21’ 30.949035”	58° 39’ 45.477910”	1,402.149
Vista (C-9 East)	134° 10’ 28.987537”	58° 42’ 33.431361”	1,564.057

[1] Height above WGS84 ellipsoid, in meters.
[2] Coordinates were obtained by single-point positioning.

APPENDIX 2
MOVEMENT PROFILE FLAG COORDINATES

PROFILE 2 (TAKU GLACIER AT GOAT RIDGE) — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	493,221.572	6,492,499.918	819.354	7/25/00	14:54
2	493,039.253	6,492,605.960	823.865	7/25/00	14:43
3	492,814.401	6,492,500.391	822.990	7/25/00	14:32
4	492,592.232	6,492,441.771	823.309	7/25/00	14:26
5	492,404.772	6,492,385.826	824.389	7/25/00	14:20
6	492,153.137	6,492,273.114	821.986	7/25/00	12:22
7	491,825.566	6,492,148.040	822.805	7/25/00	12:35
8	491,579.252	6,492,064.429	826.410	7/25/00	12:43
9	491,446.455	6,492,025.047	827.238	7/25/00	13:01
10	491,290.979	6,491,990.335	826.489	7/25/00	13:10
11	491,078.353	6,491,896.186	825.246	7/25/00	13:43

PROFILE 2 (TAKU GLACIER AT GOAT RIDGE) — EPOCH 1					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	493,222.203	6,492,497.852	819.188	7/29/00	12:00
2	493,039.984	6,492,603.381	823.606	7/29/00	11:57
3	492,815.218	6,492,497.363	822.722	7/29/00	11:52
4	492,593.154	6,492,438.555	823.029	7/29/00	11:48
5	492,405.762	6,492,382.432	824.128	7/29/00	11:44
6	492,154.173	6,492,269.584	821.653	7/29/00	11:39
7	491,826.623	6,492,144.565	822.361	7/29/00	11:35
8	491,580.301	6,492,060.989	825.998	7/29/00	12:16
9	491,447.481	6,492,021.652	826.744	7/29/00	12:19
10	491,292.003	6,491,987.108	826.070	7/29/00	12:34
11	491,079.337	6,491,893.428	824.887	7/29/00	12:50

PROFILE 3 (LOWER DEMOREST GLACIER) — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	491,627.104	6,501,358.344	1017.630	7/26/00	12:41
2	491,862.952	6,501,154.322	1023.093	7/26/00	12:50
3	492,098.756	6,500,950.761	1025.725	7/26/00	12:55
4	492,334.955	6,500,746.658	1030.338	7/26/00	13:00
5	492,570.420	6,500,543.116	1029.017	7/26/00	13:06
6	492,805.848	6,500,339.393	1028.079	7/26/00	13:11
7	493,042.059	6,500,135.379	1037.064	7/26/00	13:20
8	493,277.476	6,499,931.607	1046.876	7/26/00	13:27
9	493,513.493	6,499,727.660	1049.916	7/26/00	13:31
10	493,749.716	6,499,523.684	1048.740	7/26/00	13:35
11	493,984.225	6,499,320.662	1046.623	7/26/00	13:41
12	494,103.024	6,499,234.822	1044.087	7/26/00	13:45

PROFILE 3A (DEMOREST GLACIER EAST OF CAMP 9) — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	492,009.481	6,510,931.637	1355.955	8/7/00	16:56
2	492,309.257	6,510,940.384	1344.790	8/7/00	16:54
3	492,611.653	6,510,949.219	1338.130	8/7/00	16:51
4	492,911.711	6,510,958.528	1336.940	8/7/00	16:48
5	493,212.771	6,510,967.077	1336.238	8/7/00	16:45
6	493,513.300	6,510,976.301	1339.323	8/7/00	16:43
7	493,807.296	6,510,984.576	1343.950	8/7/00	16:40
8	494,109.300	6,510,992.797	1349.641	8/7/00	16:37
9	494,407.118	6,511,001.092	1354.025	8/7/00	15:42
10	494,706.472	6,511,009.683	1358.721	8/7/00	15:46
11	495,008.786	6,511,020.015	1366.058	8/7/00	16:14
12	495,308.840	6,511,026.733	1370.772	8/7/00	16:17
13	495,607.391	6,511,035.110	1376.863	8/7/00	16:20
14	495,907.989	6,511,043.468	1383.821	8/7/00	16:23
15	496,208.898	6,511,052.627	1398.129	8/7/00	16:26

Profile 3b (Demorest Glacier at Floprock Peak) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	496,374.336	6,506,824.832	1237.227	8/7/00	12:45
2	495,883.948	6,506,762.717	1231.053	8/7/00	12:39
3	495,387.506	6,506,702.532	1232.745	8/7/00	12:33
4	494,891.520	6,506,640.850	1229.062	8/7/00	12:21
5	494,394.521	6,506,582.798	1234.513	8/7/00	12:59
6	493,898.462	6,506,522.432	1241.417	8/7/00	13:04
7	493,402.626	6,506,463.297	1242.492	8/7/00	13:21
8	492,907.104	6,506,404.686	1289.946	8/7/00	13:37

Profile 4 (Taku Glacier at Camp 10) — Epoch 0					
Flag	**Easting (m)**	**Northing (m)**	**Height (m)**	**Date**	**Time**
1	487,744.641	6,503,055.278	1119.142	7/21/00	15:17
2	487,527.391	6,503,206.802	1125.929	7/21/00	15:25
3	487,601.453	6,502,925.681	1121.685	7/21/00	15:34
4	487,380.272	6,503,056.808	1124.695	7/21/00	15:39
5	487,454.603	6,502,792.514	1121.526	7/21/00	15:42
6	487,219.605	6,502,892.667	1121.841	7/21/00	15:47
7	487,267.496	6,502,622.713	1118.916	7/21/00	15:50
8	487,080.343	6,502,749.375	1120.945	7/21/00	15:59
9	487,090.435	6,502,461.283	1119.668	7/21/00	16:00
10	486,937.662	6,502,603.135	1120.701	7/21/00	16:09
11	486,957.167	6,502,340.004	1120.191	7/21/00	16:07
12	486,756.813	6,502,417.250	1120.473	7/21/00	16:17
13	486,718.794	6,502,123.233	1120.036	7/21/00	16:16
14	486,485.892	6,502,197.187	1122.050	7/21/00	16:31
15	486,487.030	6,501,913.672	1116.874	7/21/00	16:24
16	486,225.038	6,501,970.000	1121.363	7/21/00	16:43
17	486,195.841	6,501,649.783	1121.114	7/21/00	16:36
18	485,894.306	6,501,668.926	1127.294	7/21/00	16:56
19	485,918.533	6,501,397.909	1127.231	7/21/00	16:45
20	485,642.285	6,501,441.081	1133.361	7/21/00	17:16
21	485,639.038	6,501,144.252	1133.899	7/21/00	17:08
22	485,393.709	6,501,219.166	1137.790	7/21/00	17:27
23	485,399.943	6,500,927.511	1135.760	7/21/00	17:29
24	485,124.711	6,500,991.248	1138.108	7/21/00	17:37
25	485,112.234	6,500,666.685	1137.077	7/21/00	17:46
26	484,870.409	6,500,782.312	1139.831	7/21/00	17:50
27	484,830.951	6,500,413.161	1138.522	7/21/00	17:58
28	484,512.136	6,500,493.931	1140.008	7/21/00	18:09
29	484,572.857	6,500,179.127	1142.216	7/21/00	18:14
30	484,251.407	6,500,282.006	1141.624	7/21/00	18:24
31	484,323.815	6,499,953.101	1146.486	7/21/00	18:25

Profile 4 (Taku Glacier at Camp 10) — Epoch 1					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	487,744.704	6,503,055.239	1118.884	7/27/00	16:01
2	487,527.426	6,503,206.789	1125.707	7/27/00	11:41
3	487,601.573	6,502,925.579	1121.456	7/27/00	15:51
4	487,380.390	6,503,056.679	1124.481	7/27/00	11:48
5	487,454.953	6,502,792.193	1121.265	7/27/00	15:36
6	487,220.073	6,502,892.250	1121.560	7/27/00	11:55
7	487,268.400	6,502,621.833	1118.706	7/27/00	15:30
8	487,081.322	6,502,748.451	1120.700	7/27/00	11:59
9	487,092.098	6,502,459.747	1119.358	7/27/00	15:23
10	486,939.302	6,502,601.712	1120.435	7/27/00	12:04
11	486,959.293	6,502,338.061	1119.933	7/27/00	15:16
12	486,758.986	6,502,415.338	1120.215	7/27/00	12:10
13	486,721.381	6,502,121.012	1119.699	7/27/00	15:09
14	486,488.440	6,502,195.038	1121.745	7/27/00	12:17
15	486,489.794	6,501,911.350	1116.569	7/27/00	15:03
16	486,227.743	6,501,967.805	1121.010	7/27/00	12:24
17	486,198.719	6,501,647.498	1120.741	7/27/00	14:47
18	485,897.156	6,501,666.768	1126.851	7/27/00	12:37
19	485,921.458	6,501,395.681	1126.848	7/27/00	14:41
20	485,645.100	6,501,438.985	1133.007	7/27/00	12:45
21	485,641.853	6,501,142.131	1133.601	7/27/00	14:34
22	485,396.473	6,501,217.120	1137.343	7/27/00	12:53
23	485,402.606	6,500,925.557	1135.472	7/27/00	14:28
24	485,127.149	6,500,989.518	1137.785	7/27/00	13:01
25	485,114.352	6,500,665.238	1136.814	7/27/00	14:20
26	484,872.306	6,500,781.040	1139.580	7/27/00	13:09
27	484,832.100	6,500,412.440	1138.227	7/27/00	14:13
28	484,512.881	6,500,493.491	1139.682	7/27/00	13:17
29	484,573.238	6,500,179.010	1141.893	7/27/00	14:02
30	484,251.616	6,500,281.966	1141.368	7/27/00	13:25
31	484,323.982	6,499,953.172	1146.232	7/27/00	13:45

Profile 5 (Lower Southwest Branch) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	485,737.952	6,498,029.978	1059.882	07/25/00	15:41
2	485,856.881	6,497,874.008	1062.142	07/25/00	15:48
3	485,965.513	6,497,731.162	1065.434	07/25/00	15:54
4	486,107.229	6,497,545.288	1067.667	07/25/00	16:03
5	486,272.196	6,497,352.235	1067.642	07/25/00	16:13
6	486,448.953	6,497,148.188	1067.189	07/25/00	16:22
7	486,583.324	6,496,990.799	1070.327	07/25/00	16:35
8	486,691.161	6,496,865.899	1074.695	07/25/00	16:48
9	486,806.336	6,496,732.200	1078.422	07/25/00	17:07
10	486,901.862	6,496,619.562	1080.046	07/25/00	17:10
11	487,008.324	6,496,490.986	1081.330	07/25/00	17:16
12	487,117.383	6,496,357.579	1083.653	07/25/00	17:32

Profile 6 (Taku NW Point to Echo Mountain) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	478,980.592	6,505,811.780	1326.573	07/27/00	15:13
2	478,921.443	6,506,034.742	1328.355	07/27/00	15:06
3	478,861.342	6,506,256.904	1327.703	07/27/00	15:00
4	478,798.150	6,506,470.509	1327.438	07/27/00	14:55
5	478,770.741	6,506,588.023	1326.846	07/27/00	14:51
6	478,742.866	6,506,717.567	1325.551	07/27/00	14:48
7	478,690.363	6,506,936.263	1323.673	07/27/00	14:42
8	478,636.359	6,507,159.044	1324.666	07/27/00	13:01
9	478,581.684	6,507,384.036	1327.864	07/27/00	13:08
10	478,526.003	6,507,610.081	1331.684	07/27/00	13:16
11	478,471.791	6,507,835.238	1334.718	07/27/00	13:21
12	478,416.019	6,508,059.175	1336.650	07/27/00	13:32
13	478,358.076	6,508,285.739	1337.602	07/27/00	13:39
14	478,307.070	6,508,512.204	1338.146	07/27/00	13:52
15	478,255.066	6,508,738.860	1337.749	07/27/00	13:58
16	478,204.721	6,508,976.324	1336.690	07/27/00	14:28

Profile 7 (Camp 9 to Centurian Peak) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
3	488,875.659	6,511,059.355	1439.374	8/2/00	17:26
4	488,742.040	6,511,131.034	1430.735	8/2/00	17:22
5	488,521.033	6,511,249.372	1426.754	8/2/00	17:18
6	488,305.843	6,511,364.029	1427.080	8/2/00	17:12
7	488,075.317	6,511,486.307	1426.363	8/2/00	17:08
8	487,839.961	6,511,611.310	1424.861	8/2/00	17:04
9	487,614.218	6,511,731.638	1423.871	8/2/00	15:57
10	487,386.453	6,511,854.281	1416.704	8/2/00	16:01
11	487,147.471	6,511,982.438	1410.725	8/2/00	16:06
12	486,912.618	6,512,107.910	1415.225	8/2/00	16:11
13	486,677.873	6,512,231.596	1422.151	8/2/00	16:16
14	486,445.910	6,512,351.107	1418.868	8/2/00	16:20
15	486,214.478	6,512,478.141	1418.358	8/2/00	16:53
16	485,980.336	6,512,605.656	1426.337	8/2/00	16:49
17	485,760.265	6,512,725.742	1433.978	8/1/00	16:45
18	485,544.066	6,512,843.789	1441.668	8/2/00	16:40

Profile 8 (Blizzard Peak to Camp 8) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	490,903.240	6,522,005.100	1831.003	8/3/00	14:21
2	490,613.456	6,522,169.158	1819.359	8/3/00	14:13
3	490,366.106	6,522,305.901	1795.302	8/3/00	14:06
4	490,119.326	6,522,443.396	1789.801	8/3/00	14:00
5	489,884.964	6,522,574.454	1790.896	8/3/00	13:53
6	489,637.124	6,522,711.817	1794.511	8/3/00	13:47
7	489,366.385	6,522,858.974	1799.716	8/3/00	13:40
8	489,089.270	6,523,015.612	1803.064	8/3/00	13:34
9	488,765.875	6,523,197.564	1807.636	8/3/00	13:27
10	488,415.400	6,523,396.437	1813.749	8/3/00	13:20
11	488,105.706	6,523,570.923	1827.960	8/3/00	13:13
12	487,864.156	6,523,706.640	1849.749	8/3/00	13:04

