MEaSUREs Greenland Monthly Image Mosaics from MODIS, Version 1

USER GUIDE

How to Cite These Data

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

Haran, T., J. Bohlander, T. Scambos, and I. Joughin. 2017, updated 2018. *MEaSUREs Greenland Monthly Image Mosaics from MODIS, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/6L166FFRPCPP. [Date Accessed].

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FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0724

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This data set consists of monthly image mosaics of Greenland that include surface morphology derived from high-pass filtered MODIS Band 1 (red light) images. Scenes were selected to provide nearly cloud-free views of the coastal and ice front calving areas of the main ice sheet, including the ice caps on Baffin Island, Devon Island, Axel Heiberg Island, and Ellesmere Island. Each of the monthly mosaics were assembled from between 5 and 56 (typically 10) MODIS scenes (five-minute segments of swath data) selected from the MODIS/Aqua and MODIS/Terra Calibrated Radiances 5-Min L1B Swath 250 m data sets (MYD02QKM and MOD02QKM) for each day-lit month (March – September). Scenes were manually cloud masked and then mosaicked using:

- A stacking technique (data cumulation) that allows multiple images to contribute to a single grid cell's representation.
- A weighting scheme that favors near-nadir views and feathers the edges of contributing images.

1.1 Parameters

The image mosaics report surface morphology, and the glacier ice edge at the calving fronts in fjords, derived from brightness variations in MODIS Band 1 red light images. Many processing steps were required to create a seamless and uniform surface morphology mosaic from the numerous images that contributed to each grid cell. As such, the image values no longer have a clearly quantifiable relationship to the top-of-atmosphere, red light reflectance, from which they were derived. Instead, the mosaics provide semi-quantitative but highly consistent approximations of the surface shape and reflectivity, as illuminated by the sun across all surface types.

1.1.1 Sample Data Record

Figure 1. Sample mosaic of data collected for March 2008

1.2 File Information

1.2.1 Format

The files in the data set are provided in GeoTIFF (`.tif`) format.

1.2.2 Directory Structure

Data are available via HTTPS in the following directory:

`https://n5eil01u.ecs.nsidc.org/MEASURES/NSIDC-0724.001/`

Within this directory, the folders are named for each year, month, and day of the data collection, for example: `/01.03.2008/`.

The directory contains 126 files: 2 files for the months of March through September for each year from 2008 to 2016. One file provides the mosaic at a spatial resolution of 100 m and the other file provides it at a resolution of 500 m.

1.2.3 Naming Convention

This section explains the file naming convention, with examples, of the files in this data set. Table 1 describes the variables of the naming convention.

1.2.3.1 Example File Names

`mog100_200806_hp1_v01.tif`

`mog500_200806_hp1_v01.tif`

1.2.3.2 File Naming Convention

`mog[resolution]_[YYYYMM]_v01.[ext]`

Table 1. File Naming Convention

Variable	Description
mog[resolution]	Mosaic of Greenland at either 100 m or 500 m resolution
YYYY	Year
MM	Month
hp1	Surface morphology (high-pass filtered Band 1) image map
.v01	Version number
.tif	GeoTIFF file extension

1.2.4 File Size

The 100 m resolution `.tif` files range from 104 MB to 486 MB and the 500 m resolution `.tif` files range from 5.5 MB to 25.2 MB.

The total data volume of this data set is approximately 24 GB.

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage for this data set includes Greenland, as noted by the coverage below.

- Northernmost Latitude: 85° N
- Southernmost Latitude: 57° N
- Easternmost Longitude: 11° E
- Westernmost Longitude: 109° W

1.3.2 Resolution

The data are provided at both 100 m and 500 m resolutions. The underlying MODIS Band 1 and 2 swath data have a nominal resolution of 250 m; however, the image stacking scheme used to assemble the mosaics increases the resolution of the final product beyond that of individual MODIS scenes to between 150 m and 250 m, depending on the number of images that were stacked and how the images were weighted. See the Surface Morphology Image Map section of this document for information on Compositing via Data Cumulation.

1.3.3 Projection and Grid Description

GeoTIFFs are provided in a WGS84 polar stereographic grid with a standard latitude of 70° N and rotation angle of -45° (sometimes specified as a longitude of 45° W). With this convention, the y-axis extends south from the North Pole along the 45° W meridian (EPSG 3413).

Table 2 lists the dimensions (in pixels) for the 100 m and 500 m grids and the locations (in meters from the origin) of the upper left corner of the upper left cell:

Table 2. Grid Dimensions

Grid	x	y	Upper Left Corner, Upper Left Cell
100 m	21000 px	28000 px	-1200000.0 m from origin
500 m	4200 px	5600 px	-600000.0 from origin

NOTE: For both the 100 m and 500 m grids, the upper left corner of the upper left cell is located 1,200,000 m west and 600,000 m south of the origin, (i.e. the North Pole). Grids do not include the North Pole.

1.4 Temporal Information

1.4.1 Coverage

01 March 2008 to 30 September 2016

1.4.2 Resolution

Monthly

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Since the 1990s, studies have demonstrated that carefully processed satellite radiometry, most notably from the Landsat series and NOAA's AVHRR instruments can reveal unprecedented details about the surface morphology of ice sheets.

The twin MODIS instruments on board NASA's Terra and Aqua satellites provide an opportunity to exploit two active sensors during the compilation period with a higher spatial and radiometric resolution than AVHRR. In addition, this data set improves the accuracy, detail, and seamlessness of the final products by combining new methods with several preexisting techniques.

