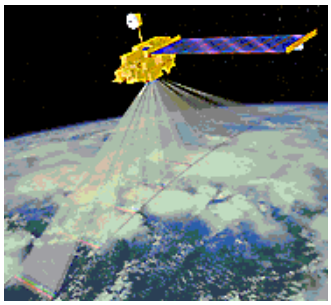
Multi-angle Imaging SpectroRadiometer (MISR) Langley DAAC Project Guide



Summary:

MISR, the Multi-angle Imaging SpectroRadiometer, is an instrument unlike any that has flown in space before. Most satellite instruments look either straight down or toward the edge of our planet. But MISR records images of the Earth simultaneously at 9 different angles in each of 4 color bands. MISR's 36 simultaneous spectral-angular images allow derivation of aerosol optical depth and particle type, characterization of scene type, surface albedo, and bi-directional reflectance, and information about cloud properties.

MISR was built for NASA by the Jet Propulsion Laboratory in Pasadena, California. It is part of NASA's first Earth Observing System spacecraft, the *Terra* spacecraft, which was launched into polar orbit from Vandenberg Air Force Base on December 18, 1999.

More detailed descriptions of this project may be found at the MISR web site.

Table of Contents:

1. Project Overview:

1.1 Name of Project:

Multi-angle Imaging SpectroRadiometer (MISR)

1.2 Project Introduction:

See the Summary section above.

1.3 Project Mission Objectives:

The purpose of the MISR experiment is to acquire systematic multi-angle imagery for global monitoring of top-of-atmosphere and surface albedos and to measure the shortwave radiative properties of aerosols, clouds, and surface scenes in order to characterize their impact on the Earth's climate. Select the thumbnail image a the right to see an enlarged cartoon of the scientific applications

of MISR. The following text discusses these applications.

Climate is what makes the Earth habitable. And the climate is constantly changing - as a consequence of both natural processes and human activities. We care a great deal about even small changes in Earth's climate, since they can affect our comfort and well-being, and possibly our survival. Even a few years of below-average rainfall, an unusually cold winter, or a change in emissions from a coal-burning power plant, can influence the quality of life of people, plants, and animals in the region involved.

The goal of NASA's Earth Observing System (EOS) is to increase our understanding of the climate changes that are occurring on our planet, and the reasons for these changes, so we are better equipped to anticipate and prepare for the future. The MISR instrument is a part of EOS. Its role is to measure how much sunlight is scattered in different directions under natural conditions. This will help quantify the amount of solar energy that heats the Earth's surface and atmosphere, and the changes that occur in these quantities over the six-year nominal lifetime of the MISR instrument.

From the MISR observations, we will also learn more about those components of the Earth environment that scatter sunlight in the first place: particles in the atmosphere, the planet's surface, and clouds. MISR will monitor changes in surface reflection properties, in atmospheric aerosol content and composition, and in cloudiness. We will use these data to study the effects of land use changes, air pollution, and volcanic eruptions, as well as processes such as desertification, deforestation, and soil erosion. As part of the EOS program, computer models that predict future climate will be improved by the results of these studies.

Further discussion of the science objectives of the MISR experiment can be found on the MISR web site's Science Goals and Objectives page .

1.4 Disciplines:

Earth Sciences
Atmospheric Sciences

1.5 Geographic Regions:

Global coverage every nine days, with repeat coverage between nine days at the equator and two days at the poles. Swath width in all cameras is 360 km. The polar orbit of the Terra spacecraft has an inclination of 98.3 degrees, so that MISR is able to view the Earth's surface up to 81 degrees latitude.

1.6 Detailed Project Description:

The MISR instrument consists of nine pushbroom cameras. It is capable of global coverage every nine days, and flies in a 705-km descending polar orbit. The cameras are arranged with one camera pointing toward the nadir (designated An), one bank of four cameras pointing in the forward direction (designated Af, Bf, Cf, and Df in order of increasing off-nadir angle), and one bank of four cameras pointing in the aftward direction (using the same convention but designated Aa, Ba, Ca, and Da). Images are acquired with nominal view angles, relative to the surface reference ellipsoid, of 0, 26.1, 45.6, 60.0, and 70.5 degrees for An, Af/Aa, Bf/Ba, Cf/Ca, and Df/Da, respectively. Each camera uses four Charge-Coupled Device (CCD) line arrays in a single focal plane. The line arrays consist of 1504 photoactive pixels and each line is filtered to provide one of four spectral bands. The spectral band shapes are nominally gaussian, centered at 443, 555, 670, and 865 nm.