Profile 9 (Upper Vaughan Lewis) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	485,620.478	6,524,358.103	1732.396	8/3/00	19:25
2	485,746.972	6,524,153.751	1733.406	8/3/00	19:20
3	485,830.003	6,523,948.214	1736.731	8/3/00	19:15
4	485,874.150	6,523,693.960	1741.389	8/3/00	19:10
5	485,877.200	6,523,472.686	1746.399	8/3/00	19:06
6	485,794.679	6,523,293.289	1751.007	8/3/00	19:01
7	485,670.153	6,523,112.897	1755.213	8/3/00	18:54
8	485,441.720	6,523,028.270	1766.610	8/3/00	18:45

Profile 9 (Upper Vaughan Lewis) — Epoch 1					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	485,620.119	6,524,357.844	1731.908	8/9/00	12:36
2	485,746.477	6,524,153.621	1733.029	8/9/00	12:49
3	485,829.358	6,523,948.448	1736.328	8/9/00	12:55
4	485,873.592	6,523,694.260	1740.939	8/9/00	13:01
5	485,876.722	6,523,473.128	1745.978	8/9/00	13:06
6	485,794.210	6,523,293.717	1750.600	8/9/00	13:12
7	485,669.974	6,523,113.436	1754.787	8/9/00	13:18
8	485,441.715	6,523,028.577	1766.012	8/9/00	13:26

Profile 11 (Llewellyn Glacier at F-10) — Epoch 0					
Flag	**Easting (m)**	**Northing (m)**	**Height (m)**	**Date**	**Time**
1	492,977.110	6,535,458.594	1751.128	8/4/00	18:25
2	493,256.371	6,535,472.677	1734.408	8/4/00	18:18
3	493,534.591	6,535,487.524	1727.308	8/4/00	18:15
4	493,816.887	6,535,501.916	1725.883	8/4/00	18:11
5	494,092.947	6,535,516.789	1727.931	8/4/00	18:08
6	494,367.104	6,535,531.364	1728.677	8/4/00	18:05
7	494,645.663	6,535,546.198	1726.411	8/4/00	18:00
8	494,926.283	6,535,561.191	1724.629	8/4/00	17:56
9	495,206.411	6,535,576.369	1725.294	8/4/00	17:52
10	495,494.497	6,535,592.075	1727.020	8/4/00	17:47
11	495,767.868	6,535,607.068	1728.232	8/4/00	17:43
12	496,061.447	6,535,622.917	1726.846	8/4/00	17:34

Profile 11 (Llewellyn Glacier at F-10) — Epoch 1					
Flag	**Easting (m)**	**Northing (m)**	**Height (m)**	**Date**	**Time**
1	492,977.326	6,535,458.975	1750.947	8/8/00	11:02
2	493,256.663	6,535,473.327	1734.170	8/8/00	11:05
3	493,534.860	6,535,488.366	1727.109	8/8/00	11:07
4	493,817.180	6,535,502.858	1725.724	8/8/00	11:09
5	494,093.242	6,535,517.798	1727.729	8/8/00	11:11
6	494,367.382	6,535,532.394	1728.470	8/8/00	11:13
7	494,645.937	6,535,547.242	1726.205	8/8/00	11:15
8	494,926.491	6,535,562.271	1724.443	8/8/00	11:17
9	495,206.588	6,535,577.380	1725.087	8/8/00	11:19
10	495,494.619	6,535,592.999	1726.850	8/8/00	11:21
11	495,767.923	6,535,607.904	1728.073	8/8/00	11:22
12	496,061.485	6,535,623.565	1726.729	8/8/00	11:24

GILKEY TRENCH PROFILES — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
D1 1995	482,609.782	6,524,214.721	1097.905	8/12/95	14:34
D2 1995	482,598.631	6,524,318.084	1104.775	8/12/95	14:13
D5 1995	482,180.283	6,524,157.490	1097.565	8/12/95	17:11
D6 1995	482,134.770	6,524,373.560	1100.472	8/12/95	17:37
D7 1995	481,881.396	6,524,226.470	1079.321	8/12/95	15:57
D8 1995	481,955.716	6,524,371.418	1094.566	8/12/95	16:39
D9 1995	481,772.240	6,524,314.892	1077.083	8/12/95	16:07
E2 1995	482,993.542	6,524,326.650	1106.680	8/12/95	13:24
E3 1995	482,914.735	6,524,267.174	1105.832	8/12/95	12:28

GILKEY TRENCH PROFILES — EPOCH 1					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
D1 2000	482,609.786	6,524,214.545	1085.722	8/12/00	13:26
D2 2000	482,598.337	6,524,318.075	1092.365	8/12/00	13:22
D5 2000	482,180.334	6,524,157.607	1085.107	8/12/00	12:27
D6 2000	482,135.082	6,524,374.294	1087.727	8/12/00	12:35
D7 2000	481,881.321	6,524,226.542	1066.057	8/12/00	12:45
D8 2000	481,954.279	6,524,370.798	1079.861	8/12/00	12:54
D9 2000	481,769.689	6,524,314.722	1063.183	8/12/00	13:01
E2 2000	482,993.614	6,524,326.802	1094.113	8/12/00	13:49
E3 2000	482,914.756	6,524,266.767	1092.045	8/12/00	13:57

VAUGHAN LEWIS OGIVES — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
Ogive0_01	482,992.231	6,523,865.694	1105.548	8/11/00	11:47
Ogive0_02	482,909.931	6,523,560.586	1121.163	8/11/00	12:15
Ogive0_03	483,012.288	6,523,355.706	1123.544	8/11/00	13:40
Ogive1_01	482,900.638	6,523,923.719	1094.141	8/11/00	15:15
Ogive1_02	482,761.423	6,523,738.124	1093.510	8/11/00	14:37
Ogive1_03	482,795.124	6,523,515.234	1108.358	8/11/00	14:25
Ogive1_04	482,965.947	6,523,286.580	1110.160	8/11/00	14:03
Ogive1_05	482,998.308	6,523,258.960	1111.710	8/11/00	13:53
Ogive2_01	482,849.539	6,523,961.710	1085.846	8/11/00	16:11
Ogive2_02	482,733.351	6,523,895.851	1089.278	8/11/00	16:22
Ogive2_03	482,618.138	6,523,655.665	1087.287	8/11/00	16:30
Ogive2_04	482,657.233	6,523,525.777	1095.171	8/11/00	16:37
Ogive2_05	482,790.000	6,523,369.056	1102.752	8/11/00	16:51
Ogive3_01	482,600.894	6,523,892.817	1089.517	8/11/00	19:03
Ogive3_02	482,502.987	6,523,773.834	1087.680	8/11/00	18:54
Ogive3_03	482,479.471	6,523,641.034	1078.482	8/11/00	17:14
Ogive3_04	482,619.362	6,523,450.776	1097.722	8/11/00	17:07
Ogive3_05	482,772.669	6,523,336.078	1101.229	8/11/00	16:57
Ogive4_01	482,371.545	6,523,778.620	1084.375	8/11/00	18:44
Ogive4_02	482,340.868	6,523,614.870	1070.829	8/11/00	17:25
Ogive4_03	482,482.234	6,523,457.805	1091.073	8/11/00	17:39
Ogive5_01	482,293.350	6,523,773.729	1081.258	8/11/00	18:33
Ogive5_02	482,178.085	6,523,573.495	1060.894	8/11/00	18:07
Ogive5_03	482,380.089	6,523,445.883	1086.368	8/11/00	17:53
Ogive6	482,003.619	6,523,496.678	1047.555	8/11/00	18:14
Ogive7 *	481,818.754	6,523,432.775	1036.533	8/11/00	19:35
Ogive8 *	481,666.739	6,523,362.670	1029.829	8/11/00	19:41
Ogive9 *	481,510.224	6,523,299.477	1023.270	8/11/00	19:47

* Mean accuracy of coordinate determination at Epoch 0 is approximately 74 cm. Due to this and limited elapsed time between survey epochs, velocity and height change are not calculated for these flags.

Vaughan Lewis Ogives — Epoch 1					
Flag	**Easting (m)**	**Northing (m)**	**Height (m)**	**Date**	**Time**
Ogive0_01	482,991.828	6,523,865.866	1105.469	8/12/00	14:38
Ogive0_02	482,909.467	6,523,560.707	1121.020	8/12/00	14:22
Ogive0_03	483,011.860	6,523,355.744	1122.519	8/12/00	13:57
Ogive1_01	482,900.345	6,523,923.787	1094.090	8/12/00	16:07
Ogive1_02	482,761.026	6,523,738.257	1093.396	8/12/00	16:20
Ogive1_03	482,794.717	6,523,515.328	1108.294	8/12/00	16:30
Ogive1_04	482,965.663	6,523,286.637	1110.136	8/12/00	13:31
Ogive1_05	482,998.045	6,523,258.981	1111.623	8/12/00	13:40
Ogive2_01	482,849.323	6,523,961.745	1085.843	8/12/00	14:42
Ogive2_02	482,733.046	6,523,895.865	1089.221	8/12/00	16:05
Ogive2_03	482,617.757	6,523,655.694	1087.223	8/12/00	17:05
Ogive2_04	482,656.895	6,523,525.822	1095.145	8/12/00	16:55
Ogive2_05	482,789.752	6,523,369.138	1102.681	8/12/00	12:54
Ogive3_01	482,600.615	6,523,892.799	1089.490	8/12/00	16:18
Ogive3_02	482,502.671	6,523,773.805	1087.652	8/12/00	16:27
Ogive3_03	482,479.077	6,523,641.003	1078.446	8/12/00	17:14
Ogive3_04	482,619.027	6,523,450.840	1097.643	8/12/00	17:22
Ogive3_05	482,772.438	6,523,336.170	1101.211	8/12/00	12:25
Ogive4_01	482,371.168	6,523,778.492	1084.301	8/12/00	16:33
Ogive4_02	482,340.479	6,523,614.751	1070.744	8/12/00	17:45
Ogive4_03	482,481.915	6,523,457.816	1091.012	8/12/00	17:40
Ogive5_01	482,292.959	6,523,773.579	1081.206	8/12/00	16:38
Ogive5_02	482,177.674	6,523,573.337	1060.840	8/12/00	17:56
Ogive5_03	482,379.726	6,523,445.914	1086.362	8/12/00	17:50
Ogive6	482,003.193	6,523,496.496	1047.483	8/12/00	18:03
Ogive7 *	481,818.475	6,523,432.088	1037.160	8/12/00	16:54
Ogive8 *	481,666.443	6,523,361.968	1029.663	8/12/00	17:00
Ogive9 *	481,509.960	6,523,298.897	1023.202	8/12/00	17:08

* Mean accuracy of coordinate determination at Epoch 0 is approximately 74 cm. Due to this and limited elapsed time between survey epochs, velocity and height change are not calculated for these flags.

Longitudinal A (Taku/Matthes/Llewellyn Glaciers) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
13	492,067.505	6,491,597.155	800.881	7/24/00	15:18
14	491,894.931	6,492,066.469	818.622	7/24/00	15:08
15	491,772.137	6,492,552.248	836.003	7/24/00	14:59
16	491,710.151	6,493,049.963	846.349	7/24/00	14:49
17	491,688.162	6,493,551.631	859.237	7/24/00	14:41
18	491,658.095	6,494,052.015	876.094	7/24/00	14:33
19	491,606.567	6,494,547.050	888.719	7/24/00	14:26
20	491,525.279	6,495,040.752	898.494	7/24/00	13:52
21	491,428.994	6,495,531.899	913.023	7/24/00	13:13
22	491,308.745	6,496,018.088	930.617	7/24/00	13:05
23	491,146.427	6,496,491.465	942.020	7/24/00	12:55
24	490,889.643	6,496,929.661	948.366	7/24/00	12:48
25	490,565.863	6,497,307.474	960.921	7/24/00	12:23
26	490,194.845	6,497,645.215	978.856	7/24/00	12:16
27	489,812.766	6,497,965.343	994.291	7/24/00	12:08
28	489,618.925	6,498,128.411	1000.526	7/24/00	12:01
29	489,235.733	6,498,449.703	1012.463	7/24/00	11:52
30	488,848.819	6,498,768.769	1027.560	7/24/00	11:44
31	488,471.511	6,499,100.979	1040.575	7/24/00	11:38
32	488,098.729	6,499,436.454	1050.744	7/24/00	11:28
33	487,723.500	6,499,767.356	1062.214	7/24/00	11:18
34	487,348.976	6,500,101.061	1075.830	7/24/00	11:05
35	486,994.944	6,500,454.829	1088.542	7/24/00	10:59
36	486,652.220	6,500,816.249	1102.067	7/24/00	10:49
37	486,312.290	6,501,181.035	1115.443	7/24/00	10:42
38	485,985.215	6,501,559.654	1125.134	7/23/00	16:30
39	485,675.686	6,501,949.495	1131.413	7/23/00	16:41
40	485,364.669	6,502,341.871	1139.389	7/23/00	16:49
41	485,064.869	6,502,746.289	1149.291	7/23/00	17:14
42	484,784.061	6,503,160.541	1162.914	7/23/00	17:20
43	484,537.377	6,503,595.952	1181.254	7/23/00	17:25
44	484,289.830	6,503,967.560	1198.185	7/23/00	17:29
45	484,084.717	6,504,427.269	1210.402	7/23/00	17:34
46	483,954.742	6,504,908.128	1217.850	7/23/00	17:39
47	483,909.201	6,505,405.730	1222.502	7/23/00	17:44
48	483,901.303	6,505,903.712	1226.961	7/23/00	17:49
49	483,952.294	6,506,402.020	1238.145	7/23/00	17:54
50	484,055.120	6,506,889.053	1259.470	7/23/00	18:00
51	484,277.433	6,507,336.758	1278.400	7/23/00	18:04
52	484,569.189	6,507,741.530	1296.455	7/23/00	18:11

