High Mountain Asia 2 m DEM, Surface Velocity, and Lagrangian Surface Mass Balance for Select Debris Covered Glaciers, Version 1

USER GUIDE

How to Cite These Data

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

Bhushan, S., D. Shean, J. M. Hu, G. Guillet, and D. R. Rounce. 2024. *High Mountain Asia 2 m DEM, Surface Velocity, and Lagrangian Surface Mass Balance for Select Debris Covered Glaciers, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/DARPX4AR2OYO. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/HMA2_DCG_SMB

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This High Mountain Asia data set contains 2 m resolution digital elevation models (DEMs), surface velocities, surface mass balance (SMB) rates, and SMB uncertainties for six debris-covered glaciers in Nepal.

SMB rate is estimated by applying a Lagrangian specification to DEMs derived from very-high-resolution optical stereo imagery acquired by Maxar Technologies satellites WorldView-1, WorldView-2, WorldView-3, and GeoEye-1.

ⓘ This data set was granted permission for public release on 1 March 2024 under the National Reconnaissance Office (NRO) Electro-Optical Commercial Layer (EOCL) program.

1.1 Parameters

Digital elevation model (DEM)
Surface velocity magnitude (VM)
E → W surface velocity component (VX)
N → S surface velocity component (VY)
Lagrangian surface mass balance (SMB)
Lagrangian SMB uncertainty (SMB-ERR)
Eulerian height change (DH)

1.2 File Information

1.2.1 Format

GeoTIFF
PNG

1.2.2 File Contents

Data are available for the following six glaciers:

- Imja Lhotse Shar (ILS)
- Khumbu (KHU)
- Black Changri Nup (BCN)
- Ngozumpa (NGO)
- Langtang (LNG)
- Lirung (LIR)

For each of the glaciers listed above, an annual product is available that was derived from DEM pairs approximately one or two years apart.

In addition, seasonal products—analyses generated from shorter temporal baselines spanning the summer and winter seasons—are available for BCN and LIR.

For both the annual and seasonal products, DEM values are instantaneous for the date/time in the file name. Surface velocities, Lagrangian SMB rates, SMB, and Eulerian elevation change span the dates indicated in the file name.

Table 1 lists the satellite source and acquisition dates for the stereoscopic images used to construct the DEMs. Additional details are available in Bhushan et al.

1.2.2.1 Annual Products

Annual products consist of the following parameters stored in separate GeoTIFF files:

- DEMs (2), m above the WGS 84 ellipsoid (G1762)
- VM (1), m/yr
- VX (1), m/yr
- VY (1), m/yr
- Lagrangian SMB rate (1), m/yr
- Lagrangian SMB-ERR (1), m/yr

Annual DEMs are also available as PNG browse images.

1.2.2.2 Seasonal Products

The BCN seasonal product consists of the following GeoTIFF files. Note that this seasonal product reports SMB (as opposed to SMB rate) due to the shorter intervals between observations:

- DEM (3), m above the WGS 84 ellipsoid (G1762)
- VM (2), m/day
- VX (2), m/day
- VY (2), m/day
- Lagrangian SMB (2), m

The LIR seasonal product[1] comprises the following GeoTIFF files:

- DEM (3), m above the WGS 84 ellipsoid (G1762)
- DH (3), m

Seasonal DEMs are also available as PNG browse images.

Table 1. Satellites and Image Acquisition Dates by Glacier

Glacier	Acquisition Date	Satellite
Imja Lhotse Shar (ILS)	02 Oct 2015	WorldView-1
	29 Oct 2016	WorldView-2
Khumbu (KHU)	02 Nov 2015	WorldView-3
	25 Oct 2016	WorldView-3
Black Changri Nup (BCN)	02 Nov 2015	WorldView-3
	22 Apr 2016[2]	WorldView-2
	25 Oct 2016	WorldView-3
Ngozumpa (NGO)	23 Dec 2012	GeoEye-1
	15 Jan 2015	WorldView-3
Langtang (LNG)	22 Feb 2015	WorldView-3
	07 Jan 2016	WorldView-2
Lirung (LIR)	22 Jan 2015[2]	WorldView-3
	08 May 2015[2]	WorldView-3
	29 Dec 2015[2]	WorldView-1
	06 Nov 2016	WorldView-2
	22 Dec 2017	WorldView-1

[1]The seasonal analysis for Lirung Glacier was generated to document the 25 April 2015 Gorkha Earthquake. Because the source images that bracket this event contain deposition from avalanches triggered by the earthquake, which obscure the surface features needed to construct velocity maps, the analysis was limited to Eulerian elevation changes, without any additional corrections.
[2]Observation used for seasonal analysis.