MISR contains 36 parallel signal chains corresponding to the four spectral bands in each of the nine cameras. Each signal chain contains the output from the detectors in each CCD array. The zonal overlap swath width of the MISR imaging data (that is, the swath seen in common by all nine cameras along a line of constant latitude) is 360 km, which provides global multi-angle coverage of the entire Earth in 9 days at the equator, and 2 days near the poles. The cross-track instantaneous field-of-view (IFOV) and sample spacing of each pixel is 275 m for all of the off-nadir cameras, and 250 m for the nadir camera. Along-track IFOV's depend on view angle, ranging from 214 m in the nadir to 707 m at the most oblique angle. Sample spacing in the along-track direction is 275 m in all cameras. The instrument is capable of buffering the data to provide 2 sample x 2 line, 4 sample x 4 line, or 1 sample x 4 line averages, in addition to the mode in which pixels are sent with no averaging. The averaging capability is individually selectable within each of the 36 channels.

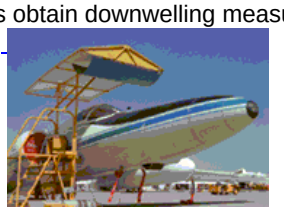
Table A: MISR Instrument Description

Parameters	Value
Camera view angles at Earth's surface	0.0 degrees (nadir), 26.1, 45.6, 60.0, and 70.5 degrees, both fore and aft of nadir
Swath width	360 kilometers overlap between cameras (9-day global coverage)
Cross-track x along-track pixel sampling (commandable)	275 x 275 meters 550 x 550 meters 1.1 x 1.1 kilometers 275 x 1.1 kilometers
Spectral bands (solar spectrum weighted)	446.4, 577.5, 671.7, 866.4 nanometers
Spectral bandwidths	41.9, 28.6, 21.9, 39.7 nanometers
Charge-Coupled Device sensor architecture	4 lines x 1504 active pixels, in each of 9 cameras
Absolute radiometric uncertainty	3 percent (1 sigma) at maximum signal
Mass	149 kilograms
Power	83 watts average, 131 watts peak
Data rate	3.9 Megabits per second, average

There are several observational modes of the MISR instrument. Global Mode (GM) refers to continuous operation with no limitation on swath length. Global coverage in a particular spectral band of one camera is provided by operating the corresponding signal chain continuously in a selected resolution mode. Any choice of averaging modes among the nine cameras that is consistent with the instrument power and data rate allocation is suitable for Global Mode. Additionally, Local Mode (LM) provides high resolution images in all 4 bands of all 9 cameras for selected Earth targets. This is accomplished by inhibiting pixel averaging in all bands of each of the cameras in sequence, one at a time, beginning with the first camera to acquire the target and ending with the last camera to view the target. The instrument geometry limits the along-track length of Local Mode targets to about 300 km. Finally, in Calibration Mode (CM) the on-board calibration hardware is deployed and calibration data are acquired for the cameras. Calibration data will be obtained for each spatial sampling mode (see above) by cycling each channel through the various modes during the calibration period. Calibration Mode will be used on a monthly basis during routine mission operations, although early in the mission it will be used more frequently.

Science validation consists of intercomparisons of parameters generated using MISR algorithms operating on radiance measurements from MISR aircraft simulator or spaceborne instruments with similar products generated using conventional ground-based solar and atmospheric observations, together with conventional methods of analysis and inversion. These intercomparisons may also serve in some instances to validate the assumed aerosol climatology and surface reflectance models used in the retrievals.

Validation of the aerosol and surface retrieval algorithms relies on several sources of data including aircraft observations, together with field observations of downwelling diffuse sky spectral radiance and irradiance, the direct solar irradiance component and the surface spectral bidirectional reflectance factor (BRF). In contrast to MISR spacecraft or aircraft observations of the upwelling radiation field at the top or middle of the atmosphere, ground-based deployments obtain downwelling measurements of sky spectral diffuse radiance and irradiance, together with the directly transmitted solar irradiance.