Longitudinal A (Taku/Matthes/Llewellyn Glaciers) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
53	484,851.957	6,508,149.898	1312.771	7/23/00	18:16
54	485,109.277	6,508,581.730	1321.900	8/1/00	13:01
55	485,355.637	6,509,017.441	1332.483	8/1/00	13:08
56	485,598.617	6,509,453.644	1347.129	8/1/00	13:16
57	485,844.131	6,509,890.218	1359.913	8/1/00	13:21
58	486,093.513	6,510,323.271	1368.479	8/1/00	13:26
59	486,352.907	6,510,750.427	1376.313	8/1/00	13:31
60	486,622.389	6,511,171.913	1388.092	8/1/00	13:39
61	486,908.001	6,511,581.519	1400.926	8/1/00	13:46
62	487,210.393	6,511,979.317	1411.900	8/1/00	13:54
63	487,520.342	6,512,370.226	1427.537	8/1/00	13:58
64	487,829.038	6,512,765.221	1444.346	8/1/00	14:03
65	488,126.819	6,513,166.644	1458.051	8/1/00	14:09
66	488,414.357	6,513,574.432	1468.833	8/1/00	14:14
67	488,676.898	6,513,996.906	1478.047	8/1/00	14:20
68	488,896.143	6,514,444.654	1490.724	8/1/00	14:25
69	489,045.087	6,514,919.248	1503.940	8/1/00	14:29
70	489,154.848	6,515,405.845	1515.973	8/1/00	14:37
71	489,161.597	6,515,900.987	1524.806	8/1/00	14:42
72	489,071.933	6,516,388.642	1538.835	8/1/00	14:47
73	488,909.586	6,516,860.487	1551.640	8/1/00	14:52
74	488,844.779	6,517,355.698	1581.444	8/1/00	14:58
75	488,837.992	6,517,852.697	1624.342	8/1/00	15:07
76	488,853.469	6,518,348.032	1646.841	8/2/00	13:37
77	488,887.163	6,518,845.247	1660.186	8/2/00	13:42
78	488,939.380	6,519,340.688	1686.748	8/2/00	13:47
79	488,996.369	6,519,837.456	1709.698	8/2/00	13:53
80	489,057.079	6,520,334.580	1727.189	8/2/00	13:58
81	489,152.258	6,520,825.167	1742.506	8/2/00	14:02
82	489,247.290	6,521,315.808	1756.967	8/2/00	14:07
83	489,358.632	6,521,802.263	1770.200	8/2/00	14:12
84	489,506.497	6,522,278.069	1782.154	8/2/00	14:16
85	489,654.329	6,522,754.050	1795.718	8/2/00	14:20
86	489,809.014	6,523,229.772	1809.706	8/2/00	14:26
87	489,979.219	6,523,699.592	1823.078	8/2/00	14:31
88	490,149.204	6,524,168.481	1833.907	8/2/00	14:39
89	490,319.305	6,524,637.905	1843.771	8/2/00	14:43
90	490,495.797	6,525,102.945	1853.091	8/2/00	14:51
91	490,706.702	6,525,556.310	1862.274	8/2/00	15:00
92	490,917.297	6,526,008.805	1869.824	8/2/00	15:04
93	491,127.741	6,526,461.178	1873.053	8/2/00	15:09

Longitudinal A (Taku/Matthes/Llewellyn Glaciers) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
94	491,338.071	6,526,913.034	1874.305	8/2/00	15:13
95	491,548.575	6,527,365.370	1872.893	8/2/00	15:19
96	491,759.587	6,527,818.787	1867.399	8/2/00	15:24
97	491,966.020	6,528,271.439	1862.697	8/2/00	15:30
98	492,172.669	6,528,724.384	1859.008	8/2/00	15:34
99	492,387.899	6,529,173.724	1854.935	8/2/00	15:38
100	492,601.931	6,529,625.694	1848.612	8/2/00	15:46
101	492,814.260	6,530,075.806	1841.155	8/2/00	15:52
102	493,026.946	6,530,527.122	1834.272	8/2/00	15:57
103	493,214.175	6,530,989.989	1825.734	8/3/00	17:38
104	493,394.103	6,531,456.003	1814.600	8/3/00	17:32
105	493,567.480	6,531,924.193	1804.428	8/3/00	17:24
106	493,730.791	6,532,395.013	1796.450	8/3/00	17:15
107	493,894.656	6,532,868.862	1785.535	8/3/00	16:48
108	494,017.907	6,533,351.545	1774.178	8/3/00	16:41
109	494,140.639	6,533,836.329	1766.481	8/3/00	15:44
110	494,263.596	6,534,319.309	1756.134	8/4/00	11:26
111	494,386.261	6,534,801.916	1744.568	8/4/00	13:37
112	494,514.951	6,535,284.678	1733.306	8/4/00	13:42
113	494,639.579	6,535,767.674	1720.881	8/4/00	13:46
114	494,744.138	6,536,255.397	1704.441	8/4/00	13:50
115	494,848.735	6,536,743.917	1689.168	8/4/00	14:46
116	494,952.862	6,537,229.597	1681.791	8/4/00	14:51
117	495,045.541	6,537,721.342	1673.392	8/4/00	14:55
118	495,109.417	6,538,214.265	1660.754	8/4/00	14:59
119	495,173.360	6,538,708.842	1646.469	8/4/00	15:04
120	495,237.152	6,539,201.906	1633.138	8/4/00	15:09
121	495,301.263	6,539,697.346	1618.862	8/4/00	15:14
122	495,380.842	6,540,179.195	1604.952	8/4/00	15:21

Longitudinal A (Taku/Matthes/Llewellyn Glaciers) — Epoch 1					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
13	492,068.744	6,491,592.789	800.429	7/29/00	11:30
14	491,896.178	6,492,062.189	818.142	7/29/00	11:27
15	491,773.572	6,492,548.043	835.547	7/29/00	11:21
16	491,711.574	6,493,045.805	845.876	7/29/00	11:17
17	491,689.271	6,493,547.469	858.680	7/29/00	11:15
18	491,658.930	6,494,047.850	875.610	7/29/00	11:12
19	491,607.304	6,494,542.911	888.286	7/29/00	11:09
20	491,526.093	6,495,036.625	898.051	7/29/00	11:06
21	491,430.012	6,495,527.828	912.403	7/29/00	11:02
22	491,309.771	6,496,014.049	930.132	7/29/00	10:59
23	491,147.499	6,496,487.421	941.605	7/29/00	10:55
86	489,808.690	6,523,228.986	1809.376	8/8/00	15:11
87	489,978.911	6,523,698.896	1822.819	8/8/00	15:08
88	490,148.931	6,524,167.963	1833.587	8/8/00	15:06
89	490,319.115	6,524,637.391	1843.393	8/8/00	15:04
90	490,495.684	6,525,102.529	1852.699	8/8/00	15:01
91	490,706.651	6,525,555.993	1861.910	8/8/00	14:59
92	490,917.404	6,526,008.595	1869.456	8/8/00	14:56
93	491,128.033	6,526,461.109	1872.655	8/8/00	14:53
94	491,338.475	6,526,913.060	1873.940	8/8/00	14:50
95	491,549.016	6,527,365.485	1872.379	8/8/00	12:44
96	491,760.005	6,527,818.929	1866.924	8/8/00	12:41
97	491,966.397	6,528,271.624	1862.181	8/8/00	12:39
98	492,173.002	6,528,724.617	1858.516	8/8/00	12:36
99	492,388.184	6,529,174.056	1854.460	8/8/00	12:33
100	492,602.160	6,529,626.070	1848.113	8/8/00	12:30
101	492,814.441	6,530,076.249	1840.634	8/8/00	12:28
102	493,027.141	6,530,527.577	1833.818	8/8/00	12:26
103	493,214.360	6,530,990.369	1825.466	8/8/00	12:24
104	493,394.298	6,531,456.415	1814.327	8/8/00	12:22
105	493,567.702	6,531,924.648	1804.136	8/8/00	12:18
106	493,731.061	6,532,395.515	1796.171	8/8/00	12:16
107	493,894.988	6,532,869.458	1785.243	8/8/00	12:14
108	494,018.331	6,533,352.240	1773.910	8/8/00	12:12
109	494,141.159	6,533,837.237	1766.114	8/8/00	12:09
110	494,264.013	6,534,320.219	1755.867	8/8/00	12:03
111	494,386.625	6,534,802.965	1744.331	8/8/00	12:01
112	494,515.219	6,535,285.800	1733.079	8/8/00	11:59
113	494,639.794	6,535,768.800	1720.679	8/8/00	11:57
114	494,744.347	6,536,256.508	1704.239	8/8/00	11:54

Longitudinal A (Taku/Matthes/Llewellyn Glaciers) — Epoch 1					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
115	494,848.926	6,536,745.052	1688.994	8/8/00	11:52
116	494,953.060	6,537,230.791	1681.632	8/8/00	11:50
117	495,045.762	6,537,722.583	1673.212	8/8/00	11:48
118	495,109.647	6,538,215.565	1660.537	8/8/00	11:46
119	495,173.547	6,538,710.184	1646.234	8/8/00	11:44
120	495,237.301	6,539,203.297	1632.925	8/8/00	11:42
121	495,301.392	6,539,698.807	1618.633	8/8/00	11:39
122	495,380.935	6,540,180.745	1604.780	8/8/00	11:36

LONGITUDINAL B (DEMOREST GLACIER) — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	490,757.103	6,497,410.706	962.014	7/26/00	14:51
2	490,726.183	6,497,907.837	977.234	7/26/00	14:44
3	490,830.583	6,498,400.544	983.134	7/26/00	14:37
4	491,050.011	6,498,839.802	986.988	7/26/00	14:31
5	491,377.912	6,499,211.980	994.381	7/26/00	14:25
6	491,791.239	6,499,497.748	1002.484	7/26/00	14:18
7	492,235.337	6,499,729.936	1012.985	7/26/00	14:13
8	492,684.865	6,499,945.322	1024.742	7/26/00	14:07
9	493,118.070	6,500,194.964	1039.468	7/26/00	14:00
10	493,564.984	6,500,418.690	1051.084	7/25/00	16:25
11	493,989.911	6,500,678.067	1059.260	7/25/00	16:34
12	494,413.136	6,500,940.186	1068.852	7/25/00	16:40
13	494,810.873	6,501,238.713	1076.795	7/25/00	16:47
14	495,165.692	6,501,591.505	1087.811	7/25/00	16:53
15	495,483.962	6,501,968.739	1103.186	7/25/00	16:59
16	495,732.478	6,502,400.975	1118.895	7/25/00	17:06
17	495,894.562	6,502,875.319	1127.771	7/25/00	17:12
18	495,987.661	6,503,365.980	1144.086	7/25/00	17:17
19	495,989.811	6,503,864.472	1169.377	7/25/00	17:22
20	495,941.016	6,504,359.722	1180.530	8/7/00	14:39
21	495,864.540	6,504,850.028	1187.749	8/7/00	14:26
22	495,718.580	6,505,325.807	1198.550	8/7/00	14:22
23	495,497.175	6,505,774.184	1209.474	8/7/00	14:02
24	495,249.044	6,506,208.748	1220.477	8/7/00	13:59
25	495,037.497	6,506,662.202	1230.359	8/7/00	13:54
26	494,854.724	6,507,127.124	1240.323	8/7/00	14:49
27	494,689.994	6,507,599.940	1254.781	8/7/00	14:57
28	494,530.332	6,508,074.966	1265.142	8/7/00	15:01
29	494,390.532	6,508,553.577	1266.717	8/7/00	15:05
30	494,281.877	6,509,041.105	1287.779	8/7/00	15:08
31	494,193.323	6,509,530.006	1311.502	8/7/00	15:11
32	494,177.361	6,510,029.045	1331.737	8/7/00	15:14
33	494,192.232	6,510,525.661	1345.157	8/7/00	15:18
34	494,282.627	6,511,013.648	1352.155	8/7/00	15:34

Longitudinal B (Demorest Glacier) — Epoch 1					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
10	493,563.997	6,500,418.298	1050.738	7/29/00	14:18
11	493,988.949	6,500,677.606	1058.882	7/29/00	14:22
13	494,809.982	6,501,238.022	1076.431	7/29/00	14:51
14	495,164.866	6,501,590.630	1087.496	7/29/00	14:58
15	495,483.349	6,501,967.662	1102.853	7/29/00	15:03
16	495,732.207	6,502,399.703	1118.596	7/29/00	15:06
17	495,894.591	6,502,873.968	1127.430	7/29/00	15:10
18	495,987.809	6,503,364.684	1143.850	7/29/00	15:13
19	495,990.004	6,503,863.175	1169.058	7/29/00	15:20

* Flag 12 was not resurveyed due to being mistakenly removed after the first survey.

Longitudinal C (Taku SW Branch) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	489,154.058	6,498,308.220	1016.848	7/25/00	19:08
2	488,654.738	6,498,350.990	1029.777	7/25/00	19:00
3	488,156.578	6,498,317.840	1036.598	7/25/00	18:50
4	487,671.523	6,498,186.048	1041.318	7/25/00	18:37
5	487,235.574	6,497,941.746	1045.400	7/25/00	18:17
6	486,870.244	6,497,605.606	1054.170	7/25/00	17:58
7	486,548.989	6,497,226.224	1064.858	7/25/00	17:44
8	486,232.915	6,496,840.905	1074.437	7/26/00	15:46
9	485,914.721	6,496,458.387	1085.987	7/26/00	15:52
10	485,611.005	6,496,063.047	1096.240	7/26/00	15:57
11	485,307.302	6,495,666.734	1111.262	7/26/00	16:09
12	485,006.607	6,495,264.263	1125.509	7/26/00	16:14
13	484,718.019	6,494,857.148	1133.712	7/26/00	16:18
14	484,440.763	6,494,442.695	1144.815	7/26/00	16:24
15	484,156.598	6,494,031.909	1158.749	7/26/00	16:28
16	483,873.116	6,493,619.062	1167.928	7/26/00	16:34

LONGITUDINAL D (TAKU NORTHWEST BRANCH) — EPOCH 0					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	483,965.084	6,504,345.776	1207.908	7/27/00	11:43
2	483,618.152	6,504,704.897	1212.898	7/27/00	11:50
3	483,260.596	6,505,053.434	1220.124	7/27/00	11:56
4	482,878.290	6,505,374.440	1231.018	7/27/00	12:02
5	482,485.927	6,505,683.185	1241.568	7/27/00	12:07
6	482,084.971	6,505,979.727	1250.644	7/27/00	12:13
7	481,673.031	6,506,262.440	1256.515	7/27/00	12:19
8	481,252.158	6,506,529.904	1267.624	7/27/00	12:25
9	480,838.365	6,506,756.734	1278.980	7/27/00	12:30
10	480,392.761	6,506,982.143	1288.241	7/27/00	12:36
11	479,914.519	6,507,132.106	1297.504	7/27/00	12:42
12	479,427.073	6,507,236.652	1308.303	7/27/00	12:47
13	478,939.219	6,507,330.886	1320.464	7/27/00	12:53
14	478,448.918	6,507,421.334	1330.410	7/27/00	17:09
15	477,957.516	6,507,506.087	1337.880	7/27/00	17:14
16	477,470.936	6,507,579.946	1347.349	7/27/00	17:19