1.2.3 Naming Convention

Data files utilize the following naming convention:

Convention

HMA2_DCG_SMB_[glac]_[prod]_[param]_[date]T[time]Z_V[nn.n].[ext]

HMA2_DCG_SMB_[glac]_[prod]_[param]_[date1]-[date2]_V[nn.n].[ext]

Examples

HMA2_DCG_SMB_ILS_ANNUAL_DEM_20151002T0651Z_V01.0.tif

HMA2_DCG_SMB_ILS_ANNUAL_DEM_20161029T0451Z_V01.0.tif

HMA2_DCG_SMB_ILS_ANNUAL_SMB_20151002-20161029_V01.0.tif

HMA2_DCG_SMB_BCN_SEASONAL_VM_20151102-20160422_V01.0.tif

HMA2_DCG_SMB_BCN_SEASONAL_VX_20151102-20160422_V01.0.tif

HMA2_DCG_SMB_BCN_SEASONAL_VY_20151102-20160422_V01.0.tif

Table 2. File Naming Convention Variables and Descriptions

Variable	Description
HMA2_DCG_SMB	Unique identifier for the “High Mountain Asia 2 m DEM, Surface Velocity, and Lagrangian Surface Mass Balance for Select Debris Covered Glaciers” data set
glac	Glacier: ILS, KHU, BCN, NGO, LNG, or LIR (see “Section 1.2.2 | File Contents“)
prod	Product: ANNUAL or SEASONAL
param	Parameter: DEM, SMB, SMB-ERR, VM, VX, VY, or DH (see “Section 1.2.2 | File Contents“)
date	DEM image acquisition date in YYYYMMDD format
time	DEM image acquisition time in HHMM format. “Z” indicates UTC time.
date1 - date 2	Date range for SMB, SMB-ERR, VM, VX, VY, and DH
Vnn.n	Major and minor version. E.g., V01.0 = Version 1 (initial release)
ext	File extension. tif (GeoTIFF) or png (browse images)

1.3 Spatial Information

1.3.1 Coverage

The six glaciers evaluated by this data set lie within the following two bounding boxes. The locations of the glaciers within these boxes is illustrated in Figure 1.

