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Earth Observing System

MISR Multi-angle Imaging Spectro-Radiometer

Data Product Specification for the MISR Cloud Top Height-Optical Depth Product

-Incorporating the Science Data Processing Interface Control Document

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Data Products Specifications

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To determine the latest released version of this document, consult the MISR web site (http://www-misr.jpl.nasa.gov).

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Document Change Log

Revision	Date	Affected Portions and Description
Release A	October 03 2019	All, original release

Which Product Versions Does this Document Cover?

Product Filename Prefix	Version Number in Filename	Brief Description
MISR_AM1_CTH_1D_OD	F02_0007	L3 CloudTopHeight-OpticalDepth Product

TABLE OF CONTENTS

Acronym List

1D OD..................Optical Depth (OD) retrieved assuming One-Dimensional (1D) plane parallel clouds

AGP ....Ancillary Geographic Product

ASCM ....Angular Signature Cloud Mask

ASDC...................Atmospheric Science Data Center

ATBD...................Algorithm Theoretical Basis Document

CTH......................Cloud-Top-Height

CTH-OD ....Cloud-Top-Height-Optical-Depth

DPS ....Data Product Specifications Document

ECS ....EOSDIS Core System (Data Production System at ASDC)

EOS ....Earth Observing System

EOSDIS ....Earth Observing System Data and Information System

ESDT....................Earth Science Datatype

HDF ....Hierarchical Data Format

JPL ....Jet Propulsion Laboratory

LaRC ....NASA Langley Research Center

MISR....................Multi-angle Imaging SpectroRadiometer

MODIS.................Moderate Resolution Imaging Spectroradiometer

NASA...................National Aeronautics and Space Administration

OD........................Optical Depth

SCF ....Science Computing Facility

SDP ....Science Data Processing

SOM.....................Space-Oblique Mercator

WGS84.................World Geodetic System 1984

1 MISR DATA PRODUCT SPECIFICATION DOCUMENT

The purpose of this document is to describe the format of the MISR Level 3 Cloud-Top-Height Optical Depth (CTH-OD) product. Other MISR standard products, as well as the ancillary datasets used in their generation, are fully detailed in their respective MISR Data Product Specification Documents (DPS).

1.1 Description

The MISR Cloud Top Height – Optical Depth (CTH-OD) product contains two-dimensional histograms of cloud occurrence (or cloud fraction) for various cloud-types defined with respect to the retrieved cloud top height (m) and one-dimensional cloud column optical depth. The histograms are provided at a global scale with a spatial resolution of 1.0° × 1.0° latitude/longitude at daily, monthly, seasonal and annual time scales. The MISR CTH-OD histograms are conceptually similar to cloud-top-pressure and optical depth histograms being produced by the International Satellite Cloud Climatology Project (ISCCP) and the MODerate resolution Imaging Spectroradiometer (MODIS) project. The ISCCP and MODIS products differ from the MISR CTH-OD product in several ways, most importantly in that the MISR CTH is determined using a stereo-imaging technique, as described below. A detailed description and assesment of the CTH-OD product can be found in Marchand et al. [2010] and Hillman et al. [2017].

While the MISR CTH-OD data can be used in the analysis of climate models (e.g., Bodas-Salcedo et al [2011], Kay et al [2012], Zelinka et al. [2018]), it has also proven useful for trend and other studies on observed cloud properties (e.g Marchand et al. [2013], McCoy et al. [2014a,2014b], Qu et al. [2015], Ceppi et al. [2016]). As regards climate model evaluation, a MISR simulator, that is software designed to emulate and produce MISR CTH-OD histograms from climate model output, is available and has been integrated in the Cloud Feedback Model Intercomparison Observation Simulator Package (COSP) (Marchand and Ackerman [2010], Bodas-Salcedo et al [2011], Web et al [2017]. We strongly encourage that comparisons between MISR CTH-OD product and climate models use the MISR simulator.

