Airborne Surface Profiling of Alaskan Glaciers, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Echelmeyer, K. A., V. B. Valentine, and S. L. Zirnheld. 2002, updated 2004. *Airborne Surface Profiling of Alaskan Glaciers, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/N5RF5RZJ. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/G01378

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

Data are stored in ASCII text files. See individual data sections below for descriptions of formats.

1.1 Glacier Outline Data

`xxxOUTL.hdr` is a Glacier Outline Header file, where "xxx" is the abbreviated name of the glacier. For example, `BaiOUTL.hdr` is the header file for the Baird Glacier outline data. Table 1 lists the glacier abbreviations. The glacier outline header files contain the following information:

Glacier Name
World Glacier Inventory (WGI) Glacier Number
Glacier Location
Approximate Center of Glacier
Approximate Length
Glacier Type
Included Tributaries/Regions
Maps used to Generate Outline
Data Fields in File (e.g., easting, northing)
File Name

`xxxOUTL.dat` is a Glacier Outline Data file, where "xxx" is the abbreviated name of the glacier (e.g., *BaiOUTL.dat* is the data file for the Baird Glacier outline data). The glacier outline is given in UTM coordinates. The data files contain two fields, either comma-delimited or tab-delimited:

Easting (NAD27, in meters)
Northing (NAD27, in meters)

NAD27 refers to the datum used (the datum is a system of measurement based on earth ellipsoids).

Sample Data Record for *BaiOUTL.dat*:

```
BAIRD GLACIER OUTLINE
EASTING(NAD27),NORTHING(NAD27)
661274.2091,6338096.646
661323.4619,6338027.883
661371.6796,6337988.571
```

1.2 Laser Altimetry Profile Data

`xxxPROF.hdr` is a Laser Altimetry Profile Header file, where "xxx" is the abbreviated name of the glacier. For example, `BaiPROF.hdr` is the header file for the Baird Glacier laser altimetry data.

Table 1 lists the glacier abbreviations. The laser altimetry profile header files contain the following information:

Glacier Name
World Glacier Inventory (WGI) Glacier Number
Glacier Location
Approximate Center of Glacier
Approximate Length
Glacier Type
Geographic Datum
UTM Zone
Profiles
Data Fields in Profile
GPS Processing
Reference
Contact Information
File Names

`xxxJDNp.83a` is a Laser Altimetry Profile Data file, where "xxx" is the abbreviated name of the glacier, JDN is the Julian day number on which data were collected, and p is the altimetry pass number (e.g., *Bai1651.83a* is a data file for the Baird Glacier laser altimetry profile data for pass number 1 collected on Julian day number 165). The data files contain four fields, either tab-delimited or fixed-width separated:

Easting (WGS84, in meters)
Northing (WGS84, in meters)
HAE (height above ellipsoid, in meters)
Error (in meters)

WGS84 refers to the datum used (the datum is a system of measurement based on earth ellipsoids).

Sample Data Record for *Bai1651.83a*:

```
BAIRD GLACIER LASER ALTIMETRY PROFILE  PASS 1
EASTING(m, WGS84)     NORTHING(m, WGS84)    HAE(m, ht above ellipsoid)   ERROR(m)
6.315543600000000e+5  6.330853800000000e+6  4.400000000000000e+0  3.600000000000000e-1
6.315572200000000e+5  6.330860450000000e+6  4.710000000000000e+0  4.300000000000000e-1
6.315578800000000e+5  6.330862100000000e+6  4.500000000000000e+0  1.100000000000000e-1
6.315586800000000e+5  6.330863770000000e+6  4.690000000000000e+0  6.200000000000000e-1
```

1.3 Glacier Surface Elevation Change Data

`xxxDZ.hdr` is a Glacier Surface Elevation Change Header file, where "xxx" is the abbreviated name of the glacier. For example, `BaiDZ.hdr` is the header file for the Baird Glacier surface

elevation change data. Table 1 lists the glacier abbreviations. The glacier surface elevation change header files contain the following information:

Glacier Name
World Glacier Inventory (WGI) Glacier Number
Glacier Location
Approximate Center of Glacier
Approximate Length
Glacier Type
Method For Determining Glacier Elevation Changes
Profiles
Geographic Datum
UTM Zone
Maps Used
Range of Geoid Height
Time Span For Elevation Change
Contact Information
Data Fields
File Name

`xxxDZ.dat` is a Glacier Surface Elevation Change Data file, where "xxx" is the abbreviated name of the glacier. For example, *BaiDZ.dat* is the data file for the Baird Glacier surface elevation change data. The data files contain five fields (either tab-delimited or fixed width separated):

Easting (NAD27, in meters)
Northing (NAD27, in meters)
Map Elevation (NGVD29, in meters)
Profile Elevation (NGVD29, in meters)
Elevation Change (in meters)

NAD27 and NGVD29 refer to the datums used (these datums are systems of measurement based on different earth ellipsoids).

Note: The Hubbard glacier surface elevation change data consist of three files:

- HubCanDZ.dat contains elevation change data for areas of Hubbard Glacier that exist in Canada, with the exception of the southeast basin. Profile year is 2000, aerial photograph years are 1976 and 1977.
- HubSEDZ.dat contains elevation change data for the southeast basin, which enters the main basin north of Mount Seattle. Profile year is 2001, aerial photograph years are 1976 and 1979.

- HubUSADZ.dat contains elevation change data for areas of Hubbard Glacier that exist in the United States. Profile year is 2000, aerial photograph year is 1959.

For more information about the Hubbard Glacier DZ files, please refer to the Hubbard Glacier Notes.

1.4 Glacier Outline and Profile Trackline Plot

`xxxPLOT.jpg` is an image file, where "xxx" is the abbreviated name of the glacier. For example, `BaiPLOT.jpg` is the image file for the Baird Glacier. Table 1 lists the glacier abbreviations. The image file contains a geographic plot of the glacier outline and the laser altimetry profile tracklines in the NAD27 datum.

1.5 Sample Data Record for BaiDZ.dat

```
BAIRD GLACIER SURFACE ELEVATION CHANGES

EASTING(m,NAD27)    NORTHING(m,NAD27)   MAP ELEVATION(m,NGVD29)       PROFILE ELEVATION(m,NGVD29)   ELEVATION CHANGE(m)
6.422415500000000e+56.337055800000000e+66.096000000000000e+25.428180300000000e+2-6.678000000000000e+1
6.417041100000000e+56.336794900000000e+65.791200000000000e+25.170471300000000e+2-6.207000000000000e+1
6.429674300000000e+56.337508700000000e+66.400800000000000e+25.784238900000000e+2-6.166000000000000e+1
```

1.6 File Size

File sizes range from 1 KB to 5.2 MB.

1.7 Spatial Coverage

The 46 glaciers represented in this data set reside in the following eight general locations. Table 1 provides the specific latitude and longitude of each glacier.