LONGITUDINAL D (TAKU NORTHWEST BRANCH) — EPOCH 1					
FLAG	EASTING (M)	NORTHING (M)	HEIGHT (M)	DATE	TIME
1	483,966.947	6,504,341.011	1207.237	8/6/00	11:08
2	483,619.863	6,504,700.241	1212.148	8/6/00	11:14
3	483,262.329	6,505,048.901	1219.395	8/6/00	11:23
4	482,880.139	6,505,370.239	1230.327	8/6/00	11:26
5	482,488.004	6,505,679.569	1240.946	8/6/00	11:29
6	482,087.250	6,505,976.964	1249.999	8/6/00	11:32
7	481,675.578	6,506,260.357	1255.828	8/6/00	11:35
8	481,254.918	6,506,528.238	1266.926	8/6/00	11:38
9	480,841.217	6,506,755.398	1278.285	8/6/00	11:42
10	480,395.700	6,506,981.101	1287.594	8/6/00	11:45
11	479,917.440	6,507,131.363	1296.861	8/6/00	11:47
12	479,430.057	6,507,236.197	1307.692	8/6/00	11:54
13	478,942.137	6,507,330.524	1319.885	8/6/00	11:58
14	478,451.763	6,507,420.990	1329.832	8/6/00	12:04
15	477,960.330	6,507,505.836	1337.349	8/6/00	12:11
16	477,473.730	6,507,579.921	1346.756	8/6/00	12:18

Longitudinal F (Taku West Branch) — Epoch 0					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	476,975.680	6,507,646.411	1356.967	7/27/00	17:26
2	476,481.476	6,507,690.457	1364.858	7/27/00	17:31
3	475,982.403	6,507,716.560	1373.004	7/27/00	17:39
4	475,483.247	6,507,736.384	1379.042	7/27/00	17:44
5	474,982.990	6,507,742.486	1390.185	7/27/00	17:48
6	474,484.912	6,507,748.703	1414.903	7/27/00	17:53
7	473,985.773	6,507,754.912	1430.420	7/27/00	17:58
8	473,486.580	6,507,758.805	1438.942	7/27/00	18:03
9	472,988.557	6,507,762.957	1444.939	7/30/00	13:46
10	472,488.340	6,507,767.684	1453.721	7/30/00	14:00
11	471,991.281	6,507,751.967	1462.216	7/30/00	14:06
12	471,492.889	6,507,736.858	1472.099	7/30/00	14:13
13	470,998.802	6,507,664.030	1482.472	7/30/00	14:21
14	470,544.151	6,507,456.641	1490.929	7/30/00	14:25
15	470,145.665	6,507,155.981	1499.098	7/30/00	14:30
16	469,813.113	6,506,784.818	1508.864	7/30/00	14:34
17	469,606.989	6,506,328.667	1515.225	7/30/00	14:41
18	469,467.391	6,505,847.339	1521.573	7/30/00	14:59

Longitudinal F (Taku West Branch) — Epoch 1					
Flag	Easting (m)	Northing (m)	Height (m)	Date	Time
1	476,978.392	6,507,646.676	1356.448	8/6/00	12:22
2	476,483.964	6,507,690.952	1364.426	8/6/00	12:26
3	475,984.714	6,507,717.190	1372.451	8/6/00	12:30
4	475,485.286	6,507,736.991	1378.506	8/6/00	13:11
5	474,984.753	6,507,742.945	1389.685	8/6/00	13:17
6	474,486.609	6,507,748.681	1414.396	8/6/00	13:22
7	473,987.127	6,507,754.495	1429.905	8/6/00	13:28
8	473,487.782	6,507,758.314	1438.413	8/6/00	13:31
9	472,989.426	6,507,762.690	1444.538	8/6/00	13:35
10	472,489.216	6,507,767.537	1453.325	8/6/00	13:39
11	471,992.124	6,507,751.954	1461.803	8/6/00	13:43
12	471,493.812	6,507,736.945	1471.640	8/6/00	13:46
13	470,999.536	6,507,664.281	1482.105	8/6/00	13:49
14	470,544.781	6,507,457.038	1490.528	8/6/00	13:53
15	470,146.169	6,507,156.472	1498.702	8/6/00	14:00
16	469,813.542	6,506,785.304	1508.455	8/6/00	14:05

* Flags 17 and 18 were not surveyed at Epoch 1 due to atmospheric conditions, which prevented the establishment of a radio link between the base and rover systems.

	Test Pits — Epoch 0			
	Test Pit ?	**Test Pit ?**	**Test Pit K**	**Test Pit L**
Location	Flag B19 of Demorest Longitudinal	Matthes/Llewellyn Divide	Camp 9 Junction	Basin of Storm Range at C-18
Latitude	58° 39' 05.7" N	58° 51' 14.7" N	58° 43' 07.9" N	58° 50' 20.4" N
Longitude	134° 04' 07.9" W	134° 10' 20.6" W	134° 12' 57.9" W	134° 14' 39.2" W
JIRP Easting	496,002.278	490,050.016	487,479.471	485,897.804
JIRP Northing	6,503,860.272	6,526,427.675	6,511,372.446	6,524,760.413
Date Measured	8/7/00	8/8/00	8/7/00	8/7/00

Appendix 3
Surface Movement Vectors

Profile 2 (Taku Glacier at Goat Ridge) July 25, 2000 ? July 29, 2000							
Flag	Flag Distances		Flag Movement			Surface Height Change	
	Flag to Flag (m)	Sum (m)	Total (m)	Daily (m)	Bearing (gon)	Total (cm)	Daily (cm)
1	—	0.000	2.160	0.557	181.1486	-0.167	-4.29
2	210.915	210.915	2.681	0.690	182.4232	-0.259	-6.67
3	248.401	459.317	3.136	0.806	183.2101	-0.268	-6.88
4	229.773	689.089	3.346	0.860	182.2178	-0.281	-7.21
5	195.630	884.719	3.535	0.908	181.9245	-0.262	-6.72
6	275.724	1160.444	3.679	0.927	181.8253	-0.334	-8.40
7	350.638	1511.081	3.632	0.917	181.1976	-0.444	-11.23
8	260.118	1771.199	3.597	0.903	181.1625	-0.411	-10.33
9	138.513	1909.712	3.546	0.893	181.3205	-0.494	-12.45
10	159.304	2069.016	3.385	0.852	180.4332	-0.419	-10.55
11	232.538	2301.554	2.928	0.739	178.1703	-0.359	-9.06
Mean	**230.155**	**—**	**3.239**	**0.823**	**181.3667**	**-0.336**	**-8.53**

Profile 4 — Downglacier Line (Taku Glacier at Camp 10) July 21, 2000 ? July 27, 2000							
Flag	**Flag Distances**		**Flag Movement**			**Surface Height Change**	
	Flag to Flag (m)	**Sum (m)**	**Total (m)**	**Daily (m)**	**Bearing (gon)**	**Total (cm)**	**Daily (cm)**
1	—	0.000	0.075	0.012	135.1641	-0.258	-4.28
3	193.127	193.127	0.158	0.026	145.0645	-0.229	-3.81
5	198.238	391.365	0.475	0.079	147.2997	-0.261	-4.35
7	252.669	644.034	1.262	0.211	149.1295	-0.210	-3.51
9	239.604	883.638	2.263	0.379	147.4814	-0.310	-5.19
11	180.191	1063.830	2.881	0.483	147.1361	-0.258	-4.33
13	322.197	1386.027	3.409	0.573	145.1573	-0.337	-5.66
15	312.459	1698.486	3.610	0.607	144.4831	-0.304	-5.12
17	392.974	2091.460	3.675	0.620	142.7205	-0.373	-6.29
19	374.620	2466.080	3.677	0.622	141.4395	-0.383	-6.48
21	377.438	2843.518	3.525	0.598	141.0977	-0.298	-5.05
23	322.711	3166.229	3.303	0.562	140.3171	-0.287	-4.89
25	388.338	3554.568	2.565	0.438	138.1686	-0.263	-4.49
27	378.675	3933.243	1.356	0.232	135.6760	-0.295	-5.05
29	348.402	4281.645	0.399	0.068	119.0594	-0.323	-5.54
31	336.318	4617.964	0.181	0.031	74.3530	-0.254	-4.37
Mean	**307.864**	**—**	**2.051**	**0.346**	**137.1092**	**-0.290**	**-4.90**

Profile 4 — Upglacier Line (Taku Glacier at Camp 10) July 21, 2000 ? July 27, 2000							
Flag	**Flag Distances**		**Flag Movement**			**Surface Height Change**	
	Flag to Flag (m)	**Sum (m)**	**Total (m)**	**Daily (m)**	**Bearing (gon)**	**Total (cm)**	**Daily (cm)**
2	—	0.000	0.037	0.006	123.1411	-0.222	-3.81
4	210.101	210.101	0.175	0.030	152.8287	-0.214	-3.67
6	229.687	439.788	0.627	0.107	146.3741	-0.281	-4.81
8	199.816	639.604	1.346	0.231	148.1606	-0.244	-4.19
10	204.314	843.917	2.170	0.372	145.4931	-0.266	-4.56
12	259.345	1103.262	2.894	0.497	145.9208	-0.258	-4.42
14	349.035	1452.298	3.333	0.572	144.6148	-0.305	-5.23
16	345.917	1798.215	3.484	0.599	143.4085	-0.353	-6.07
18	447.247	2245.462	3.575	0.614	141.2500	-0.443	-7.61
20	339.746	2585.208	3.509	0.604	140.7438	-0.354	-6.09
22	333.221	2918.429	3.438	0.592	140.5718	-0.447	-7.70
24	352.571	3271.000	2.989	0.515	139.3004	-0.323	-5.56
26	329.126	3600.126	2.284	0.393	137.6267	-0.252	-4.33
28	459.917	4060.042	0.864	0.149	133.9798	-0.326	-5.62
30	335.994	4396.036	0.212	0.037	112.0780	-0.256	-4.42
Mean	**314.003**	**—**	**2.063**	**0.355**	**139.6995**	**-0.303**	**-5.21**

Profile 9 (Upper Vaughan Lewis Glacier) August 3, 2000 ? August 9, 2000							
Flag	Flag Distances		Flag Movement			Surface Height Change	
	Flag to Flag (m)	Sum (m)	Total (m)	Daily (m)	Bearing (gon)	Total (cm)	Daily (cm)
1	—	0.000	0.443	0.077	260.2931	-0.489	-8.55
2	240.333	240.333	0.511	0.089	283.6069	-0.378	-6.59
3	221.675	462.009	0.686	0.120	322.1804	-0.403	-7.03
4	258.058	720.067	0.634	0.110	331.3800	-0.451	-7.85
5	221.295	941.362	0.651	0.113	347.5649	-0.421	-7.33
6	197.466	1138.828	0.635	0.110	347.0632	-0.407	-7.07
7	219.199	1358.027	0.568	0.099	379.5415	-0.425	-7.38
8	243.605	1601.632	0.307	0.053	398.9003	-0.598	-10.34
Mean	**228.805**	—	**0.554**	**0.096**	**333.8163**	**-0.447**	**-7.77**

Profile 11 (Llewellyn Glacier at F-10) August 4, 2000 ? August 8, 2000							
Flag	Flag Distances		Flag Movement			Surface Height Change	
	Flag to Flag (m)	Sum (m)	Total (m)	Daily (m)	Bearing (gon)	Total (cm)	Daily (cm)
1	—	0.000	0.438	0.119	32.8263	-0.181	-4.90
2	279.616	279.616	0.713	0.193	26.7991	-0.238	-6.43
3	278.616	558.232	0.884	0.239	19.6612	-0.199	-5.38
4	282.663	840.895	0.987	0.266	19.1918	-0.158	-4.27
5	276.460	1117.354	1.051	0.283	18.1333	-0.202	-5.44
6	274.544	1391.898	1.067	0.287	16.7691	-0.206	-5.55
7	278.954	1670.852	1.079	0.290	16.3199	-0.206	-5.54
8	281.020	1951.872	1.101	0.296	12.1219	-0.186	-5.01
9	280.539	2232.411	1.027	0.276	11.0456	-0.207	-5.55
10	288.514	2520.926	0.933	0.250	8.3569	-0.170	-4.54
11	273.782	2794.707	0.838	0.224	4.2050	-0.159	-4.25
12	294.006	3088.713	0.649	0.173	3.7313	-0.116	-3.11
Mean	**280.792**	—	**0.897**	**0.241**	**15.7635**	**-0.186**	**-5.00**

Vaughan Lewis Ogives (Base of Vaughan Lewis Icefall) August 11, 2000 ? August 12, 2000							
Flag	**Flag Distances**		**Flag Movement**			**Surface Height Change**	
	Flag to Flag (m)	**Sum (m)**	**Total (m)**	**Daily (m)**	**Bearing (gon)**	**Total (cm)**	**Daily (cm)**
Ogive0-1	—	0.000	0.438	0.391	325.8335	-0.079	-7.10
Ogive0-2	316.012	316.012	0.480	0.441	316.0976	-0.143	-13.10
Ogive0-3	229.026	545.038	0.430	0.425	305.6296	-1.025 [1]	-101.29 [1]
Ogive1-1	—	0.000	0.301	0.290	314.4210	-0.051	-4.88
Ogive1-2	232.005	232.005	0.418	0.390	320.5651	-0.113	-10.56
Ogive1-3	225.424	457.429	0.418	0.384	314.4168	-0.064	-5.92
Ogive1-4	285.417	742.846	0.289	0.296	312.6314	-0.023	-2.39
Ogive1-5	42.546	785.392	0.264	0.267	305.1349	-0.087	-8.81
Ogive2-1	—	0.000	0.219	0.233	310.3892	-0.003	-0.29
Ogive2-2	133.555	133.555	0.305	0.309	302.8169	-0.056	-5.69
Ogive2-3	266.390	399.945	0.382	0.373	304.8414	-0.064	-6.21
Ogive2-4	135.644	535.589	0.341	0.337	308.3497	-0.026	-2.55
Ogive2-5	205.398	740.987	0.261	0.313	320.1829	-0.071	-8.52
Ogive3-1	—	0.000	0.280	0.316	295.8787	-0.026	-2.98
Ogive3-2	154.086	154.086	0.318	0.354	294.0491	-0.027	-3.06
Ogive3-3	134.867	288.953	0.395	0.395	295.0965	-0.036	-3.59
Ogive3-4	236.151	525.104	0.341	0.337	312.0245	-0.080	-7.87
Ogive3-5	191.465	716.569	0.249	0.307	324.0384	-0.018	-2.27
Ogive4-1	—	0.000	0.398	0.438	279.0819	-0.075	-8.21
Ogive4-2	166.599	166.599	0.406	0.401	281.0339	-0.084	-8.33
Ogive4-3	211.315	377.914	0.319	0.319	302.2356	-0.061	-6.06
Ogive5-1	—	0.000	0.420	0.456	276.6413	-0.053	-5.72
Ogive5-2	231.040	231.040	0.440	0.444	276.6354	-0.054	-5.46
Ogive5-3	238.936	469.976	0.364	0.365	305.3002	-0.006	-0.60
Ogive6	—	0.000	0.464	0.467	274.2689	-0.072	-7.23
Mean	**198.460**	**—**	**0.387**	**0.398**	**297.3180**	**-0.057**	**-5.72**

[1] Data are unreliable. Not used in calculation of the mean.