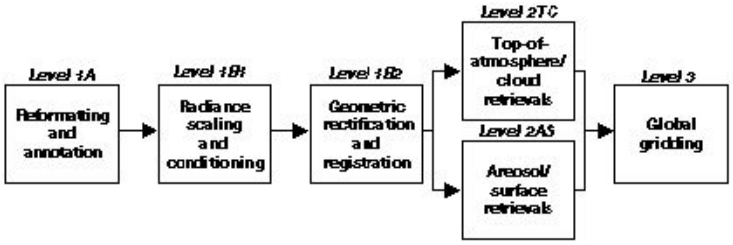


The validation approach adopted for MISR consists of comparing geophysical parameters generated using MISR algorithms adapted to use with aircraft; MISR algorithms adapted to retrievals using the downwelling radiation field at the bottom-of-the-atmosphere; and using independent algorithms on ground-based observations in order to secure ground-based estimates of aerosol spectral optical depth, effective size distribution, phase function, and single scattering albedo. Validation of cloud parameters focuses on the RLRA retrieval, using stereo imagery, accurate manual and automated stereo-photogrammetric techniques, and comparison with MISR algorithm results.

A more expansive discussion of the instrument and experiment design can be found on the MISR website's Instrument Description page.

2. Data Availability:

2.1 MISR data processing and product levels:



The generation of standard MISR science data products at the LaRC DAAC can be divided into five production steps. Each step has at least one primary output product, but may have other secondary output products. It is convenient to think of these five steps as occurring in sequence, with the predecessor producing at least one complete product, a portion of which is the primary input for the successor. The five steps are:

1. Level 1A instrument data reformatting and annotation
2. Level 1B1 radiometric scaling and conditioning,
3. Level 1B2 geometric rectification and registration,
4. Level2 science retrievals, and
5. Level 3 global gridding.

Each of these steps corresponds to processing levels of a product generation flow, as shown inthe above diagram. These levels conform to the EOS scheme from Level 1 toLevel 3, where each successive level has a higher degree of processing.

Level 1 Products - These have been processed and calibrated to remove many of the instrument effects. The resulting products thus contain minimal instrument artifacts and are most suitable for subsequent scientific derivations.

Level 1A: Reformatted Annotated Product - The raw data from the instrument, which is intricately structured and compressed, is reformatted into more straightforward computer files. At the same time, many checks are made on the quality of the data to ensure that the instrument is working correctly. There are three categories of products at Level 1A:

1. sciencedata/imagery,
2. engineering data,
3. calibration/mechanism data.

Only thefirst of these three categories, science data, is processed to products higherthan Level 1A.

Level 1B1: Radiometric Product - Two types of processing are included in this product. Firstly, the Radiance Scaling operation converts the camera's digital number output to a measure of energy incident on the front optical surface. The measurement is expressed in units called radiance (energy per unit area, wavelength, and solid angle) as defined by the international scale. Secondly, Radiance Conditioning modifies the radiances to remove instrument-dependent effects. Specifically, image sharpening is provided, and focal-plane scattering is removed. Additionally, all radiances are adjusted to remove slight spectral sensitivity differences among the 1504 detector elements of each spectral band and each camera. In addition to the Level 1B1 radiometric product for MISR's Global Mode imagery, there is a separate Level 1B1 product for each high-resolution Local Mode scene.

Level 1B2: Georectified Radiance Product - The nine sets of imagery from the nine cameras are registered to one another and to the ground. This is an image processing application made necessary because the nine views of each point on the ground are not acquired simultaneously (images from cameras at the two extreme angles are 7 minutes apart.) This product is mapped into the Space Oblique Mercator (SOM) map projection. The product embraces three sets of parameters:

1. radiances projected to surface terrain,
2. radiancesprojected to the surface ellipsoid, and
3. a radiometric camera-by-cameracloud mask.

In addition to the Level 1B2 Global Mode imagery, there is a separate Level 1B2 product for each high-resolution Local Mode scene.

Level 2 Products - These are geophysical measurements derived from the instrument data.

Level 2TC: Top-of-Atmosphere/Cloud Product - This product contains measurements of top-of-atmosphere bidirectional reflectance factors, stereoscopically-derived cloud and land (reflecting level) elevation, cloud fraction, cloud texture, and other related parameters. The horizontal sampling of this product is 2.2 km, except for a few parameters at 1.1 km and 17.6 km.

Level 2AS: Aerosol/Surface Product - This product includes a range of parameters such as tropospheric aerosol

optical depth; aerosol composition and size; surface directional reflectance factors and bi-hemispherical reflectance; and other related parameters. The horizontal sampling of this product is 17.6 km.