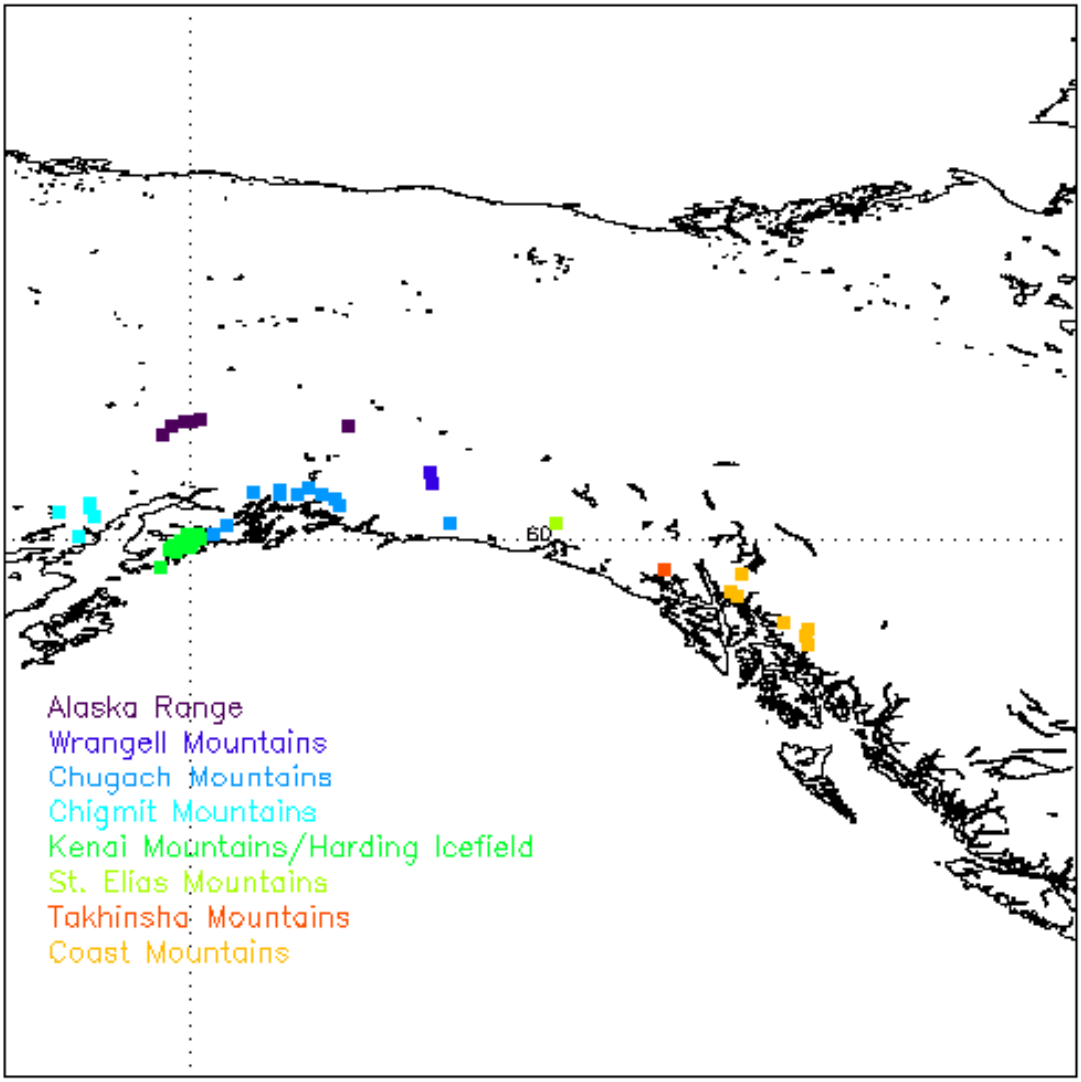
- Central Alaska - Alaska Range: East Fork Toklat, Gulkana Glacier, MIddle Toklat, Muldrow, Ruth, and Scott Peal Toklat Glaciers
- Southcentral Alaska - Wrangell Mountains: Kennicott and Nabesna Glaciers
- Southcentral Alaska - Chugach Mountains: Bear Lake, Bering Glacier-Bagley Icefield, Columbia, Harvard, Knik, Tazlina, Valdez, Wolverine, Worthington, Wortmanns, and Yale Glaciers
- Southcentral Alaska - Chigmit Mountains: Double, Shamrock, Tanaina, Tuxedni, and Turquoise Glaciers
- Southcentral Alaska - Kenai Mountains and Harding Icefield: Aialik, Bear, Chernof, Dinglestadt, Exit, Holgate, Kachemak, Little Dinglestadt, McCarty, Northeastern, Northwestern, Skilak, and Tustumena Glaciers
- Southeast Alaska - St. Elias Mountains: Hubbard Glacier
- Southeast Alaska, in the Takhinsha Mountains: Muir Glacier
- Southeast Alaska and British Columbia - Coast Mountains: Baird, LeConte, Lemon Creek, Llewellyn, Mendenhall, North Dawes, and Triumph Glaciers