Longitudinal A (Taku / Matthes / Llewellyn Glaciers) Flags 13-23 Surveyed July 24, 2000 ? July 29, 2000 Flags 86-102 Surveyed August 2, 2000 ? August 8, 2000 Flags 103-109 Surveyed August 3, 2000 ? August 8, 2000 Flags 110-122 Surveyed August 4, 2000 ? August 8, 2000							
Flag	Flag Distances		Flag Movement			Surface Height Change	
	Flag to Flag (m)	Sum[1] (m)	Total (m)	Daily (m)	Bearing (gon)	Total (cm)	Daily (cm)
13	0.000	0.000	4.538	0.937	182.3997	-0.453	-9.35
14	500.038	500.038	4.458	0.920	181.9506	-0.480	-9.90
15	501.058	1001.096	4.443	0.916	179.0577	-0.456	-9.40
16	501.560	1502.656	4.394	0.906	179.0036	-0.473	-9.75
17	502.150	2004.806	4.307	0.887	183.4165	-0.557	-11.48
18	501.287	2506.093	4.248	0.874	187.4093	-0.484	-9.96
19	497.709	3003.802	4.204	0.865	188.7808	-0.433	-8.91
20	500.349	3504.151	4.206	0.861	187.6038	-0.443	-9.06
21	500.496	4004.648	4.197	0.855	184.4038	-0.620	-12.64
22	500.838	4505.486	4.167	0.848	184.1619	-0.485	-9.86
23	500.433	5005.919	4.183	0.851	183.5094	-0.415	-8.45
86	500.239	36181.077	0.850	0.141	224.8664	-0.330	-5.48
87	499.700	36680.778	0.761	0.126	226.5298	-0.259	-4.30
88	498.750	37179.528	0.586	0.097	230.9162	-0.320	-5.31
89	499.293	37678.821	0.548	0.091	222.5679	-0.378	-6.29
90	497.405	38176.225	0.431	0.072	216.8581	-0.392	-6.53
91	500.021	38676.246	0.321	0.054	210.1848	-0.364	-6.06
92	499.101	39175.347	0.236	0.039	170.0491	-0.368	-6.13
93	498.927	39674.274	0.300	0.050	114.7871	-0.398	-6.64
94	498.410	40172.684	0.405	0.068	95.9910	-0.366	-6.11
95	498.919	40671.603	0.456	0.077	83.7469	-0.514	-8.72
96	500.113	41171.716	0.441	0.075	79.1834	-0.475	-8.07
97	497.502	41669.218	0.420	0.071	70.9984	-0.516	-8.77
98	497.858	42167.076	0.406	0.069	61.1675	-0.492	-8.37
99	498.227	42665.304	0.438	0.075	45.1599	-0.475	-8.09
100	500.087	43165.390	0.440	0.075	34.9005	-0.500	-8.52
101	497.679	43663.069	0.478	0.082	24.6466	-0.521	-8.89
102	498.920	44161.990	0.495	0.084	25.7965	-0.454	-7.75
103	499.300	44661.289	0.423	0.088	28.9381	-0.268	-5.60
104	499.543	45160.832	0.456	0.095	28.1305	-0.273	-5.71
105	499.262	45660.094	0.506	0.106	28.8526	-0.292	-6.10
106	498.339	46158.432	0.571	0.119	31.4430	-0.279	-5.82
107	501.383	46659.816	0.682	0.142	32.3019	-0.291	-6.06
108	498.170	47157.986	0.814	0.169	34.9084	-0.268	-5.58
109	500.079	47658.065	1.046	0.216	33.0680	-0.367	-7.56

LONGITUDINAL A (TAKU / MATTHES / LLEWELLYN GLACIERS) FLAGS 13-23 SURVEYED JULY 24, 2000 ? JULY 29, 2000 FLAGS 86-102 SURVEYED AUGUST 2, 2000 ? AUGUST 8, 2000 FLAGS 103-109 SURVEYED AUGUST 3, 2000 ? AUGUST 8, 2000 FLAGS 110-122 SURVEYED AUGUST 4, 2000 ? AUGUST 8, 2000							
FLAG	FLAG DISTANCES		FLAG MOVEMENT			SURFACE HEIGHT CHANGE	
	FLAG TO FLAG (M)	SUM[1] (M)	TOTAL (M)	DAILY (M)	BEARING (GON)	TOTAL (CM)	DAILY (CM)
110	498.385	48156.450	1.001	0.249	27.3142	-0.266	-6.62
111	497.951	48654.401	1.110	0.282	21.2683	-0.237	-6.04
112	499.620	49154.022	1.154	0.294	14.9347	-0.227	-5.79
113	498.816	49652.838	1.146	0.292	12.0220	-0.202	-5.16
114	498.805	50151.643	1.131	0.288	11.8885	-0.202	-5.16
115	499.592	50651.235	1.150	0.297	10.6238	-0.174	-4.48
116	496.716	51147.952	1.211	0.312	10.4705	-0.159	-4.10
117	500.402	51648.354	1.260	0.326	11.2171	-0.180	-4.65
118	497.045	52145.399	1.320	0.341	11.1124	-0.217	-5.62
119	498.694	52644.092	1.354	0.351	8.8128	-0.235	-6.09
120	497.173	53141.266	1.399	0.363	6.7939	-0.213	-5.51
121	499.571	53640.836	1.467	0.381	5.6199	-0.229	-5.96
122	488.377	54129.213	1.553	0.404	3.8106	-0.172	-4.46
MEAN	**499.001**	**—**	**1.586**	**0.337**	**94.450**	**-0.358**	**-7.101**

[1] Distance from Longitudinal A, Flag 13.

[2] Flags 24-85 were surveyed only once in 2000 so that annual surface height change, relative to 1999, can be computed. Velocities at these flags were obtained in 1999, therefore velocities were not necessary in 2000.

Longitudinal B (Demorest Glacier) July 25, 2000 ? July 29, 2000							
Flag	Flag Distances		Flag Movement			Surface Height Change	
	Flag to Flag (m)	Sum[1] (m)	Total (m)	Daily (m)	Bearing (gon)	Total (cm)	Daily (cm)
10	499.785	4490.639	1.062	0.271	275.9332	-0.346	-8.84
11	497.835	4988.474	1.066	0.273	271.5677	-0.378	-9.66
12[2]	—	—	—	—	—	—	—
13	497.306	5983.601	1.128	0.288	258.0390	-0.364	-9.29
14	500.359	6483.960	1.204	0.307	248.1446	-0.314	-8.02
15	493.560	6977.519	1.240	0.316	232.9454	-0.333	-8.49
16	498.587	7476.106	1.301	0.332	213.3764	-0.299	-7.63
17	501.272	7977.377	1.352	0.345	198.6248	-0.341	-8.70
18	499.415	8476.792	1.305	0.333	192.7667	-0.236	-6.04
19	498.496	8975.289	1.311	0.335	190.5641	-0.318	-8.13
Mean	**498.513**	**—**	**1.219**	**0.311**	**231.329**	**-0.325**	**-8.311**

[1] Distance upglacier from Longitudinal B, Flag 1.
[2] Flag 12 was surveyed on July 25 only, therefore velocity and height change are not available.

Longitudinal D (Northwest Branch of Taku Glacier) July 27, 2000 ? August 6, 2000							
Flag	Flag Distances		Flag Movement			Surface Height Change	
	Flag to Flag (m)	Sum[1] (m)	Total (m)	Daily (m)	Bearing (gon)	Total (cm)	Daily (cm)
1	—	0.000	5.117	0.513	176.2709	-0.671	-6.72
2	499.329	499.329	4.961	0.497	177.5786	-0.750	-7.52
3	499.324	998.653	4.854	0.486	176.7510	-0.728	-7.30
4	499.202	1497.855	4.590	0.460	173.6115	-0.692	-6.93
5	499.272	1997.126	4.170	0.418	166.8161	-0.623	-6.25
6	498.701	2495.828	3.582	0.359	156.0850	-0.645	-6.47
7	499.621	2995.449	3.290	0.330	143.6356	-0.687	-6.89
8	498.669	3494.118	3.224	0.323	134.5847	-0.699	-7.01
9	471.886	3966.004	3.149	0.316	127.8811	-0.696	-6.98
10	499.373	4465.376	3.119	0.313	121.6841	-0.647	-6.49
11	501.202	4966.579	3.014	0.303	115.8761	-0.643	-6.46
12	498.532	5465.111	3.019	0.303	109.6338	-0.611	-6.14
13	496.872	5961.982	2.941	0.295	107.8571	-0.579	-5.81
14	498.573	6460.555	2.865	0.293	107.6701	-0.578	-5.91
15	498.658	6959.213	2.826	0.289	105.6625	-0.531	-5.42
16	492.154	7451.367	2.794	0.285	100.5787	-0.594	-6.06
Mean	**496.758**	**—**	**3.595**	**0.362**	**137.636**	**-0.648**	**-6.523**

[1] Distance upglacier from Longitudinal D, Flag 1.

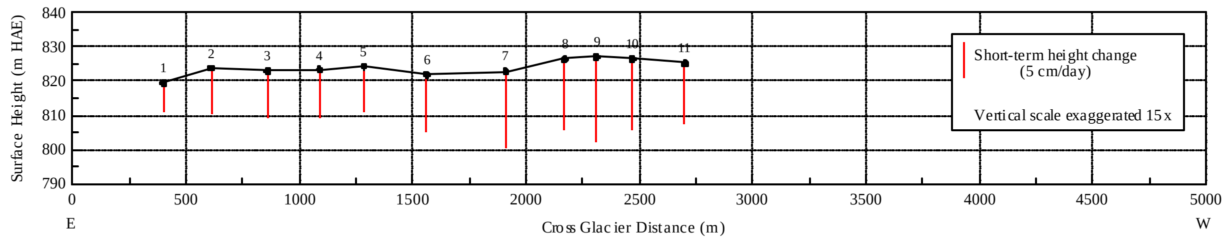
LONGITUDINAL F (WEST BRANCH OF TAKU GLACIER) FLAGS 1-8 SURVEYED JULY 27, 2000 ? AUGUST 6, 2000 FLAGS 9-16 SURVEYED JULY 30, 2000 ? AUGUST 6, 2000							
FLAG	FLAG DISTANCES		FLAG MOVEMENT			SURFACE HEIGHT CHANGE	
	FLAG TO FLAG (M)	SUM[1] (M)	TOTAL (M)	DAILY (M)	BEARING (GON)	TOTAL (CM)	DAILY (CM)
1	0.000	0.000	2.725	0.278	93.8046	-0.519	-5.30
2	496.162	496.162	2.536	0.259	87.4930	-0.432	-4.41
3	499.756	995.918	2.396	0.245	83.0778	-0.553	-5.65
4	499.549	1495.467	2.127	0.217	81.5803	-0.536	-5.46
5	500.295	1995.762	1.822	0.186	83.7880	-0.500	-5.10
6	498.116	2493.878	1.697	0.173	100.8367	-0.507	-5.17
7	499.178	2993.056	1.417	0.144	119.0116	-0.515	-5.25
8	499.208	3492.264	1.299	0.132	124.6888	-0.529	-5.39
9	498.040	3990.305	0.909	0.130	118.9248	-0.401	-5.74
10	500.239	4490.544	0.888	0.127	110.5502	-0.396	-5.67
11	497.307	4987.851	0.843	0.121	100.9589	-0.413	-5.91
12	498.621	5486.472	0.927	0.133	94.0281	-0.459	-6.57
13	499.426	5985.897	0.776	0.111	79.0161	-0.367	-5.26
14	499.718	6485.615	0.745	0.107	64.1576	-0.400	-5.74
15	499.187	6984.802	0.704	0.101	50.7736	-0.396	-5.67
16	498.350	7483.152	0.648	0.093	46.0319	-0.410	-5.87
17 [2]	500.560	7983.712	—	—	—	—	—
18 [2]	501.163	8458.776	—	—	—	—	—
MEAN	**499.110**	**—**	**1.404**	**0.160**	**89.920**	**-0.458**	**-5.510**

[1] Distance upglacier from Longitudinal F, Flag 1.

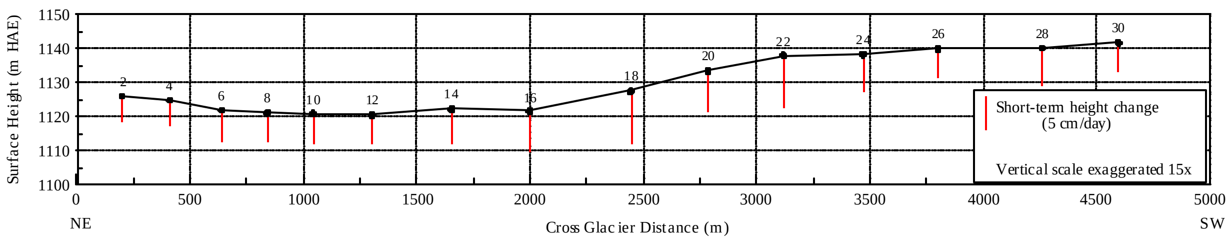
[2] Flags 17 and 18 were not surveyed at Epoch 1 due to atmospheric conditions, which prevented the establishment of a radio link between the base and rover.

APPENDIX 4
SHORT-TERM HEIGHT CHANGE GRAPHS

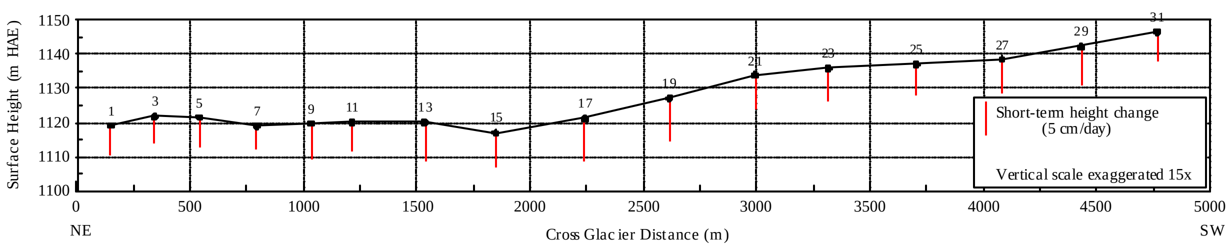
The following graphs show the magnitude of the change in surface height for those profiles surveyed twice during the summer of 2000. Vertical red bars indicate the magnitude of change during the survey periods. All profiles experienced a lowering of the surface.