The MISR CTH-OD histograms are computed as follows. Each MISR image pixel that is determined to be cloudy contributes a single count to 1 bin within the CTH-OD histogram. The total number of valid (or good) pixels (both cloudy and clear) is also stored so that histogram counts can be converted into relative fractions (or cloud fractions) be dividing counts in any (or all) histogram bins by the total number of pixels.

Clouds are assigned height bins based on their top height as retrieved using stereoscopic techniques applied to several MISR images. The height retrieval tries to account for the effect of cloud motion between the MISR images. This is done using the MISR best-winds stereo-height retrieval, when a high-quality wind retrieval is obtained and otherwise using the retrieved height without any wind correction (i.e., the MISR without-winds retrieval). The heights are also spatially filtered using a 11x11 pixel (12 × 12 km) median following the analysis of Marchand et al. [2007], who showed that such filtering produced good agreement with cloud radar observations of CTH.

The optical depth retrieval is based on the MISR measured radiance from the MISR NIR channel from ONE MISR view angle. The product actually contains two-histograms. In one histogram, the MISR measurement from the view angle closest to nadir, but at least 40 degrees away from the specular (or sun glint) angle is used. This is called the **"Best Camera"** product, and is the primary output that we expect most users will want to apply. The other histogram has an additional dimensions (called MisrCamera) and contains the OD values associated with each of the 9 MISR radiance measurements.

The measured MISR radiances are compared with (interpolated using) a look-up-table of values calculated for a one-dimensional (plane parallel or perfectly horizontally homogenous) cloud for a range of optical depths, solar and view geometries. The OD retrieval is only run for pixels determined to be (1) over ice-free ocean and (2) cloudy (with high confidence) by the MISR radiometric cloud mask (for the camera being used), as described by Zhao and Di Girolamo [2004], and otherwise pixels are considered clear (cloud free). The radiometric cloud mask is based on thresholding of observed reflectances and the standard deviation of the 275 m reflectances at a scale of 1.1 km. While the surface reflectance is small, it is nonetheless accounted for using an anisotropic ocean model following ISCCP. Clouds with a CTH below the climatological freezing level are assumed to be composed of water drops with an effective radius of 10 microns, while those above the freezing level are treated as ice particles with an effective radius 50 microns and an aggregate-like crystal habit. McFarlane et al. [2008] found that this aggregate model fits well the angular scattering pattern observed by all nine MISR view angles much of the time. The underlying scattering phase function used in the MISR retrieval is very similar to that used in ISCCP, which has likewise been found to match multiangle reflectance measurements from clouds reasonably well [Doutriaux-Boucher et al., 2000; Descloitres et al., 1998].

1.2 MISR DATA PRODUCTS

The MISR project is a component of the Earth Observing System (EOS) Terra Mission and the EOS Data and Information System (EOSDIS), which are components of the National Aeronautics and Space Administration's (NASA) Earth Science Enterprise. An integral part of the MISR project is the Science Data Processing (SDP) of the observations coming from the MISR instrument on-board the EOS Terra satellite.

MISR SDP exists to produce science and supporting data products from MISR instrument data. All functions of the MISR SDP system are directed toward this goal. MISR SDP does not operate as an independent entity, but rather is linked to the functionality of the EOSDIS at the Langley Research Center (LaRC) Atmospheric Sciences Data Center (ASDC). The EOSDIS Core System (ECS) ingest subsystem at the LaRC ASDC is the agent for receiving and organizing all of the input data needed by MISR SDP. These data are then made available to MISR SDP through the data server and staging facilities provided by ECS at the LaRC ASDC. After MISR standard data processing is complete, the standard output products are archived through the EOSDIS data server and made available to users through ECS client services.

The MISR Science Computing Facility (SCF) at the Jet Propulsion Laboratory (JPL) supports the development of MISR science algorithms and software, instrument calibration and performance assessment, as well as providing quality assessment and data validation services with respect to MISR SDP. The MISR SCF is used to produce software, supporting data, and coefficients that are required to operate MISR SDP software at the LaRC ASDC.

