High Mountain Asia Gridded 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. 2018. *High Mountain Asia Gridded 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/GGGSQ06ZR0R8. [Date Accessed].

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

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

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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 glacier thickness changes for individual glaciers of the Himalayan mountains, in the form of digital elevation models (DEMs). These DEMs 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.

These data are provided as multi-decadal averages for two subsequent time periods: 1975 to 2000 and 2000 to 2016. These time periods represent nominal reference periods; the time period of an individual file can extend as early as 01 January 1974 and as late as 31 December 2017.

1.1 Parameters

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

Note: The netCDF files also contain the global attribute `RGIId` (Randolph Glacier Inventory 5.0 unique ID). E.g.: `RGIId = RGI50-13.26239` for file `HMA_Glacier_dH_2000-2016_RGI50_13_26239.nc`.

Table 1. Parameter Descriptions

Parameter	Description	Units
elevationTrend	Glacier thickness change grid	m/yr
glacierEndMask	Binary grid delineating glacier pixels at the end of the analysis interval	N/A
glacierStartMask	Binary grid delineating glacier pixels at the beginning of the analysis interval	N/A
latitude	Latitudinal referencing vector for the grids	° N
longitude	Longitudinal referencing vector for the grids	° E
timestamps	Years corresponding to acquisition times of DEMs used in the analysis	yr

1.2 File Information

1.2.1 Format

Each data file is provided in netCDF (.nc) and in TIFF (.tif) format. Each netCDF file is paired with an associated XML file (.xml), which contains additional metadata.

1.2.2 File Contents

Figures 1 and 2 show the glacier thickness changes for 1975–2000 and 2000–2016, respectively, on the example of a glacier with Randolph Glacier Inventory 5.0 unique ID 13.26239 (RGI50-13.26239).

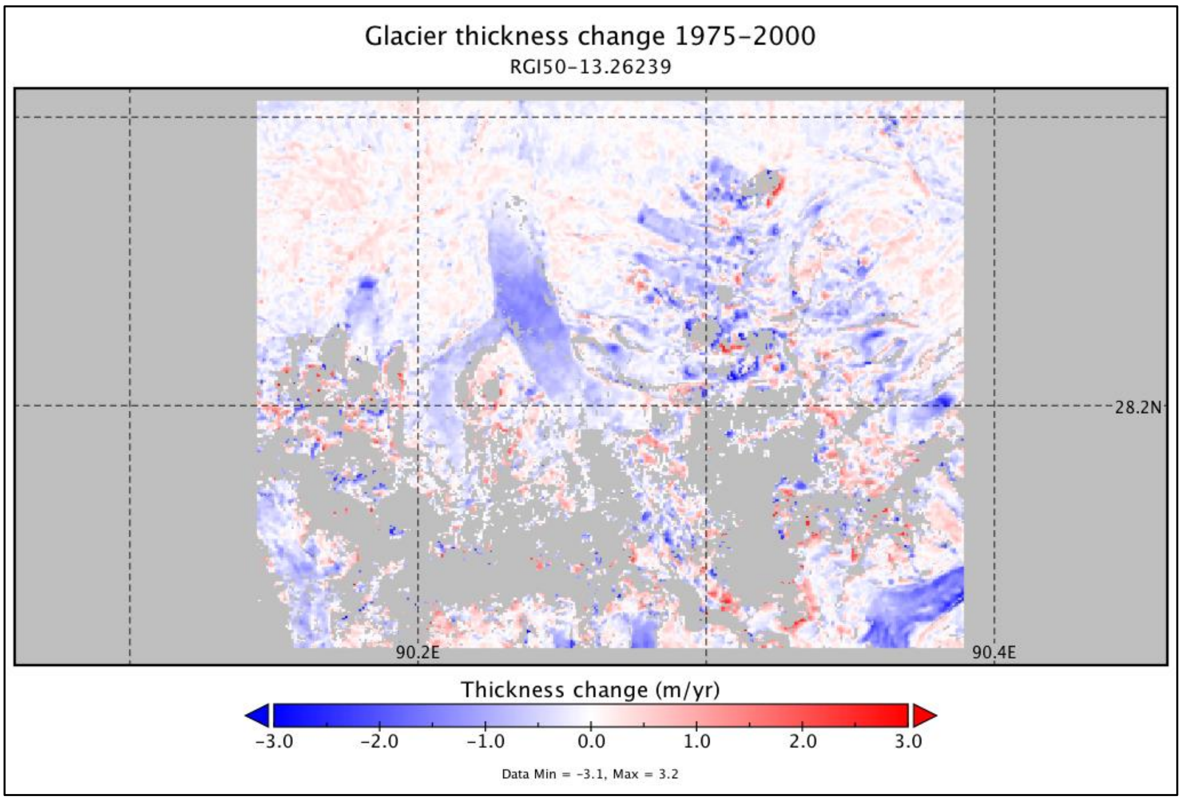

Figure 1. Thickness change for glacier RGI50-13.26239 from 1975 to 2000. Figure created using the netCDF-visualization software Panoply.

