High Mountain Asia Average Glacier Thickness Change from Multi-Sensor DEMs, Version 1

USER GUIDE

How to Cite These Data

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

Maurer, J., S. Rupper, and J. Schaefer. 2019. *High Mountain Asia Average Glacier Thickness Change from Multi-Sensor DEMs, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/93BANQZIG1KD. [Date Accessed].

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

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

TABLE OF CONTENTS

1 DATA DESCRIPTION

Himalayan glaciers are crucial suppliers of meltwater to densely populated areas in South Asia. To better understand regional climate forcing and assess resulting impacts on glacier-fed rivers, regional observations of glacier change over multiple decades are necessary.

This data set contains averaged glacier thickness changes for individual glaciers of the Himalayan mountains for two subsequent time periods: 1975 to 2000 and 2000 to 2016. The underlying data are digital elevation models (DEMs), which were derived from imagery from KH-9 HEXAGON, a series of military satellites used by US intelligence agencies for reconnaissance during the Cold War era; and from ASTER, a sensor launched aboard the satellite Terra as part of a cooperative effort between NASA and Japan's Ministry of Economic Trade Industry in 1999.

The DEMs are provided in the related data set *High Mountain Asia Gridded Glacier Thickness Change from Multi-Sensor DEMs* in netCDF format. The data set *High Mountain Asia Glacier Thickness Change Mosaics from Multi-Sensor DEMs* provides mosaics in GeoTIFF format created from these DEMs for the same time periods.

1.1 Parameters

The parameters found in the data files are described in Table 1.

Table 1. Parameter Descriptions

Parameter	Description	Units
id	Randolph Glacier Inventory 5.0 (RGI50) unique ID; example: `id` = RGI50-15.06896	-
pctDeb	Percentage of glacier area that is covered in debris	%
glacierStartMask	Binary grid delineating glacier pixels at the beginning of the analysis interval	-
lon	Longitude	° E
lat	Latitude	° N
VolChj	Volume change	m^3 yr^{-1}
VolChjSig	1-sigma uncertainty estimate of `VolChj`	m^3 yr^{-1}
meanElevCh	Mean elevation change	m yr^{-1}
meanElev_1	1-sigma uncertainty estimate of `meanElevCh`	m yr^{-1}
geoMassBal	Geodetic mass balance	w.e. yr^{-1} (meters water equivalent per year)
geoMassB_1	1-sigma uncertainty estimate of `geoMassBal`	w.e. yr^{-1} (meters water equivalent per year)

Parameter	Description	Units
pctCov	Percentage of glacier area with data coverage	%
demYears	Years of the underlying DEMs used to derive the elevation change trends	Years
geo_mb_num	Duplicate of `geoMassBal`	w.e. yr^{-1} (meters water equivalent per year)

1.2 File Information

1.2.1 Format

The data files are provided as ESRI shapefiles (`.shp`, `.shx`, `.dbf`, and `.prj`). An associated Keyhole Markup Language (`.kml`) file is also provided.

1.2.2 File Contents

Figure 1 is a screenshot of the QGIS user interface displaying the contents of the file `HMA_GlacierAvg_dH_GeodeticMassBalance_Himalayas_1975-2000.shp`. The left side of the figure shows the locations of all the Himalayan glaciers surveyed from 1975 to 2000; the right side lists the parameters for the glacier with Randolph Glacier Inventory 5.0 unique ID 15.02201 (RGI50-15.02201; red dot).