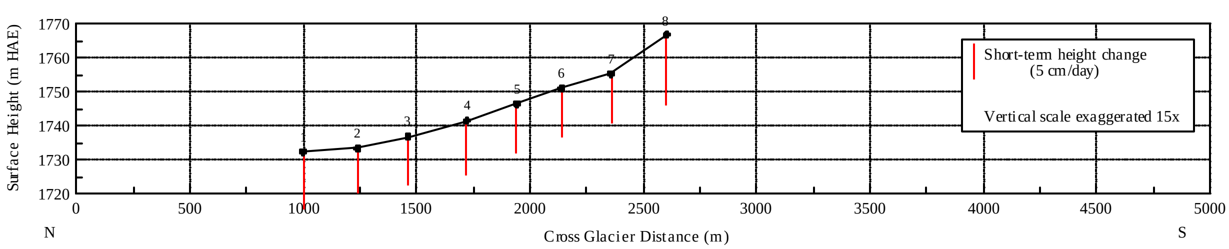
Short-term Height Change at Profile 2 (July 25 to July 29, 2000)



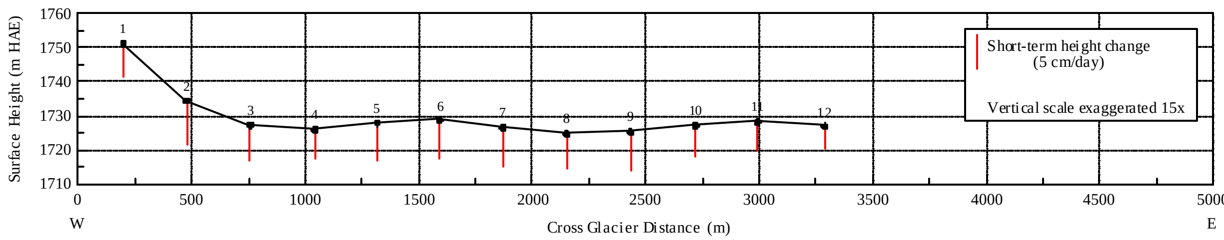
Short-term Height Change at Profile 4 - Upper Line (July 21 to July 27, 2000)



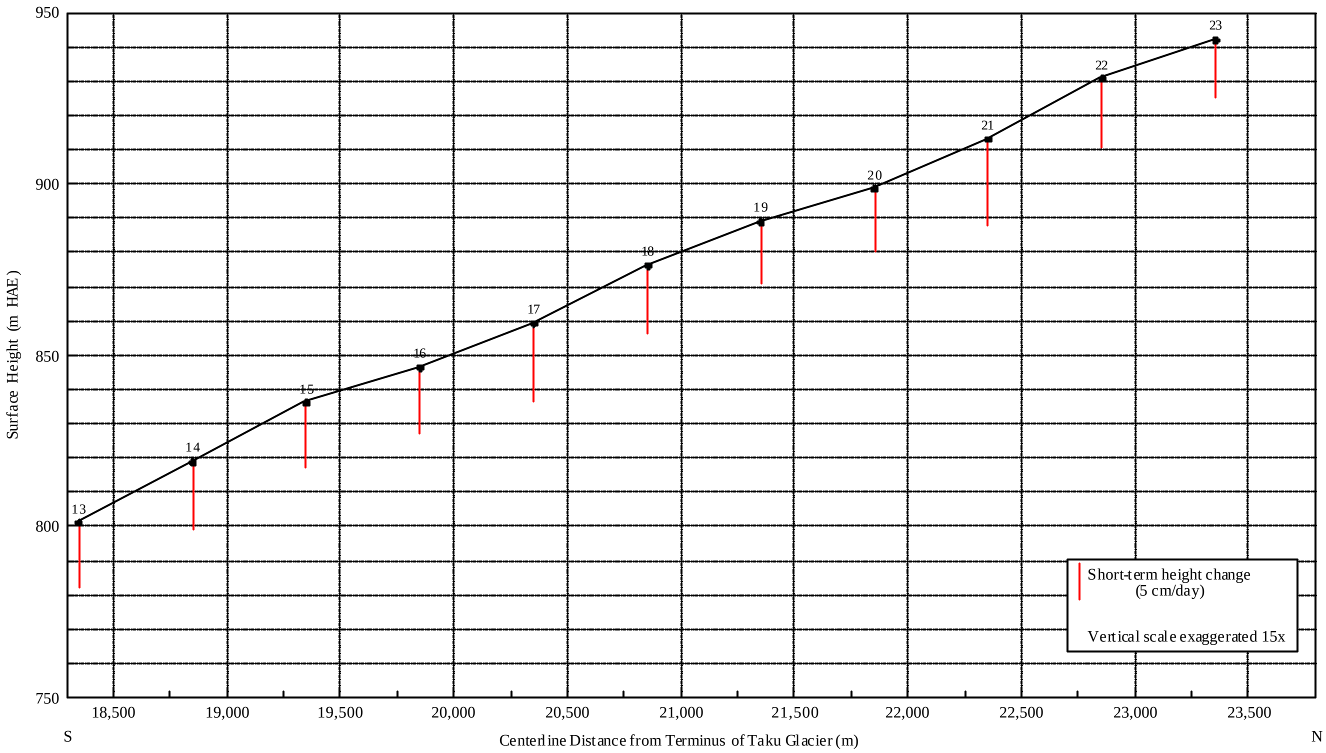
Short-term Height Change at Profile 4 - Lower Line (July 21 to July 27, 2000)



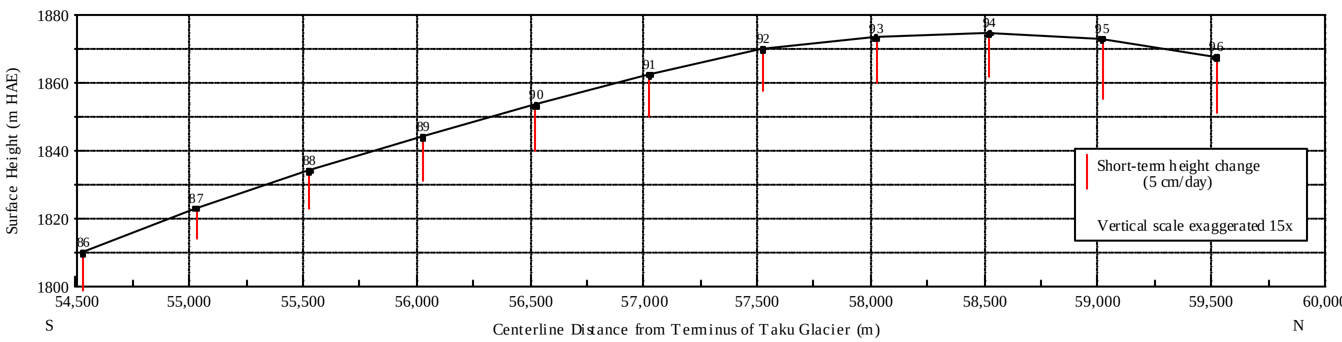
Short-term Height Change at Profile 9 (August 3 to August 9, 2000)



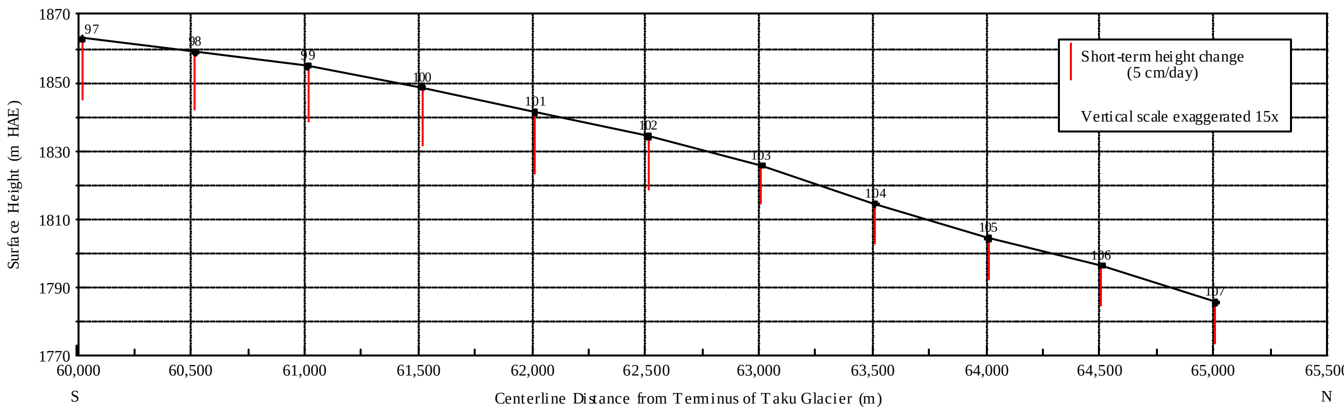
Short-term Height Change at Profile 11 (August 4 to August 8, 2000)



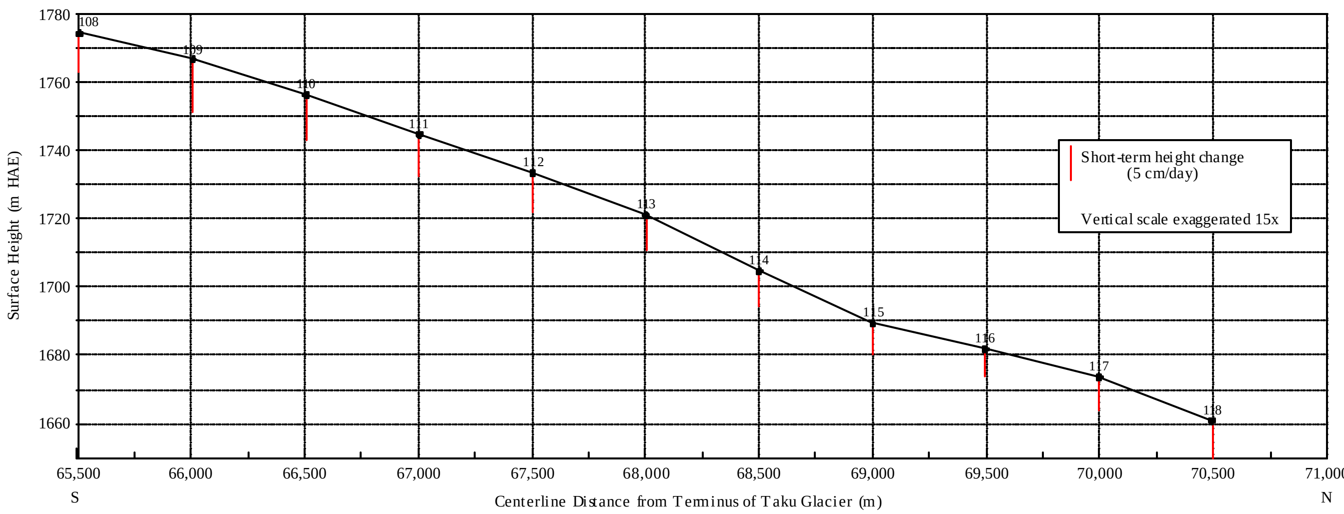
Short-term Height Change along Longitudinal A - Points 13 to 23 (July 24 to July 29, 2000)



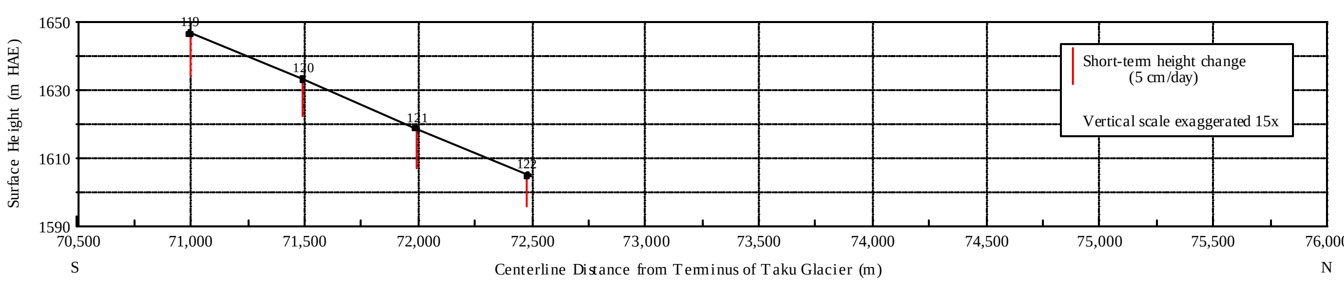
Short-term Height Change along Longitudinal A - Points 86 to 96 (August 2 to August 8, 2000)



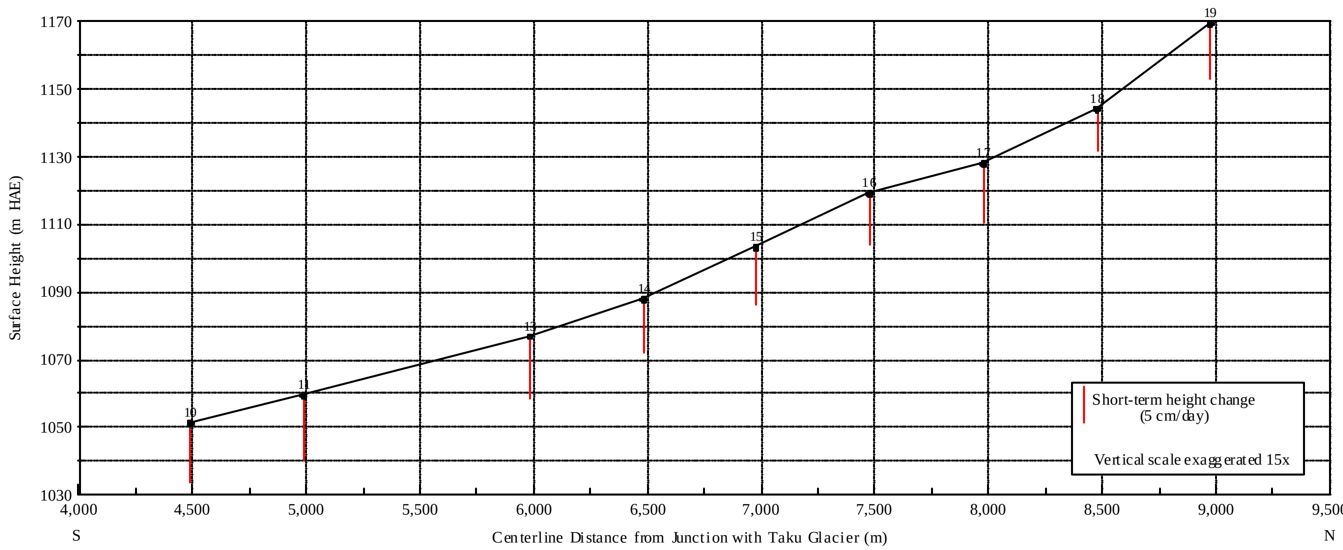
Short-term Height Change along Longitudinal A - Points 97 to 107 (August 2-3 to August 8, 2000)