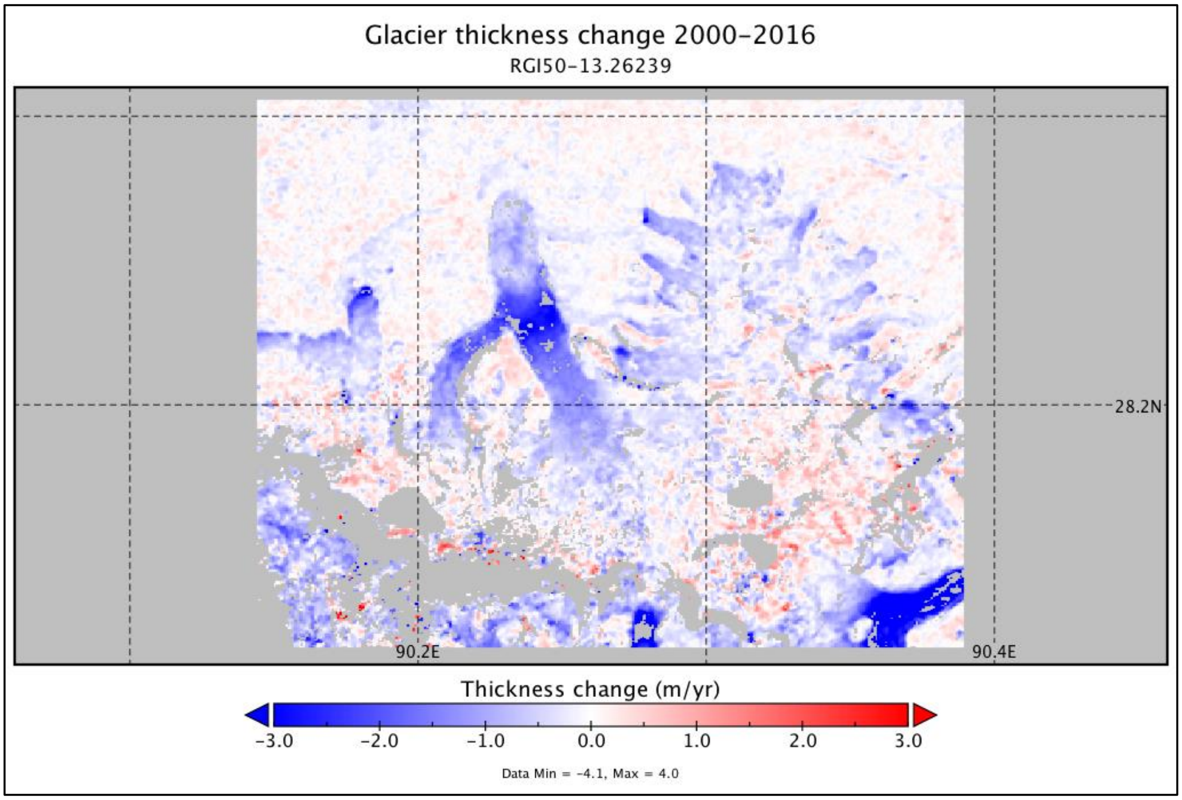

Figure 2. Thickness change for glacier RGI50-13.26239 from 2000 to 2016. Figure created using the netCDF-visualization software Panoply.

1.2.3 Naming Convention

Each file name contains the time period of the calculated thickness change and the Randolph Glacier Inventory (RGI 5.0) unique ID. Example file names include:

```
HMA_Glacier_dH_2000-2016_RGI50_13_04767.tif
HMA_Glacier_dH_2000-2016_RGI50_13_04767.nc
HMA_Glacier_dH_2000-2016_RGI50_13_04767.nc.xml
```

The files are named according to the following convention and as described in Table 2.

```
HMA_Glacier_dH_YYYY-yyyy_RGI50_xx_xxxxx.ext
```

Table 2. File Naming Convention

Variable	Description
HMA_Glacier_dH	Short name for High Mountain Asia Gridded Glacier Thickness Change from Multi-Sensor DEMs
YYYY-yyyy	Time period of data averaging: 1975–2000 2000–2016

Variable	Description
RGI50_xx_xxxxx	Randolph Glacier Inventory (RGI 5.0) unique ID; the dash and period were replaced by underscores; e.g., RGI50-13.26239 becomes RGI50_13_26239.
.ext	File type: `.tif` = TIFF data file `.nc` = netCDF data file `.nc.xml` = XML metadata file

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage includes the Himalayas, 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

30 m by 30 m

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 periods of individual files 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 km2.

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.

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

2.4 Quality, Errors, and Limitations

The glacier thickness change error can be quantified by analyzing the vertical elevation change over assumed stable (non-glacier) terrain, which is expected to be close to zero. For the full data set, the mean and standard deviation of elevation change over non-glacier terrain is 0.00 and 0.42 m/yr, respectively. Users should note that the data quality and coverage varies between glaciers and sub-regions, with many glaciers exhibiting incomplete coverage over accumulation zones as a result of sensor oversaturation due to areas of high albedo, such as bright snow.

3 SOFTWARE AND TOOLS

NetCDF files can be opened using netCDF-visualization software such as Panoply.

Software that recognizes the TIFF file format includes QGIS and ArcMap. The metadata fields can be extracted using the gdalinfo command line utility available from the Geospatial Data Abstraction Library (GDAL) website.

4 RELATED DATA SETS

High Mountain Asia Glacier Thickness Change Mosaics from Multi-Sensor DEMs
High Mountain Asia Average Glacier Thickness Change 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