Level 3 Products - These are global maps of a range of parameters from the Level 2 products. The Levels 1 and 2 products are in swaths, each derived from a single MISR orbit, where the imagery is 360 km wide and approximately 20,000 km long. At Level 3 the product parameters from multiple swaths are combined to make complete, global maps. The Level 3 products will typically be monthly averages of various Level 2 parameters. Note that Level 3 MISR products are expected to be available sometime towards the end of the first year of the mission.

Production of standard products at the DAAC includes a dependency on the MISR Science Computing Facility (SCF) for certain functions. For example, there is critical dependence on calibration parameters and lookup data such as threshold data sets, climatologies, model data sets or the like. These functions are separated from DAAC activities because they require close day-by-day scrutiny by the MISR science team. Updates to these data structures occur infrequently compared to the rate of standard product generation, and therefore fit into the more limited processing capabilities of the SCF. Other essential functions that have activity at the SCF include quality assessment, algorithm validation, software development, and instrument operations.

Production software design

Select the thumbnail diagram at the right to see the hierarchy of the product generation executables (PGEs) used to generate the MISR standard products. This illustrates how each successively higher product is created from the lower level products.

2.2 Ancillary products and data sets

In addition to the product files, most users need to be cognizant of certain ancillary files associated with MISR data product generation. In some instances, the ancillary file is essential to a complete understanding and utilization of the data product. These ancillary files are referred to as the Ancillary Data Products. On the other hand, there are other ancillary files not relevant to utilization of the products. Here is a more complete definition of the terminology.

- **Standard product:** This is a product generated routinely at the DAAC. This is what is usually understood when talking about data products.
- **Ancillary data set:** This is a data set generated at the MISR Science Computing Facility (SCF) and delivered to the DAAC for use as input during routine processing. Ancillary data sets may be updated either on a regular or sporadic basis at the SCF and new versions delivered to the DAAC. In some cases, automated updating may occur at the DAAC. Ancillary data sets are not required by users of MISR data to interpret the contents of standard products, and are not designed for end-user usage. These data sets are not designed for distribution but may be available on request, with the exception of a few that are restricted because of their origin within the non-NASA community.
- **Ancillary product:** This is a product generated at the SCF and delivered to the DAAC for use during routine processing or as a supportive product necessary for the interpretation of standard products. Ancillary products may be updated either on a regular or sporadic basis at the SCF and new versions delivered tot he DAAC. Ancillary products are distinguished from ancillary data sets in that they are needed by users of MISR data to interpret the contents of standard products.
- **Parameter:** This is a variable contained within a product or data set.

2.3 Product summary:

MISR's data products are summarized in the following table. There are many parameter files making up the MISR products, and in most instances these can be ordered individually. Table B is designed to introduce the ways in which the many constituent parts of the products are grouped as high-level, logical collections. The Product ID column refers to the designations given in the EOS Data Products Handbook. Note that the final three products listed in this table are Ancillary Products, as defined above.

Note that Table B is not necessarily a breakdown of MISR products for ordering purposes. That topic is addressed in Section 2.5.

Table B: Products breakdown

Product ID	Product level and description	Parameter summary and associated ancillary products
MIS-01C	***1A - Reformatted Annotated Products for calibration and mechanism data***	*Standard products/parameters:*