MISR SDP depends upon the availability of MISR instrument data, internal data sets produced at the MISR SCF, and external data sets that are products of other EOS data processing systems.

1.3 CONTROLLING DOCUMENTS

1) MISR Data System Science Requirements, JPL D-11398, September 1996 (or latest version).
2 MISR Level 2 Cloud Algorithm Theoretical Basis, JPL D-73327, April 2012 (or latest version).
3) MISR Level 3 Cloud Top Height – Optical Depth Algorithm Theoretical Basis, JPL D-69146, October 2019 (or latest version).
4) MISR Science Data Product Guide, JPL D-73355, April 2012 (or latest version).

APPLICABLE DOCUMENTS

5) SDP Toolkit Users Guide for the ECS Project, HAIS 194-809-SD4-001 (or latest version

2 MISR Level 3 CTH-OD Product Specification

The MISR Cloud Top Height – Optical Depth product contains a two dimensional histogram of counts in cloud occurrence for various ranges of cloud top height and 1-dimensional optical depth for each 1-degree by 1-degree latitude/longitude grid cell. The histogram product is generated at four different time scales: daily, monthly, seasonally and annually. All these files have an identical file format, with the monthly files obtained by aggregating daily files, etc. The corresponding granule names are listed below in respective order.

2.1 Granule Names

Table 1 - MISR Cloud Top Height – Optical Depth Data Products

MISR LEVEL 3 FILE GRANULE NAME[1]	ESDT Name	File Type	Applicable Product Version
MISR_AM1_CTH_1D_OD_mmm_dd_yyyy_Fff_vvvv.hdf	MIL3DCOD	HDF-EOS latitude-longitude grid	F02_0007
MISR_AM1_CTH_1D_OD_mmm_yyyy_Fff_vvvv.hdf	MIL3MCOD	HDF-EOS latitude-longitude grid	F02_0007
MISR_AM1_CTH_1D_OD_sss_yyyy_Fff_vvvv.hdf	MIL3QCOD	HDF-EOS latitude-longitude grid	F02_0007
MISR_AM1_CTH_1D_OD_yyyy_Fff_vvvv.hdf	MIL3YCOD	HDF-EOS latitude-longitude grid	F02_0007

2.2 File Metadata

Table 2 – CTH_1D_OD File Metadata

File Attribute Name	Definition	Data Type	Units	Valid Range
NearIR Correction	Coefficient used to correct NearIR BRF (camera by camera).	FLOAT32 x 9	N/A	N/A
Month_Start	"Starting month" for BRF correction calculations.	UINT32	N/A	1

1 "mmm" is the three character month (one of "JAN", "FEB", "MAR", "APR", "MAY", "JUN", "JUL", "AUG", "SEP", "OCT", "NOV", "DEC"), "sss" is the season (one of "WIN", "SPR", "SUM", "FALL"), "dd" is the two digit day (e.g., "03"), "yyyy" is the four digit year (e.g., "2002"), "ff" is the format version number (e.g. "01"), and "vvvv" is the data version number (e.g., "0002").

Year_Start	"Starting year" for BRF correction calculations.	UINT32	N/A	2002

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
Source File	Orbit Number	List of orbits that are summarized in this Level 3 file	INT32	N/A	1-999999
	Path Number	List of paths that are summarized in this Level 3 file	INT32	N/A	1-233
	Start Date and Time	Timestamp of beginning of orbit acquisition.	CHAR8 x 59	N/A	N/A
	Local Granule ID	Local Granule ID (unique filename) of input product.	CHAR8 x 59	N/A	N/A

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
Latitude Boundary	Boundary Value	Lower Boundaries of Latitude bins (plus upper boundary of last bin)	FLOAT32	degrees	-90.0 to 90.0

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
Latitude Enumeration	Value	Boundaries of each Latitude bin	CHAR8 x 13	N/A	N/A