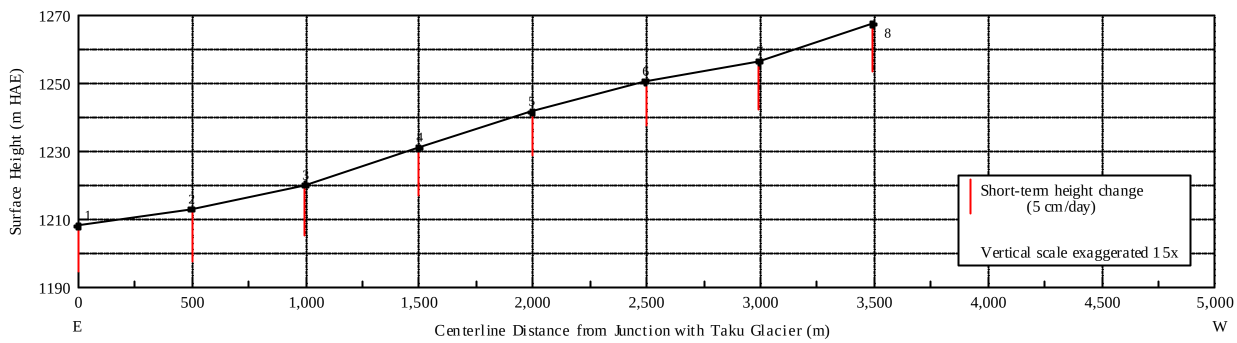
Short-term Height Change along Longitudinal A - Points 108 to 118 (August 4 to August 8, 2000)



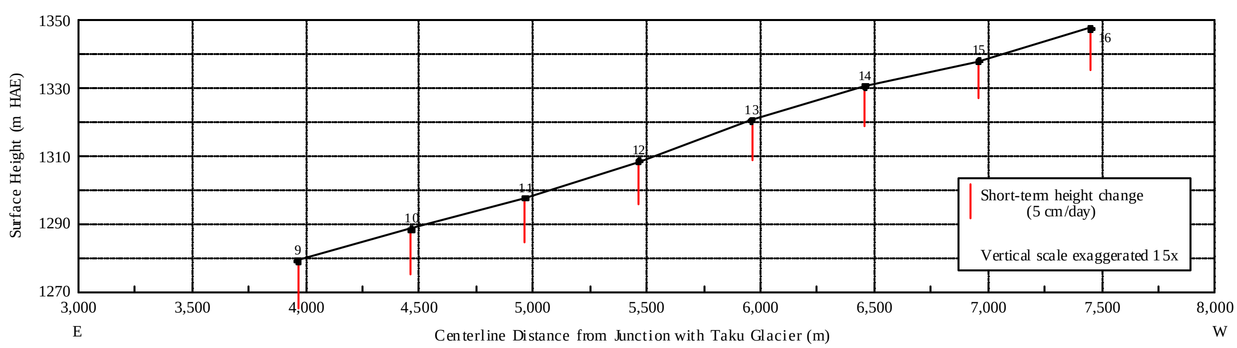
Short-term Height Change along Longitudinal A - Points 119 to 122 (August 4 to August 8, 2000)



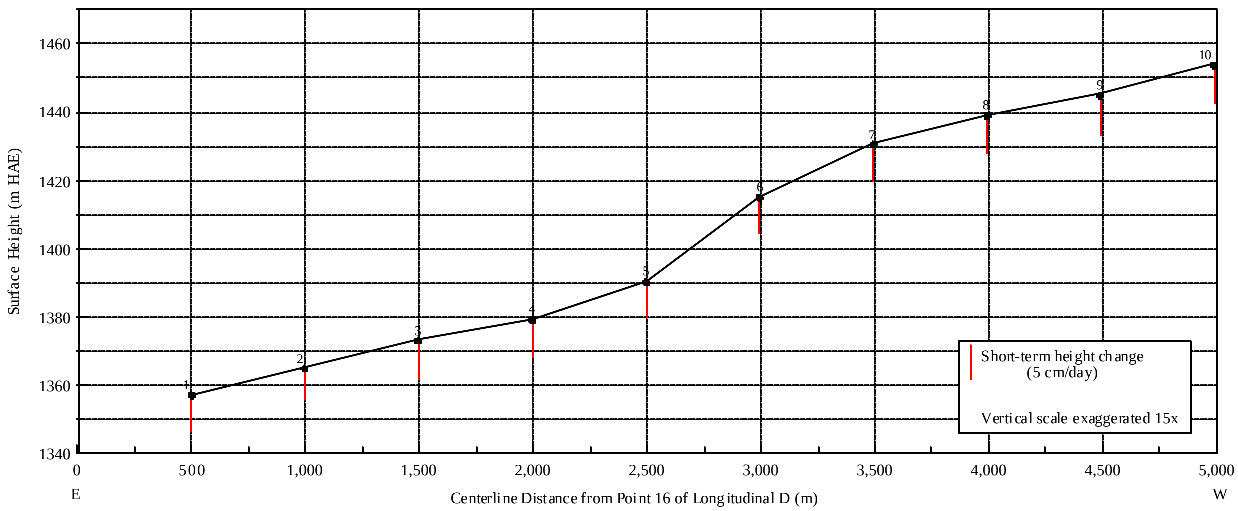
Short-term Height Change along Longitudinal B - Points 10 to 19 (July 27 & 30 to August 6, 2000)



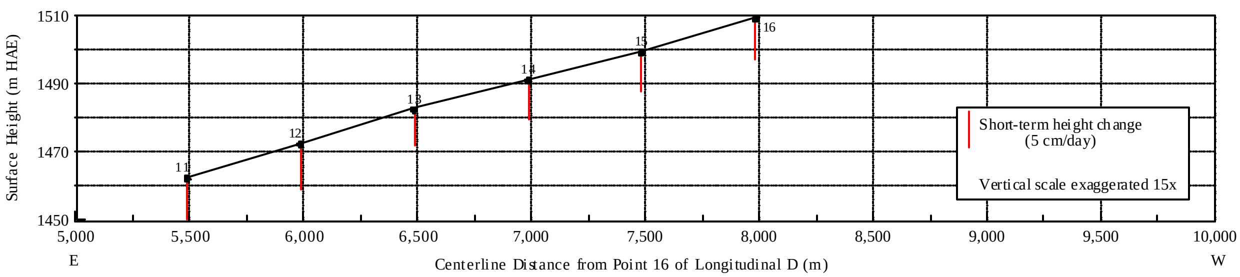
Short-term Height Change along Longitudinal D - Points 1 to 8 (July 27 to August 6, 2000)



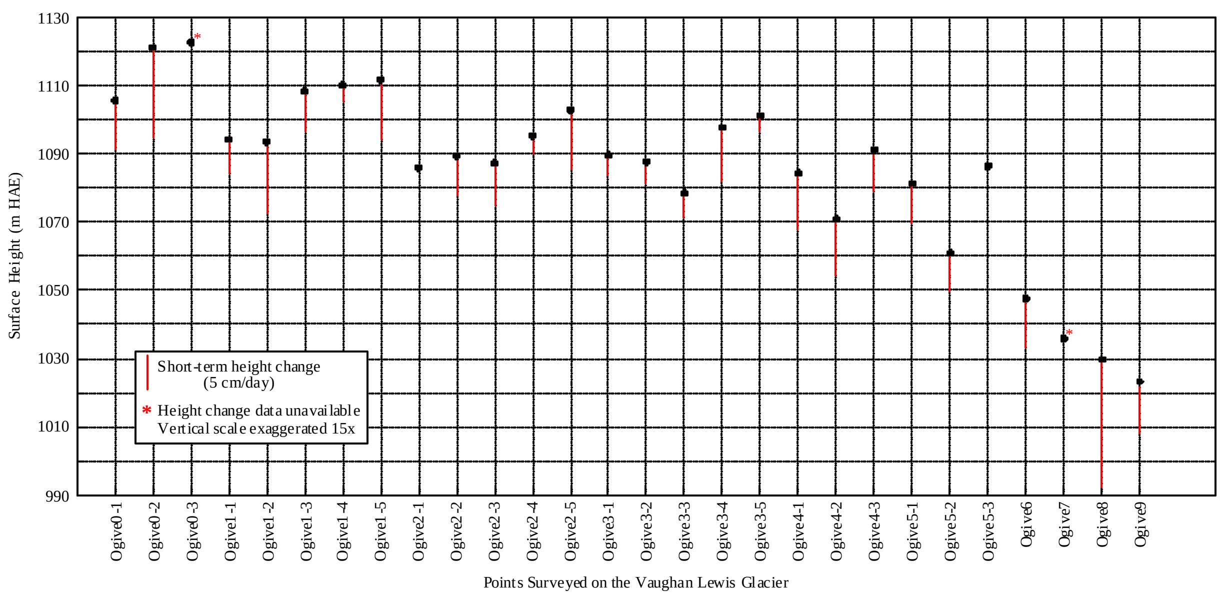
Short-term Height Change along Longitudinal D - Points 9 to 16 (July 27 to August 6, 2000)



Short-term Height Change along Longitudinal F - Points 1 to 10 (July 27 & 30 to August 6, 2000)



Short-term Height Change along Longitudinal F - Points 11 to 16 (July 30 to August 6, 2000)



Short-term Height Change at Ogives 1-9, Vaughan Lewis Glacier (August 11 to August 12, 2000)

APPENDIX 5
LONGITUDINAL FLOW LAG TIMES

LONGITUDINAL A (MATTHES AND TAKU GLACIERS)					
FROM — TO	MEAN VELOCITY/DAY BETWEEN FROM AND TO POINTS (M)	FROM — TO SLOPE DISTANCE (M)	FROM – TO MOVEMENT TIME (YEARS)	CUMULATIVE SLOPE DISTANCE (KM)	CUMULATIVE MOVEMENT TIME (YEARS)
a92 — a91	0.046	499.158	29.407	0.499	29.407
a91 — a90	0.063	500.105	21.864	0.999	51.271
a90 — a89	0.081	497.492	16.740	1.497	68.011
a89 — a88	0.094	499.390	14.515	1.996	82.526
a88 — a87	0.112	498.868	12.216	2.495	94.741
a87 — a86	0.134	499.879	10.245	2.995	104.986
a86 — a85	0.147	500.467	9.324	3.495	114.310
a85 — a84	0.160	498.542	8.517	3.994	122.826
a84 — a83	0.175	498.518	7.815	4.492	130.641
a83 — a82	0.190	499.151	7.202	4.992	137.843
a82 — a81	0.216	499.938	6.330	5.492	144.173
a81 — a80	0.257	499.981	5.320	5.991	149.492
a80 — a79	0.300	501.187	4.579	6.493	154.071
a79 — a78	0.337	500.544	4.069	6.993	158.141
a78 — a77	0.375	498.907	3.640	7.492	161.781
a77 — a76	0.416	498.598	3.280	7.991	165.061
a76 — a75	0.474	495.951	2.867	8.487	167.928
a75 — a74	0.511	498.927	2.675	8.986	170.603
a74 — a73	0.492	500.349	2.782	9.486	173.386
a73 — a72	0.459	499.126	2.976	9.985	176.361
a72 — a71	0.431	495.994	3.150	10.481	179.512
a71 — a70	0.410	495.316	3.311	10.976	182.823
a70 — a69	0.396	499.009	3.452	11.475	186.275
a69 — a68	0.380	497.592	3.581	11.973	189.856
a68 — a67	0.358	498.638	3.815	12.472	193.671
a67 — a66	0.340	497.541	4.005	12.969	197.677
a66 — a65	0.331	499.010	4.122	13.468	201.798
a65 — a64	0.325	499.995	4.209	13.968	206.008
a64 — a63	0.326	501.648	4.217	14.470	210.225
a63 — a62	0.334	499.086	4.092	14.969	214.317
a62 — a61	0.340	499.806	4.027	15.469	218.344
a61 — a60	0.353	499.606	3.872	15.968	222.216
a60 — a59	0.343	500.356	3.996	16.469	226.212
a59 — a58	0.325	499.806	4.207	16.968	230.419
a58 — a57	0.348	499.793	3.928	17.468	234.347
a57 — a56	0.379	500.984	3.620	17.969	237.967
a56 — a55	0.388	499.527	3.529	18.469	241.497

LONGITUDINAL A (MATTHES AND TAKU GLACIERS)					
FROM — TO	MEAN VELOCITY/DAY BETWEEN FROM AND TO POINTS (M)	FROM — TO SLOPE DISTANCE (M)	FROM – TO MOVEMENT TIME (YEARS)	CUMULATIVE SLOPE DISTANCE (KM)	CUMULATIVE MOVEMENT TIME (YEARS)
a55 — a54	0.397	500.687	3.450	18.969	244.947
a54 — a53	0.412	502.995	3.344	19.472	248.291
a53 — a52	0.406	496.930	3.351	19.969	251.642
a52 — a51	0.408	499.358	3.347	20.469	254.989
a51 — a50	0.422	498.754	3.238	20.968	258.228
a50 — a49	0.430	499.065	3.177	21.467	261.404
a49 — a48	0.440	501.037	3.118	21.968	264.523
a48 — a47	0.445	497.866	3.064	22.465	267.587
a47 — a46	0.454	499.856	3.013	22.965	270.599
a46 — a45	0.479	498.318	2.849	23.464	273.448
a45 — a44	0.510	503.245	2.700	23.967	276.149
a44 — a43	0.531	446.994	2.305	24.414	278.454
a43 — a42	0.541	500.534	2.532	24.914	280.986
a42 — a41	0.547	500.988	2.506	25.415	283.492
a41 — a40	0.555	503.300	2.482	25.919	285.974
a40 — a39	0.568	500.870	2.415	26.420	288.389
a39 — a38	0.580	497.783	2.349	26.917	290.738
a38 — a37	0.598	500.339	2.292	27.418	293.030
a37 — a36	0.613	498.873	2.228	27.917	295.259
a36 — a35	0.619	498.274	2.206	28.415	297.464
a35 — a34	0.628	500.530	2.182	28.915	299.647
a34 — a33	0.646	501.918	2.127	29.417	301.773
a33 — a32	0.655	500.506	2.093	29.918	303.866
a32 — a31	0.670	501.486	2.049	30.419	305.916
a31 — a30	0.731	502.886	1.882	30.922	307.798
a30 — a29	0.755	501.655	1.819	31.424	309.616
a29 — a28	0.741	500.305	1.848	31.924	311.464
a28 — a27	0.747	253.377	0.929	32.178	312.393
a27 — a26	0.766	498.622	1.783	32.676	314.176
a26 — a25	0.828	502.139	1.660	33.178	315.836
a25 — a24	0.842	497.649	1.619	33.676	317.455
a24 — a23	0.832	507.937	1.671	34.184	319.126
a23 — a22	0.850	500.563	1.613	34.684	320.739
a22 — a21	0.852	501.147	1.611	35.186	322.350
a21 — a20	0.858	500.707	1.598	35.686	323.948
a20 — a19	0.863	500.445	1.588	36.187	325.536
a19 — a18	0.869	497.870	1.568	36.685	327.104
a18 — a17	0.880	501.570	1.560	37.186	328.663
a17 — a16	0.896	502.316	1.534	37.688	330.198
a16 — a15	0.911	501.667	1.508	38.190	331.706

