GROUND PENETRATING RADAR (GPR) DATA ON NORTH AMERICAN GLACIERS

ABSTRACT

U.S. Geological Survey researchers conducted time-series ground-penetrating radar (GPR) surveys with a Sensors and Software 500-MHz Pulse Ekko Pro system. This data release contains ground-based (ski and snowmobile) as well as airborne common-offset profiles. All profiles are linked to coincident GPS observations. Additionally, common-midpoint data was collected at specific glacier locations. Coincident in-situ data may provide calibration information, and may be composed of any of the following: snow pits and/or snow-pit/snow-core combinations, probe profiles, and ablation stake data. This supplemental information provides estimates of snow properties which may be used to calibrate radar velocity.

OVERVIEW:

This document describes the contents of the accompanying GPR data sets.

ORGANIZATION:

GPR data is organized according to the glacier on which it was collected. General folder structure is as follows:

Glacier

- **Glacier_site_locations.csv**
  - Locations of named sites on the glacier, referenced in the "in_situ_data" folder
- **Year**
  - **GPR_data**
    - Contains raw GPR data; one .HD, .GPS, .DT1 file per profile.
  - **in_situ_data**
    - Contains in-situ information on snow depth and density, as available. Not present in some locations and years. The file name takes the format "Glacier_inSitu_Summary_YYYY_DataType.csv". The "SnowDepthAndDensity" files contain information on snow depth and density, at long-term stake sites and pits. The "ProbedSnowDepth" files contain snow depth as probed, and from pits (as indicated) at various locations around the glacier. The location of these sites is found in the Glacier_site_locations.csv file. The "GPR_Fiducials" files contain information on GPR profile collection, specifically, information on what a profile may be covering, and what fiducials (marks within the GPR data file) are indicating, and where depths have been probed along the GPR track.

DETAILS

In some areas, data is grouped into a single collection covering multiple glaciers. This is the case most frequently for airborne campaigns, and a single GPR file may span multiple glaciers; it is indicated by the plural "Glaciers" in the folder label.

Within each glacier's directory, data is organized by year of collection. A summary map, sub-directories of raw GPR data, and in-situ data are provided in year directories. The map shows location of GPR profiles, and direction of travel. Additional information including GPR organization (directory and line number), or date collected may be present. If not presented on map, this information is available in GPR header (.HD) files. The GPR_data folder contains raw GPR data, including a header (.HD), GPS (.GPS), and data (.DT1; sensors and software proprietary files) file for each profile collected. Proprietary files are hosted here for compactness, but can be viewed and processed using a number of freely available applications. These include Matlab GPR, available at http://users.uoa.gr/~atzanis/matgpr/matgpr.html and GPRSoft viewer, available at http://www.geoscanners.com/downloads.htm. Python, R, Octave, or other publicly available data software can be used to display the data visually. Metadata related to hardware settings is available in the .HD file; date of collection in this file may not be correct, depending on time setting of GPR during use. Use this date with caution, and trust dates in in-situ folder or folder label over internal GPR stored date.

Spatial Information

Spatial information (profile location, recorded every 20th trace) is paired to GPR profiles using GPGGA-format NMEA strings, contained within .GPS file (e.g., http://www.gpsinformation.org/dale/nmea.htm). Locations for on-glacier in-situ measurements referenced in Glacier_site_locations.csv files are given in latitude and longitude.

In-situ information:

Stakes, snow pits, and probe data are collected via the USGS Benchmark Glacier Project [*O'Neel et al.*, 2014]. To a large degree, the project follows guidelines in Hubbard and Glasser [2005]. Associated data is released on an approximately annual basis, and is available on a USGS data release page at https://dx.doi.org/10.5066/F7HD7SRF.

For more information about data collection, visit the project website at http://www.usgs.gov/climate_landuse/clu_rd/glacierstudies/ , and if needed, contact USGS principal investigator Dr. Shad O'Neel (soneel@usgs.gov).

Stake: Ablation stakes measured annually/semi-annually provide measurement of surface ablation and annual accumulation. Standard methods are followed [*Hubbard and Glasser*, 2005].

Pit: Snow pits and snow cores dug through annual snow accumulation provide stratigraphic and density data in addition to measurements of snow accumulation. Standard sampling methods are followed [*Hubbard and Glasser*, 2005], with one deviation. Snow pits are dug through first two meters of snow, and snow cores are taken below that depth.

Probe: Grid of 7-9 probe measurements of snow thickness surrounding the stake or snow pit at a distance of 20-40 meters. Given snow depth is the average ± 1 standard deviation of these measurements. In GPR_Fiducials tab of in-situ data, this may also be a single probe, or the average of multiple at a single point along the GPR track.

Other: There may be additional ground information in the form of probe profiles, observations, photographs, snow pits, etc. This information is not standardized; it is included in the "Glacier_inSitu_Summary_YYYY.xlsx" sheets as appropriate.

Use

Users of these data should cite the U.S. Geological Survey and listed authors, and credit the data. When appropriate, please consider co-authorship with the USGS data originators. These data are the result of efforts by many of government and non-government participants in the field, including USGS and various researchers and managers. All publications based on these data should acknowledge all of these efforts. If a publication is based solely on the analysis of this data, we suggest that you involve the authors of this data with the writing and/or review of the manuscript. We would also appreciate receiving a reprint or copy of any publications or reports that make use of the data.

Citation

Please cite this data as:

O'Neel, S., McGrath, D., Wolken, G. J., Whorton, E. N., Candela, S. G., Sass, L. C., McNeil, C. J., Baker, E. H., Peitzsch, E. H., Fagre, D. B., Clark, A. M., Florentine, C. E., Miller, Z. S., Christian, J. E., Christianson, K., Babcock, E. L., Loso, M. G., Arendt, A. A., Burgess, E. W., Gusmeroli, A., 2018, Ground Penetrating Radar Data on North American Glaciers, ver 2.1, September 2018: U.S. Geological Survey data release, https://doi.org/10.5066/F7M043G7.

References

Hubbard, B., and N. F. Glasser (2005), Field techniques in glaciology and glacial geomorphology. Wiley, Chichester. 400p.

O'Neel, S., E. Hood, A. Arendt, and L. Sass (2014), Assessing streamflow sensitivity to variations in glacier mass balance, Clim. Change, 123(2), 329–341, https://doi:10.1007/s10584-013-1042-7.

O'Neel, S. R., Sass, L. C., McNeil, C. and McGrath, D. (2016), USGS Alaska Benchmark Glacier Mass Balance Data - Phase 1; Gulkana and Wolverine Glaciers: U.S. Geological Survey data release, https://doi.org/10.5066/F7HD7SRF.

Sass, L. C., Loso, M. G. and Geck, J. (2017), Point Measurements of Surface Mass Balance, Eklutna Glacier, Alaska, 2008-2015: U.S. Geological Survey data release, https://doi.org/10.5066/F7MP51CB.