Table 1. Glacier Names, Abbreviations, Locations, and WGI Glacier Numbers

GLACIER (Abbrev.)	LATITUDE (N)	LONGITUDE (W)	WGI GLACIER NUMBER
AIALIK (Aia)	59.96700	149.81700	US2N31850000
BAIRD (Bai)	57.23330	132.37500	US2P00101800
BEAR (Bea)	60.05000	149.66700	US2N32050000
BEAR LAKE (Blk)	60.18000	149.25000	US2P00200402
BERING BAGLEY (BerBag)	60.50000	142.50000	US2N00700001
CHERNOF (Che)	59.85800	150.41700	US2N28020000
COLUMBIA (Col)	61.30000	146.88330	US2T00200627
DINGLESTADT (Din)	59.75000	150.50000	US2N28080000
DOUBLE (Dou)	60.66700	152.66700	US2N10499990
EXIT (Exi)	60.16700	149.70000	US2N32630000
GULKANA (Gul)	63.27000	145.42000	US2O01200001
HARVARD (Har)	61.40000	147.38000	US2T00200628
HOLGATE (Hol)	59.86700	149.91700	US2N31680000
HUBBARD (Hub)	60.50000	139.50000	US2T00300001
KACHEMAK (Kac)	59.70000	150.55000	US2N28110000
KENNICOTT (Ken)	61.60000	143.05000	US2N00400604
KNIK (Kni)	61.35000	148.13000	US2N00600001
LECONTE (Lec)	57.00000	132.33333	US2T00101803
LEMON CREEK (Lem)	58.37000	134.35000	US2P00201804
LITTLE DINGLESTADT (Ldg)	59.66700	150.35800	US2N30140000
LLEWELLYN (Llew)	59.00000	134.17000	CD2O010DA001
MCCARTY (Mcc)	59.21700	150.78300	US2N30350000
MENDENHALL (Men)	58.50000	134.53000	US2T00101805
MUIR 1948 (Mui)	59.15000	136.40000	US2N75000010
MUIR 1972 (Mui)	59.15000	136.40000	US2N75000010
MUIR 2000 (Mui)	59.15000	136.40000	US2N75000010
MULDROW (Mul)	63.25000	150.50000	US2O47900010
NABESNA (Nab)	61.92000	143.08000	US2O01200002
NORTH DAWES (NDw)	57.63000	133.00000	US2N84200500
NORTHEASTERN (Nea)	59.80000	149.96700	US2N31350000
NORTHWESTERN (Nwn)	59.88300	150.05000	US2N31250000
RUTH (Rut)	62.98000	150.73000	US2N18503000
SHAMROCK (Sha)	61.05000	152.83300	US2N11800010

GLACIER (Abbrev.)	LATITUDE (N)	LONGITUDE (W)	WGI GLACIER NUMBER
SKILAK (Ski)	60.16700	150.01700	US2N26450000
TANAINA (Tan)	60.91700	152.83300	US2N10605000
TAZLINA (Taz)	61.50000	146.58330	US2N00400602
TOKLAT 1-East Fork (TEF)	63.42000	149.67000	US2O46000100
TOKLAT 2-Middle (TkM)	63.38000	149.91000	US2O46200100
TOKLAT 3-Scott Peak (TSP)	63.38000	150.12000	US2O46300100
TRIUMPH (Tri)	57.44000	132.28000	CD2N001EA555
TURQUOISE (Tur)	60.78300	153.66700	US2O16100010
TUSTUMENA (Tus)	59.95000	150.25000	US2N27250000
TUXEDNI (Tux)	60.12000	153.12000	US2N09100010
VALDEZ (Val)	61.29000	146.20000	US2N00500501
WOLVERINE (Wol)	60.41670	148.90000	US2P00200411
WORTHINGTON (Wor)	61.16667	145.79170	US2N00400603
WORTMANNS (Wrt)	60.95000	145.70000	US2N00500502
YALE (Yal)	61.32000	147.38000	US2T00200629

1.7.1 Spatial Coverage Map



1.7.2 Projection

Universal Transverse Mercator (UTM) projection.