Longitudinal A (Matthes and Taku Glaciers)					
From — To	Mean Velocity/day Between From and To Points (m)	From — To Slope Distance (m)	From – To Movement Time (years)	Cumulative Slope Distance (km)	Cumulative Movement Time (years)
a15 — a14	0.918	501.359	1.495	38.692	333.201
a14 — a13	0.929	500.353	1.475	39.192	334.676

Longitudinal A (Llewellyn Glacier)					
From — To	Mean Velocity/day Between From and To Points (m)	From — To Slope Distance (m)	From — To Movement Time (years)	Cumulative Slope Distance (km)	Cumulative Movement Time (years)
a93 — a94	0.059	498.412	23.177	0.498	23.177
a94 — a95	0.073	498.921	18.834	0.997	42.011
a95 — a96	0.076	500.143	17.990	1.497	60.000
a96 — a97	0.073	497.524	18.620	1.995	78.621
a97 — a98	0.070	497.872	19.394	2.493	98.015
a98 — a99	0.072	498.244	18.990	2.991	117.005
a99 — a100	0.075	500.127	18.313	3.491	135.318
a100 — a101	0.078	497.735	17.401	3.989	152.719
a101 — a102	0.083	498.968	16.449	4.488	169.169
a102 — a103	0.086	499.373	15.806	4.987	184.975
a103 — a104	0.092	499.667	14.886	5.487	199.861
a104 — a105	0.100	499.365	13.606	5.986	213.467
a105 — a106	0.112	498.403	12.144	6.485	225.611
a106 — a107	0.130	501.502	10.527	6.986	236.138
a107 — a108	0.155	498.299	8.775	7.485	244.913
a108 — a109	0.192	500.138	7.117	7.985	252.030
a109 — a110	0.232	498.493	5.880	8.483	257.910
a110 — a111	0.265	498.086	5.137	8.981	263.047
a111 — a112	0.288	499.747	4.751	9.481	267.798
a112 — a113	0.293	498.971	4.664	9.980	272.461
a113 — a114	0.290	499.076	4.707	10.479	277.168
a114 — a115	0.293	499.826	4.678	10.979	281.846
a115 — a116	0.305	496.771	4.467	11.476	286.313
a116 — a117	0.319	500.473	4.295	11.976	290.608
a117 — a118	0.334	497.205	4.082	12.473	294.689
a118 — a119	0.346	498.898	3.946	12.972	298.635
a119 — a120	0.357	497.352	3.816	13.470	302.452
a120 — a121	0.372	499.774	3.680	13.969	306.132
a121 — a122	0.392	488.575	3.409	14.458	309.541

Longitudinal B (Demorest Glacier)					
From — To	**Mean Velocity/day Between From and To Points (m)**	**From — To Slope Distance (m)**	**From — To Movement Time (years)**	**Cumulative Slope Distance (km)**	**Cumulative Movement Time (years)**
b34 — b33	0.184	496.338	7.401	0.496	7.401
b33 — b32	0.190	497.020	7.174	0.993	14.575
b32 — b31	0.205	499.704	6.689	1.493	21.264
b31 — b30	0.212	497.422	6.429	1.990	27.693
b30 — b29	0.219	499.933	6.248	2.490	33.940
b29 — b28	0.248	498.613	5.498	2.989	39.438
b28 — b27	0.258	501.247	5.315	3.490	44.753
b27 — b26	0.245	500.899	5.598	3.991	50.350
b26 — b25	0.252	499.658	5.434	4.491	55.784
b25 — b24	0.257	500.470	5.334	4.991	61.118
b24 — b23	0.260	500.536	5.275	5.492	66.393
b23 — b22	0.265	500.181	5.159	5.992	71.552
b22 — b21	0.278	497.782	4.906	6.490	76.458
b21 — b20	0.293	496.287	4.642	6.986	81.100
b20 — b19	0.316	497.773	4.309	7.484	85.409
b19 — b18	0.334	499.138	4.091	7.983	89.500
b18 — b17	0.339	499.681	4.032	8.483	93.532
b17 — b16	0.339	501.350	4.052	8.984	97.585
b16 — b15	0.324	498.834	4.212	9.483	101.797
b15 — b14	0.312	493.799	4.338	9.977	106.135
b14 — b13	0.297	500.480	4.608	10.477	110.743
b13 — b11	0.280	994.289	9.982	11.471	120.725
b11 — b10	0.272	497.902	5.011	11.969	125.736
b10 — b9	0.257	499.920	5.333	12.469	131.069
b9 — b8	0.248	500.205	5.518	12.969	136.587
b8 — b7	0.266	498.602	5.133	13.468	141.720
b7 — b6	0.278	501.244	4.939	13.969	146.659
b6 — b5	0.280	502.561	4.913	14.472	151.572

Longitudinal C (Southwest Branch of the Taku Glacier)					
From — To	Mean Velocity/day Between From and To Points (m)	From — To Slope Distance (m)	From — To Movement Time (years)	Cumulative Slope Distance (km)	Cumulative Movement Time (years)
c14 — c13	0.100	498.728	13.693	0.499	13.693
c13 — c12	0.087	498.593	15.606	0.997	29.299
c12 — c11	0.081	502.715	17.083	1.500	46.382
c11 — c10	0.079	499.864	17.222	2.000	63.604
c10 — c9	0.088	498.480	15.529	2.498	79.133
c9 — c8	0.089	497.653	15.318	2.996	94.451
c8 — c7	0.088	498.587	15.566	3.495	110.018
c7 — c6	0.094	497.263	14.560	3.992	124.578

Longitudinals D and F (Northwest and West Branches of the Taku Glacier)					
From — To	Mean Velocity/day Between From and To Points (m)	From — To Slope Distance (m)	From — To Movement Time (years)	Cumulative Slope Distance (km)	Cumulative Movement Time (years)
f16 — f15	0.097	498.445	14.086	0.498	14.086
f15 — f14	0.104	499.254	13.167	0.998	27.254
f14 — f13	0.109	499.789	12.557	1.497	39.810
f13 — f12	0.122	499.534	11.213	1.997	51.023
f12 — f11	0.127	498.719	10.774	2.496	61.797
f11 — f10	0.124	497.379	10.988	2.993	72.785
f10 — f9	0.129	500.317	10.652	3.493	83.436
f9 — f8	0.131	498.076	10.391	3.992	93.827
f8 — f7	0.138	499.281	9.875	4.491	103.702
f7 — f6	0.159	499.419	8.617	4.990	112.319
f6 — f5	0.179	498.729	7.616	5.489	119.935
f5 — f4	0.201	500.419	6.808	5.989	126.743
f4 — f3	0.231	499.585	5.926	6.489	132.669
f3 — f2	0.252	499.822	5.431	6.989	138.100
f2 — f1	0.269	496.225	5.055	7.485	143.155
f1 — d16	0.282	499.789	4.854	7.985	148.009
d16 — d15	0.287	492.245	4.696	8.477	152.705
d15 — d14	0.291	498.714	4.697	8.976	157.402
d14 — d13	0.294	498.672	4.644	9.474	162.046
d13 — d12	0.299	497.020	4.550	9.971	166.596
d12 — d11	0.303	498.649	4.509	10.470	171.105
d11 — d10	0.308	501.288	4.460	10.971	175.565
d10 — d9	0.314	499.459	4.348	11.471	179.913
d9 — d8	0.320	472.022	4.042	11.943	183.955
d8 — d7	0.327	498.793	4.179	12.442	188.135
d7 — d6	0.345	499.655	3.970	12.941	192.104

APPENDIX 6
SURFACE ELEVATIONS AT PROFILE 4, 1993 TO 2000

The data in the following table represent the annual surveyed elevations of the 31 flags of Profile 4 as adjusted to the standard July 25 measurement date.

FLAG	ELEVATION (METERS ABOVE WGS84 ELLIPSOID)							
	1993	1994	1995	1996	1997	1998	1999	2000
1	1119.852	1119.712	1119.258	1118.492	1117.755	1116.810	1117.351	1118.836
2	1126.923	1127.012	1126.009	1125.174	1124.304	1123.633	1124.055	1125.623
3	1122.832	1122.969	1122.095	1121.371	1120.630	1119.721	1120.234	1121.379
4	1125.882	1126.146	1124.930	1124.049	1123.357	1122.611	1122.956	1124.389
5	1122.850	1122.966	1121.965	1121.496	1120.560	1119.512	1119.849	1121.220
6	1123.484	1123.614	1122.522	1121.613	1120.742	1119.897	1120.193	1121.535
7	1120.656	1120.882	1119.808	1118.947	1118.077	1117.092	1117.425	1118.610
8	1122.545	1122.874	1121.783	1120.645	1119.810	1119.043	1119.256	1120.639
9	1121.201	1121.600	1120.377	1119.311	1118.679	1117.479	1117.916	1119.362
10	1122.394	1122.754	1121.279	1120.202	1119.514	1118.770	1119.014	1120.395
11	1121.657	1122.262	1120.793	1120.109	1119.511	1118.267	1118.696	1119.885
12	1121.675	1121.901	1120.663	1120.006	1119.448	1118.405	1118.821	1120.167
13	1121.566	1121.661	1120.580	1119.590	1119.200	1117.612	1118.472	1119.730
14	1123.383	1123.648	1122.108	1121.450	1121.101	1119.661	1120.482	1121.744
15	1117.945	1117.940	1116.604	1115.803	1115.383	1114.449	1115.128	1116.568
16	1122.471	1122.218	1121.047	1120.528	1120.005	1119.013	1119.617	1121.057
17	1121.898	1122.234	1120.483	1119.877	1119.899	1118.589	1119.360	1120.808
18	1128.331	1128.335	1126.707	1126.491	1125.941	1124.837	1125.678	1126.988
19	1128.305	1128.404	1126.888	1126.455	1126.134	1124.804	1125.842	1126.925
20	1134.260	1134.696	1132.867	1132.486	1132.003	1130.874	1131.705	1133.055
21	1134.681	1134.869	1133.364	1132.868	1132.584	1131.601	1132.204	1133.593
22	1138.596	1138.685	1137.382	1136.945	1136.534	1135.168	1136.062	1137.484
23	1136.935	1136.628	1135.203	1135.003	1134.798	1133.288	1134.164	1135.454
24	1139.334	1139.522	1138.113	1137.418	1136.997	1136.037	1136.551	1137.802
25	1138.734	1139.024	1137.252	1136.849	1136.301	1135.319	1136.060	1136.771
26	1140.840	1141.494	1140.094	1139.224	1138.843	1137.834	1138.078	1139.525
27	1139.350	1139.409	1138.197	1137.490	1137.453	1136.608	1136.864	1138.216
28	1141.612	1141.157	1139.878	1139.152	1138.967	1137.734	1138.566	1139.702
29	1143.362	1142.899	1141.810	1141.122	1140.884	1139.981	1140.338	1141.910
30	1143.137	1142.646	1141.209	1140.486	1140.228	1139.432	1140.128	1141.318
31	1147.676	1147.197	1145.975	1145.288	1145.017	1144.250	1144.952	1146.180
MEAN	**1129.496**	**1129.592**	**1128.298**	**1127.611**	**1127.118**	**1126.075**	**1126.646**	**1127.964**

APPENDIX 7
SURFACE STRAINS AT PROFILE 4, JULY 21 TO JULY 27, 2000

TRIANGLE	FLAGS	? STRAIN / DAY			ORIENTATION (?)
		MAXIMUM STRAIN (*e*1)	MINIMUM STRAIN (*e*2)	VERTICAL STRAIN (*e*3)	
1	1 2 3	61.92	-19.62	-42.30	186.43
2	2 3 4	70.96	-34.83	-36.13	200.44
3	3 4 5	156.01	-106.21	-49.80	192.08
4	4 5 6	166.46	-173.02	6.56	194.51
5	5 6 7	326.93	-219.75	-107.18	194.01
6	6 7 8	342.79	-291.76	-51.03	197.14
7	7 8 9	370.07	-348.18	-21.89	194.56
8	8 9 10	385.34	-377.03	-8.30	191.47
9	9 10 11	353.08	-288.75	-64.33	193.30
10	10 11 12	370.68	-190.67	-180.01	186.99
11	11 12 13	196.52	-149.47	-47.06	182.55
12	12 13 14	228.21	-94.37	-133.84	174.66
13	13 14 15	138.14	-48.37	-89.77	171.11
14	14 15 16	164.22	-49.05	-115.17	164.47
15	15 16 17	119.03	-47.38	-71.65	156.79
16	16 17 18	116.50	-52.48	-64.02	158.53
17	17 18 19	83.46	-33.43	-50.03	156.89
18	18 19 20	110.46	-10.40	-100.05	143.44
19	19 20 21	89.35	-6.42	-82.93	131.63
20	20 21 22	52.64	-0.92	-51.72	137.03
21	21 22 23	54.74	-54.59	-0.15	102.57
22	22 23 24	164.81	-66.31	-98.50	112.88
23	23 24 25	176.76	-141.82	-34.94	101.10
24	24 25 26	234.99	-143.29	-91.70	102.71
25	25 26 27	308.83	-233.10	-75.73	95.31
26	26 27 28	304.17	-239.98	-64.19	93.80
27	27 28 29	282.10	-215.83	-66.27	97.04
28	28 29 30	177.35	-207.42	30.07	89.33
29	29 30 31	107.23	-72.66	-34.57	103.42

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