# High Mountain Asia Daily 5km Landslide Hazard Indicator, Version 1

# USER GUIDE

**How to Cite These Data**

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

Stanley, T. A., R. B. Soobitsky, P. M. Amatya, and D. B. Kirschbaum. 2024. *High Mountain Asia Daily 5km Landslide Hazard Indicator, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/CU0JWHT2RNIW. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/HMA2_LHI

National Snow and Ice Data Center

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# 1 DATA DESCRIPTION

This data set projects the daily hazard of rainfall-triggered landslides in the High Mountain Asia region from 2015 through 2100, at 5 km resolution. Projections are provided for two Shared Socioeconomic Pathways (SSPs)—SSP2-4.5 and SSP5-8.5—based on temperature and precipitation projections from a 30-member ensemble climate model.

Landslide hazard is represented by a landslide hazard indicator (LHI), computed with a machine learning model trained on historical temperatures and precipitation and a catalog of documented landslides.

The historical landslides used to train the model are available as a separate record.

ⓘ The Shared Socioeconomic Pathways, or SSPs, comprise five different projected climate futures based on both emissions scenarios and socioeconomic factors, such as population, economic growth, education, urbanization, and technological development. See Riahi et al 2017 for details.

## 1.1 Parameters

Landslide hazard indicator (LHI). See “Section 2 | Data Acquisition and Processing” for more information.

## 1.2 File Information

### 1.2.1 Format

NetCDF-4

### 1.2.2 File Contents

Projection data files contain 10 years of daily LHIs (except for the initial 6-year period from 2015-2020), stored in d × 520 × 1020 (d, lat, lon) arrays, where d = the number of days of data in the file. As a result, d = 2192 for the file spanning 1 January 2015 through 31 December 2020; d = 3652 or 3653 for the decadal files, depending on whether the decade contains two or three leap years.

Historical data files each contain a single day of data (i.e., d = 1). As such, LHIs in historical files are stored in 520 × 1020 arrays.

Both the projection and historical files contain the variables listed in the following table:

Table 1. Data File Variables and Descriptions

| Variable | Description | Dimensions | Data Type |
|---|---|---|---|
| LHI | Landslide hazard indicator, expressed as 0 ≥ LHI ≥ 1 (actual range: 0.000007 ≥ LHI ≥ 0.0012345). Fill/no-data value = -9999.0. | d × 520 × 1020 or 520 × 1020 | 32-bit float |
| crs | Information about the coordinate reference system, stored as attributes. | Empty array | 64-bit int |
| latitude | Latitude (°N) | 1 × 520 | 64-bit float |
| longitude | Longitude (°E) | 1 × 1020 | 64-bit float |
| time | Days since first day of data. E.g., for decades with d = 3652, time = [0, 1, 2,…3651]. For the historical arrays, “time” is an empty array. | d × 1 or empty array | 64-bit int |

## 1.2.3 Naming Convention

The following sections describe the file naming conventions for the projection and historical data files.

### 1.2.3.1 Projection

**Example**

HMA2_LHI_SSP245_r16_20410101-20501231_v01.0.nc

**Naming Convention**

HMA2_LHI_SSP[nnn]_r[xx]_[StartDate]-[EndDate]_v[MM].[m].nc

The following table describes the variables in the projection file naming convention.

Table 2. Projection File Name Variables and Descriptions

| Variable | Description |
|---|---|
| HMA2_LHI | High Mountain Asia Daily 5km Landslide Hazard Indicator data set |
| SSP[nnn] | Either “SSP245” (SSP2-4.5) or “SSP585” (SSP5-8.5) |
| r[xx] | Two-digit realization index (r01, r02, r03…r30) corresponding to the downscaled SPEAR climate model ensemble member used as input. See “Section \| 2.3” for details. |
| StartDate, EndDate | File start date and end date in YYYYMMDD format |
| v[MM].[m] | Data set major [MM], minor [m] version number. E.g., v01.0 = Version 1.0 |
| nc | NetCDF file extension |

#### 1.2.3.2 Historical

**Example**

HMA2_LHI_hist_20180111T1900PKT_v01.0.nc

**Naming Convention**

HMA2_LHI_hist_[DataDate]T[StartTime]PKT_v[MM].[m].nc

Table 3. Historical File Name Variables and Descriptions

| Variable Name | Description |
|---|---|
| HMA2_LHI | High Mountain Asia Daily 5km Landslide Hazard Indicator data set |
| hist | Historical data |
| DataDate | Year (YYYY), month (MM), and (DD) of the file |
| T[StartTime]PKT | Start time (hhmm) of file, Pakistan Standard Time (PKT)[1] (UTC+5). Historical files span the 24 hour period from 19:00:00 PKT (14:00:00 UTC) on the day specified in the file name to 18:59:59 PKT (13:59:59 UTC) on the following day. |
| v[MM].[m] | Data set major [MM], minor [m] version number. E.g., v01.0 = Version 1.0 |
| nc | NetCDF file extension |

## 1.3 Spatial Information

### 1.3.1 Coverage

N: 46° N

S: 20° N

E: 111° E

W: 60° E

### 1.3.2 Resolution

5 km

### 1.3.3 Geolocation

The following table contains information for geolocating this data set.