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
Longitude Boundary	Boundary Value	Lower Boundaries of Longitude bins (plus upper boundary of last bin)	FLOAT32	degrees	-180.0 to 180.0

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
Longitude Enumeration	Value	Boundaries of each Longitude bin	CHAR8 x 15	N/A	N/A

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
HeightBin Boundary	Boundary Value	Lower Boundaries of Height bins (plus upper boundary of last bin)	FLOAT32	meters	-180.0 to 180.0

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
HeightBin Enumeration	Value	Boundaries of each Longitude bin	CHAR8 x 15	N/A	N/A

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
OpticalDepthBin Boundary	Boundary Value	Lower Boundaries of Optical Depth bins (plus upper boundary of last bin)	FLOAT32	N/A	-180.0 to 180.0

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
OpticalDepthBin Enumeration	Value	Boundaries of each Longitude bin	CHAR8 x 13	N/A	N/A

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
MisrCamera	Boundary Value	Camera numbers for each bin	FLOAT32	N/A	1.0 to 9.0

Vdata Name	Vdata Field Name	Definition	Data Type	Units	Valid Range
MisrCamera Enumeration	Value	Camera names for each bin	CHAR8 x 2	N/A	N/A

2.3 File Dimensions

Table 3 – CTH-OD Field Dimension Descriptions

Dimension	Description	Number of values	Values
OpticalDepthBin	Optical Depth	8	1 = No retrieval 2 = (0, 0.3) 3 = [0.3 – 1.3) 4 = [1.3 – 3.6) 5 = [3.6 – 9.4) 6 = [9.4 – 23.0) 7 = [23.0 – 60.0) 8 = [60.0 – 1000.0]
HeightBin	Height bin	16	1 = No retrieval 2 = < 500 m 3 = [500m, 1000m)

			4 = [1000m, 1500m) 5 = [1500m, 2000m) 6 = [2000m, 2500m) 7 = [2500m, 3000m) 8 = [3000m, 4000m) 9 = [4000m, 5000m) 10 = [5000m, 7000m) 11 = [7000m, 9000m) 12 = [9000m, 11000m) 13 = [11000m, 13000m) 14 = [13000m, 15000m) 15 = [15000m, 17000m) 16 = [17000m, 100000m)
MisrCamera	Camera number	9	1 = Df 2 = Cf 3 = Bf 4 = Af 5 = An 6 = Aa 7 = Ba 8 = Ca 9 = Da

2.4 Grid Dataset Description

Table 4 – CTH-OD Product Grid Dataset Description

Field Name **Parameter Description**	**Dimensions List**	**Number Type**	**Units**	**Flag Values**
CloudTopHeight_OpticalDepth (1.0 degree x 1.0 degree, XDim = 360, YDim = 180) XDim and YDim are the longitude and latitude dimensions respectively. For row-based reads, the upper-left corner of the grid (element [0, 0]) is centered at (89.50 N, 179.50 W), and the lower-right corner of the grid (element [359, 719]) is centered at (89.50 S, 179.50 E). This assumes zero-based arrays. For column-major languages, the array dimensions will be reversed so the data will appear to have the dimensions [720, 360].				
Cloud Top Height – Optical Depth Histogram Number of counts for each cloud-top-height/optical-depth bin (camera by camera)	YDim, XDim, MISRCamera, HeightBin, OpticalDepthBin	UINT32	N/A	0 = fill
Cloud Top Height – Optical Depth Histogram (Best Camera) Number of counts for each cloud-top-height/optical-depth bin (for camera closest to nadir with smallest amount of sunglint)	YDim, XDim, HeightBin, OpticalDepthBin	UINT32	N/A	0 = fill
TotalCounts Number of cloudy, oceanic pixels with no snow-ice present for each camera.	YDim, XDim, MISRCamera	UINT32	N/A	0 = fill
Total Counts (Best Camera) Number of cloudy, oceanic pixels with no snow-ice present for "best camera" (closest to nadir with smallest amount of sunglint)	YDim, XDim	UINT32	N/A	0 = fill