2.2 Acquisition

The MODIS scenes were selected to maximize clear-sky area and coverage of the Greenland coastline.

2.3 Derivation Techniques and Algorithms

2.3.1 Geolocation and Processing

The scenes used to create the image maps were selected from a combination of Collections 4, 5, and 6 MODIS/Aqua and MODIS/Terra data sets (MYD02QKM and MOD02QKM). Band 1 and Band 2 scenes from MYD02QKM and MOD02QKM, together with illumination and viewing angles from MYD03 and MOD03[1], were geolocated and resampled onto the projection grid using NSIDC's MODIS Swath-to-Grid Toolbox (MS2GT). The software interpolated the MYD03 and MOD03 latitude/longitude data from 1 km resolution to 250 m and then resampled the MODIS/Aqua and MODIS/Terra Level-1B calibrated radiances to the grid using a forward elliptical weighted average algorithm (Greene et al., 1986).

[1]MODIS Level 1A Geolocation Fields from EOS Aqua and EOS Terra

2.3.2 Destriping of MODIS Image Data

The MS2GT algorithm was modified to remove MYD02QKM and MOD02QKM striping artifacts, a known problem with all Terra and Aqua MODIS 250 m Level-1B data, by adding a Lambertian solar zenith angle normalization on the swath data for both bands. Telemetry noise and line drops, which have the appearance of chads in the projected images, were reset to zero (treated as masked

cloud areas). This procedure is discussed in detail in the Destriping of MODIS Image Data section of the MOA2004 documentation.

2.3.3 Cloud Masking

The geolocated scenes were manually masked to remove clouds, cloud shadows, fog, blowing snow, and heavy surface frost. Refer to the Cloud Masking section of the MOA 2004 documentation. The final image maps are nearly perfectly cloud-cleared, except for some areas of thin clouds, cirrus cloud shadows, and fog or low-lying small clouds.

2.3.4 Surface Morphology Image Map

Geolocated and destriped Band 1 images were high-pass filtered to reduce non-Lambertian illumination and to reset the mean grayscale range to a common value for compositing. For each gridded image, the investigators created a corresponding weight image in which each non-masked pixel is assigned a scalar value or weight. Weights were computed based on proximity to the nadir track, favoring near-nadir areas, and proximity to an image or mask edge to feather the edges of the component images. Finally, weight images were then combined using stacking techniques called image super-resolution or data cumulation. These techniques allow multiple images to contribute to how a single grid cell is represented in the final composite.

The algorithms used to compute and combine the weight images into the final mosaics are provided in the MOA2004 Compositing the Image Swaths documentation.

2.4 Quality, Errors, and Limitations

2.4.1 Error Sources

Wolfe et al. (2002) estimated the accuracy of the MYD03/MOD03 Level-1A geolocation data to be 50 m, considerably better than the MYD02QKM/MOD02QKM ground-equivalent nadir pixel size of 250 m. The accuracy and precision of this geolocation was also tested for the MOA2004 using known surface sites, such as South Pole Station, Vostok Station, Siple Dome camp and traverse trail, and areas of well-mapped coastline such as Ross Island and the northern Antarctic Peninsula. The investigators did not find discrepancies greater than 125 m in the projected location of any fixed object.

2.5 Instrumentation

2.5.1 Description

The MODIS instruments collect 12-bit radiometric data in 36 spectral bands, ranging from 0.4 µm to 14.4 µm in wavelength. Bands 1 and 2 are imaged at a nominal resolution of 250 m at nadir. The Terra satellite crosses the equator from north to south (descending node) at 10:30 AM local time; Aqua crosses from south to north (ascending node) at 1:30 PM local time. Both satellites occupy sun-synchronous, near-polar, circular orbits at an altitude of 705 km. The MODIS instruments' ±55 degree scanning pattern produces a 2330 km cross-track by 10 km along-track swath with nearly complete global coverage every one to two days.

3 SOFTWARE AND TOOLS

GeoTIFF files can be viewed with a variety of Geographical Information System (GIS) software packages including:

Blue Marble Geographics Global Mapper
QGIS
GDAL
Esri ArcGIS

4 RELATED DATA SETS

Greenland Ice Sheet Mapping Project (GIMP)
MEaSUREs MODIS Mosaic of Greenland (MOG) 2005, 2010, and 2015 Image Maps
MODIS Mosaic of Antarctica 2003-2004 (MOA2004) Image Map
MODIS Mosaic of Antarctica 2008-2009 (MOA2009) Image Map

5 RELATED WEBSITES

MEaSUREs at NSIDC | Overview

6 CONTACTS AND ACKNOWLEDGMENTS

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7 REFERENCES

Greene, N. and P. S. Heckbert. 1986. Creating Raster Omnimax Images from Multiple Perspective Views Using the Elliptical Weighted Average Filter. IEEE Computer Graphics and Applications 6(6): 21-27.

Wolfe, R. E., M. Nishihama, A. J. Fleig, J. A. Kuyper, D. P. Roy, J. C. Storey, and F. S. Patt. 2002. Achieving sub-pixel geolocation accuracy in support of MODIS land science. Remote Sensing of the Environment 83(1-2): 31-49.

8 DOCUMENT INFORMATION

8.1 Publication Date

July 2017

8.2 Date Last Updated

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