1.8 Temporal Coverage

Glaciers were profiled in May 1994; May and June 1995; June 1996; May, June, and August, 2000; and May and June, 2001.

2 SOFTWARE AND TOOLS

The data can be read with any text editor/reader.

3 DATA ACQUISITION AND PROCESSING

3.1 Data Acquisition Methods

This study used a laser altimeter for measuring the distance from a small aircraft to the glacier surface, a gyro and compass for determining the pointing direction of the laser beam, and continuous kinematic Global Positioning System (GPS) equipment for determining the exact position of the aircraft during the flight over a glacier. Carrier phase measurements were made once per second with two GPS receivers. The laser altimeter (ranger) operated at 905 nm, and sampled at 25 Hz, which corresponds to a measurement interval of about 1.2 m along the surface at a typical aircraft speed of 30m/s. The laser beam footprint diameter was 0.18 m at a distance of 100 m. Reflections were obtained at a maximum distance of 500 m from snow and approximately 200 m from ice, rock, and vegetation. The orientation of the beam was measured by a vertical-axis gyro and a magnetic compass, each sampled at 25 Hz.

The data were stored by an onboard computer and by the GPS receivers, and later processed to give an elevation profile along a specific track on the surface of the glacier. The measured glacier surface elevations were compared to map elevations at the same coordinates to obtain elevation changes over the period of time between the map photo date and the laser profiling date. The glacier profiles were compared to contours on 15-min US Geological Survey (USGS) and Canadian Department of Energy, Mines, and Resources topographic maps made from aerial photographs acquired in the 1950s to early 1970s (depending on location). The investigators digitized contour lines on topographic maps using a Numonics digitizing board and Sigma Scan software. A cubic spline was fit to the contour points to increase the data density. Where a laser altimetry profile crossed a contour line, the nearest profile point to any of the contour points (original or interpolated) was taken as the crossing point (these points were within a few meters horizontally of each other). The measured glacier surface elevation from the profile was compared to the elevation of the contour line from the map. The profile elevation, in height above the ellipsoid, was corrected to the map datum (NGVD29) by subtracting the height of the geoid at the crossing point coordinates (source: NGS Alaska Geoid93 Model or NGS Alaska Geoid99 Model).

3.2 Error Sources

Accuracy of the elevation data is typically 0.3 m or better. Error sources include GPS-determined elevation of the aircraft, and pitch and roll of the aircraft. Accuracy of the profile and elevation change data is approximately 5 m, due to map and digitization errors. Please refer to the following for additional quality and accuracy information:

Echelmeyer, K.A., W.D. Harrison, C.F. Larsen, J. Sapiano, J.E. Mitchell, J. DeMallie, B. Rabus, G. Adalgeirsdottir, and L. Sombardier. 1996. Airborne Surface Profiling of Glaciers: a Case-Study in Alaska. *J. Glaciol.*, 42, 142:538-546.

Supporting Online Material for Arendt, A.A., K.A. Echelmeyer, W.D. Harrison, C.S. Lingle, and V.B. Valentine. 2002. Rapid Wastage of Alaska Glaciers and Their Contribution to Rising Sea Level. *Science*, 297:382-386.

4 REFERENCES AND RELATED PUBLICATIONS

Echelmeyer, K.A., W.D. Harrison, C.F. Larsen, J. Sapiano, J.E. Mitchell, J. DeMallie, B. Rabus, G. Adalgeirsdottir, and L. Sombardier. 1996. Airborne Surface Profiling of Glaciers: a Case-Study in Alaska. J. Glaciol., 42, 142:538-546.

Sapiano, J.J., W.D. Harrison, and K.A. Echelmeyer. 1998. Elevation, Volume and Terminus Changes of Nine Glaciers in North America. J. Glaciol., 44, 146:119-135.

Arendt, A.A., K.A. Echelmeyer, W.D. Harrison, C.S. Lingle, and V.B. Valentine. 2002. Rapid Wastage of Alaska Glaciers and Their Contribution to Rising Sea Level. Science, 297:382-386.

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

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