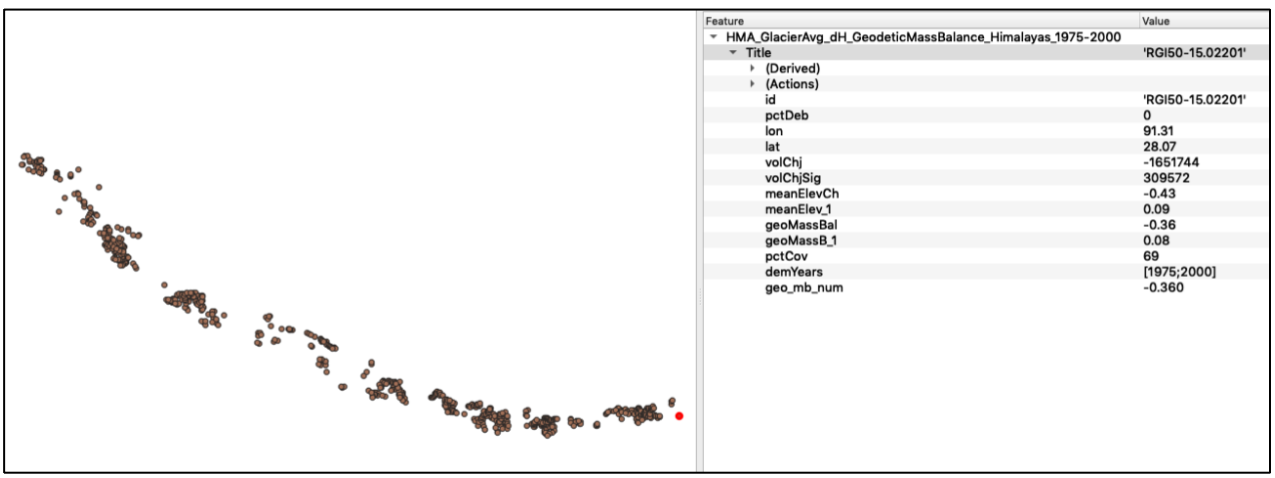

Figure 1. Left: locations of all the Himalayan glaciers surveyed from 1975 to 2000. Right: parameters for the glacier RGI50-15.02201 (highlighted by the red dot on the left). Figure is a screenshot of the QGIS user interface.

1.2.3 Naming Convention

Each file name contains the time period of the calculated thickness change. Example file names include:

```
HMA_GlacierAvg_dH_GeodeticMassBalance_Himalayas_1975-2000.shp
```

The files are named according to the following convention, which is described in detail in Table 2:

```
HMA_GlacierAvg_dH_GeodeticMassBalance_Himalayas_YYYY-yyyy.ext
```

Table 2. File Naming Convention

Variable	Description
HMA_GlacierAvg_dH	Short name for High Mountain Asia Average Glacier Thickness Change from Multi-Sensor DEMs
GeodeticMassBalance_Himalayas	Indicates that this data set provides geodetic mass balances.
YYYY-yyyy	Time period of data averaging: 1975–2000 2000–2016
.ext	File type: .shp, .shx, .dbf, and .prj = ESRI shapefiles .kml = Keyhole Markup Language file

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage includes the High Mountain Asia region, as noted by the spatial extents below.

Northernmost latitude: 34.4° N

Southernmost latitude 27.4° N

Easternmost longitude: 92.9° E

Westernmost longitude: 75.4° E

1.3.2 Resolution

Single point; averaged over each glacier

1.3.3 Geolocation

Table 3 provides geolocation information for this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326

1.4 Temporal Information

1.4.1 Coverage

01 January 1975 to 01 January 2016 (nominal reference period)

The time period of an underlying DEM can extend as early as 01 January 1974 and as late as 31 December 2017.

1.4.2 Resolution

Multi-decadal averages: 1975–2000 and 2000–2016

2 DATA ACQUISITION AND PROCESSING

2.1 Instrumentation

KH-9 Hexagon: Also known as Big Bird or Keyhole-9, KH-9 Hexagon was a series of photographic satellites launched by the US between 1971 and 1986. The KH-9 Hexagon images used in this data set were obtained for reconnaissance purposes between 1973 and 1980 by US intelligence agencies. A telescopic camera system acquired film photographs, which were subsequently ejected in capsules from the satellites and parachuted back to Earth over the Pacific Ocean. The ground resolution of the frame camera is approximately 6 to 9 m, and individual frames overlap by 55 to 70%, allowing for stereo photogrammetric processing.