[1]As of this data set's publication (February 2024), the High Mountain Asia region of interest does not observe daylight savings time (i.e., remains on PKT for the entire year).

Table 4. Geolocation Details

| | |
|---|---|
| **Geographic coordinate system** | World Geodetic System 1984 |
| **Projected coordinate system** | N/A |
| **Longitude of true origin** | Prime Meridian, Greenwich |
| **Latitude of true origin** | N/A |
| **Scale factor at longitude of true origin** | N/A |
| **Datum** | WGS 84 |
| **Ellipsoid/spheroid** | WGS 84 |
| **Units** | degree |
| **False easting** | N/A |
| **False northing** | N/A |
| **EPSG code** | EPSG: 4326 |
| **PROJ4 string** | +proj=longlat +datum=WGS84 +no_defs +type=crs |
| **Reference** | https://epsg.org/crs_4326/WGS-84.html |

## 1.4 Temporal Information

### 1.4.1 Coverage

1 Jan 2015 through 31 Dec 2100

1 Feb 1990 through 1 Jan 2019

### 1.4.2 Resolution

Daily

# 2 DATA ACQUISITION AND PROCESSING

## 2.1 Background

High Mountain Asia (HMA) is an established hotspot for landslides. Landslide hazard in the region will likely increase over the coming decades, given more frequent extreme precipitation events and the nonlinear response of landslides relative to increasing global temperatures. As these changes will vary geographically, having a broad view of the hazard across the whole HMA region will be beneficial.

## 2.2 Acquisition

The following data sets were used to train the machine learning model and project the LHIs:

- High Mountain Asia Daily 0.05 x 0.05 deg Noah-MP Land Surface Model Reanalysis, Version 1
- High Mountain Asia Landslide Catalog, Version 2
- High Mountain Asia Daily 5 km Downscaled SPEAR Precipitation and Air Temperature Projections, Version 1

## 2.3 Processing

Historical LHIs were first constructed by training a machine-learning model on historical temperature and precipitation data from High Mountain Asia Daily 0.05 x 0.05 deg Noah-MP Land Surface Model Reanalysis, Version 1 and landslides in the High Mountain Asia Landslide Catalog, Version 2. LHIs for 2015 through 2100 were then projected for SSP2-4.5. and SSP5-8.5 using the downscaled temperatures and precipitation data in High Mountain Asia Daily 5 km Downscaled SPEAR Precipitation and Air Temperature Projections, Version 1.

The LHI is designed such that the sum of LHIs in a given space/time domain matches the total number of grid cells with a recorded landslide—not the total number of landslides in the domain, which could be higher. For this reason, and because the landslide catalog is substantially incomplete in the HMA region, the LHI represents a minimum level of landslide hazard. Nevertheless, it can be used to analyze trends in landslide seasonality and hazard that cannot be detected as reliably from biased or short-term landslide inventories alone.

## 2.4 Quality, Errors, and Limitations

This data set relies on static representations of soils, topography, seismicity, and lithology. In addition, it assumes landslide risk across the region can be inferred from the High Mountain Asia Landslide Catalog, even though the catalog is neither complete nor unbiased.

# 3 VERSION HISTORY

Version 1 (initial release)

# 4 RELATED DATA SETS

- High Mountain Asia Daily 0.05 x 0.05 deg Noah-MP Land Surface Model Reanalysis, Version 1
- High Mountain Asia Landslide Catalog, Version 2

- High Mountain Asia Daily 5 km Downscaled SPEAR Precipitation and Air Temperature Projections, Version 1

# 5 RELATED WEBSITES

NASA's High Mountain Asia Team

# 6 ACKNOWLEDGMENTS

The data providers would like to thank Fadji Maina[2] for providing easy access to and information about the historical temperature and precipitation data. They also thank Efthymios Nikolopoulos[3] and Diogo Stalin De Alcantara Araujo[3] for providing the downscaled precipitation data.

# 7 REFERENCES

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J. C., KC, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., … Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change (Vol. 42, pp. 153–168). Elsevier BV. https://doi.org/10.1016/j.gloenvcha.2016.05.009

# 8 DOCUMENT INFORMATION

## 8.1 Publication Date

February 2024

## 8.2 Date Last Updated

March 2024

[2]Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland
[3]Hydrology and Remote Sensing, Department of Civil & Environmental Engineering, Rutgers University-New Brunswick, Piscataway, NJ