N: 28.39° N
S: 28.20° N
E: 85.77° E
W: 85.51° E

N: 28.12° N
S: 27.85° N
E: 87.0° E
W: 86.64° E

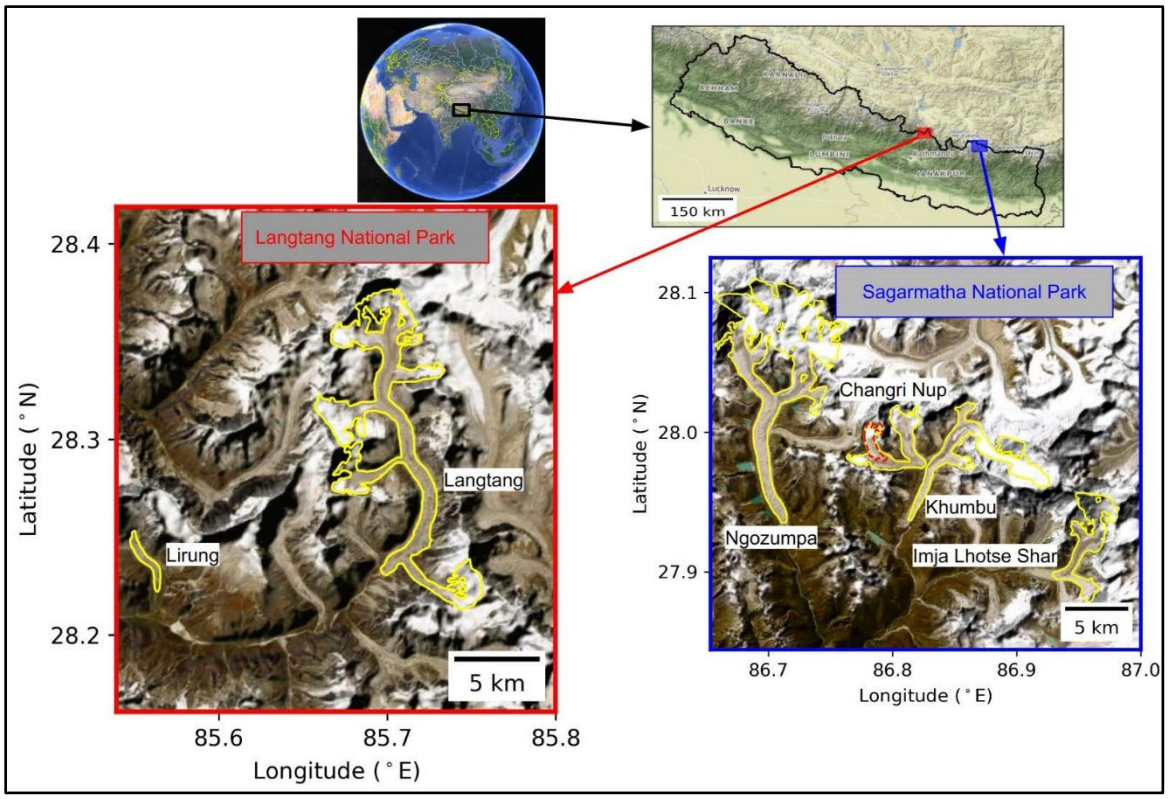

Figure 1. Bounding Box and Glacier Locations (from Bhushan et al.)

1.3.2 Resolution

2 m

1.3.3 Geolocation

Data are provided in EPSG:32645 (WGS 84/UTM Zone 45N). A complete description of the coordinate reference system is stored in file metadata of the GeoTIFF data files.

1.4 Temporal Information

1.4.1 Coverage

23 December 2012 through 22 December 2017

Although the imagery used to generate this data set spans the date range above, coverage for any given glacier is approximately 1 – 2 years. Table 1 in “Section 1.2.2 | File Contents“ lists the image acquisition dates (i.e., date ranges) for each glacier.

1.4.2 Resolution

Annual (all six glaciers)
Seasonal (BCN and LIR)

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

This data set was generated from archived, cloud-free, Level-1B panchromatic stereo images, acquired between 23 December 2012 and 22 December 2017, with ground sample distances of 0.3 m to 0.5 m within the study sites.

2.2 Processing

In-track stereo images were processed using the NASA Ames Stereo Pipeline (Beyer et al., 2018) to create DEM pairs posted at 2 m, with temporal baselines of approximately one or two years. For each glacier site and time period, DEM pairs were first co-registered and then feature tracking was applied to DEM shaded relief products to produce surface velocity maps. Finally, a Lagrangian specification was used to combine the velocity maps and create maps of flow-corrected glacier surface mass balance.

Height changes for the LIR seasonal product were generated based on surface elevation differences between co-registered DEMs and an Eulerian approach, without further correction.

These procedures are described in detail in Bhushan et al. Additional information and resources are available from the data producers’ GitHub repository (archived on Zenodo).

3 VERSION HISTORY

Version 1 (initial release)

4 RELATED WEBSITES

High Mountain Asia (NSIDC)

NASA's High Mountain Asia Team

GitHub Repository | uw-cryo/debris_cover_smb (archived on Zenodo)

5 ACKNOWLEDGMENTS

This data set was granted permission for public release on 1 March 2024 under the National Reconnaissance Office (NRO) Electro-Optical Commercial Layer (EOCL) program.

6 REFERENCES

Bhushan S., D. Shean, J.M. Hu, G. Guillet, and D. R. Rounce (2024). Deriving seasonal and annual surface mass balance for debris-covered glaciers from flow-corrected satellite stereo DEM time series. Journal of Glaciology 1–22. https://doi.org/10.1017/jog.2024.57

Beyer, R. A., Alexandrov, O., & McMichael, S. (2018). The Ames Stereo Pipeline: NASA's Open Source Software for Deriving and Processing Terrain Data. In Earth and Space Science (Vol. 5, Issue 9, pp. 537–548). American Geophysical Union (AGU). https://doi.org/10.1029/2018ea000409

7 DOCUMENT INFORMATION

7.1 Publication Date

October 2024

7.2 Date Last Updated

October 2024