ASTER: The ASTER satellite sensor is one of the five state-of-the-art instrument sensor systems onboard the satellite Terra, which was launched on 18 December 1999. ASTER's nadir and backward-viewing telescopes provide stereoscopic capability at a ground resolution of 15 m. A single ASTER DEM covers approximately 3600 km^2.

2.2 Acquisition

The KH-9 Hexagon images were digitally scanned by the USGS at a resolution of 7 µm, and are available for download at the USGS EarthExplorer website. For more information on how the DEMs were extracted from overlapping KH-9 Hexagon images, see Maurer et al. (2015).

The ASTER DEMs were downloaded via the METI AIST satellite Data Archive System (MADAS), which is maintained by the Japanese National Institute of Advanced Industrial Science and Technology and the Geological Survey of Japan (AIST).

2.3 Processing

All individual DEMs were processed to minimize cloud errors, spatially co-registered to JPL's Shuttle Radar Topography Mission (SRTM) data set, and resampled to a horizontal resolution of 30 m. Manually refined versions of the Randolph Glacier Inventory (RGI 5.0) were used to delineate glaciers from surrounding terrain, and robust linear trends were fit to every time series of elevation pixels over glacier surfaces using the random sample consensus (RANSAC) method.

To compute the glacier thickness change averages, all of the glacier thickness change pixels (in units of m/yr) are multiplied by their corresponding areas (pixel width x pixel height) and summed up to obtain a total ice volume change for a given glacier. The resulting ice volume change is then divided by the average glacier area to obtain the average glacier thickness change. To compute the average glacier area, the average of the initial and final glacier areas for a given time interval is computed, excluding slopes greater than 45° to remove any cliffs and nunataks.

Note: Due to cloud cover, shadows, and low radiometric contrast, some glacier accumulation zones have gaps in the DEMs and the resulting thickness change maps. To calculate the average thickness changes in this data set, as well as the estimated volume changes and geodetic mass balances, the following method is used: a circular search area with a radius of 50 km around the center of a given glacier is defined. Then, all thickness change pixels from all glaciers in this surrounding region are binned into 50 m elevation bins. Finally, any missing data in the glacier are set to the mean value of this regional bin at the corresponding elevation.

For more information on the acquisition and processing steps, see Maurer et al. (2015).

2.4 Quality, Errors, and Limitations

This data set doesn't provide any specific error quantifications or quality assessments. For more information on the glacier thickness change error, see the documentation for the related data set *High Mountain Asia Gridded Glacier Thickness Change from Multi-Sensor DEMs*.

3 SOFTWARE AND TOOLS

Shapefiles files can be opened using software that recognizes the TIFF file format, such as QGIS and ArcMap. The KML files can be opened with any web browser. Metadata can be extracted using GDAL's ogrinfo tool.

4 RELATED DATA SETS

High Mountain Asia Gridded Glacier Thickness Change from Multi-Sensor DEMs
High Mountain Asia Glacier Thickness Change Mosaics from Multi-Sensor DEMs
High Mountain Asia at NSIDC | Data Sets

5 RELATED WEBSITES

High Mountain Asia at NSIDC | Overview
NASA High Mountain Asia Project
NASA Research Announcement: Understanding Changes in High Mountain Asia

6 CONTACTS

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7 REFERENCES

Maurer, J., & Rupper, S. (2015). Tapping into the Hexagon spy imagery database: A new automated pipeline for geomorphic change detection. ISPRS Journal of Photogrammetry and Remote Sensing, 108, 113–127. https://doi.org/10.1016/j.isprsjprs.2015.06.008

8 DOCUMENT INFORMATION

8.1 Publication Date

12 March 2019

8.2 Date Last Updated

16 March 2020