	categories: This contains raw MISR data that have been decommutated and annotated (e.g., with time information). These data are not used as input to any of the other MISR products. They are normally used only at the MISR SCF for calibration and instrument characterization purposes.	• CCD calibration data • On-board calibrator data • Motor data *Associated ancillary products:* • None
MIS-01E	***1A - Reformatted Annotated Product for engineering data category:*** This contains raw MISR data that have been decommutated and annotated (e.g. with time information). These data are not used as input to any of the other MISR products. They are normally used only at the MISR SCF for instrument monitoring and characterization purposes. Note that the navigation data included here are raw data supplied on board the spacecraft, and do not include the corrections potentially applied to the navigation information obtained separately from the spacecraft and used at the DAAC in MISR data processing.	*Standard products/parameters:* • Engineering data • Navigation data *Associated ancillary products:* • None
MIS-01	***1A - Reformatted Annotated Product for science data category:*** This contains raw MISR data that have been decommutated, reformatted (12-bit Level 0 data shifted to byte boundaries, reversal of square-root encoding applied, and converted to 16 bits), and annotated (e.g., with time information). These data are used by the Level 1B1 processing algorithm to generate calibrated radiances. The science data output preserves the spatial sampling rate of the Level 0 raw MISR CCD science data. CCD data are collected during routine science observations of the sunlit portion of the Earth. Each product represents one "granule" of data. A "granule" is defined to be the smallest unit of data required for MISR processing. Also, included in the Level 1A product will be pointers to calibration coefficient files provided for Level 1B processing.	*Standard products/parameters:* • CCD science data *Associated ancillary products:* • None
MIS-02	***1B1 - Radiometric Product:*** This contains spectral radiances for all MISR channels (four spectral bands and nine cameras). Each radiance value represents the incident radiance averaged over the sensor's total band response. Processing includes both radiance scaling and conditioning steps. Radiance scaling converts the Level 1A data from digital counts to radiances, using coefficients derived in combination with the On-Board Calibrator (OBC) and vicarious calibrations. The OBC contains Spectralon calibration panels which are deployed monthly and reflect sunlight into the cameras. The OBC detector standards then measure this reflected light to provide the calibration. Vicarious field campaigns are conducted less frequently but provide an independent methodology useful for reducing systematic errors. Radiance conditioning removes undesirable instrument effects. Image enhancement is provided by deconvolving the scene with the sensor's point-spread-function. Additionally, in-band scaling adjusts the reported radiances to correspond to a nominal band response	*Standard products/parameters:* • Global mode radiance • Local Mode radiance (one parameter set per Local Mode site) *Associated ancillary products:* • Ancillary Radiometric Product (ARP)

	profile. This frees the Level 2 software from the need to correct for detector element non-uniformities. No out-of-band correction is done for this product, nor are the data geometrically corrected or resampled.	
MIS-03	***1B2 - georectified radiance product (GRP):*** This consists of parameters that have had geometric corrections applied and have been projected to a Space Oblique Mercator (SOM) map grid. Included in this product is the surface-projected TOA radiance which is the calibrated radiance from the Level 1B1 data (MIS-02) that has had a geometric correction applied to remove spacecraft position and pointing knowledge errors as well as effects due to topography. The radiance is then orthorectified on a reference ellipsoid at the surface. Also, part of the GRP is the ellipsoid-projected TOA radiance which uses supplied spacecraft position and pointing and is not corrected for topography, but is resampled at the surface reference ellipsoid. In addition, geometric parameters such as solar and view zenith and azimuth angles are included. Resampling of MISR data at Level 1B2 is critical because the pushbroom images from the nine cameras are obtained at widely separated locations along the subspacecraft rack. However, derivation of geophysical products requires that the multiangle, multispectral radiances for any single ground target be coregistered.	*Standard products/parameters:* • Geometric parameters • Terrain-projected top-of-atmosphere (TOA) radiance • Terrain-projected TOA radiance for Local Mode (one parameter set per Local Mode scene) • Ellipsoid-projected TOA radiance • Ellipsoid-projected TOA radiance for Local Mode (one parameter set per Local Mode scene • Radiometric camera-by-camera cloud mask (RCCM) *Associated ancillary products:* • Ancillary Geographic Product (AGP)
MIS-04	***2TC - Top-of-Atmosphere/Cloud (TOA/Cloud) Product:*** This consists of TOA radiation and cloud information including: finely-sampled (2.2 km) TOA albedo, coarsely-sampled TOA albedos projected to 30-km altitude (35.2 km), TOA bidirectional reflectance factor (BRF) at 2.2 km, and Reflecting Level Reference Altitude (RLRA) for 2.2-km regions, texture indices at 2.2 km, altitude-binned (high, middle, and low) and total cloud fractions at 17.6 km. The coarse TOA albedos provided will include a restrictive albedo, derived from the nine multiangle observations of a single region, and an expansive albedo which is calculated including contributions from surrounding regions, at the appropriate angles. Nadir cloud masks on 1.1-km centers for thick and high clouds will also be included.	*Standard products/parameters:* • Cloud and reflecting level parameters • Cloud classifiers • Albedos *Associated ancillary products:* • Ancillary Geographic Product • Ancillary Radiometric Product
MIS-05	***2AS - Aerosol/Surface product:*** This contains a variety of information on the Earth's atmosphere and surface. The aerosol data include tropospheric aerosol optical depth on 17.6-km centers, archived with a compositional model identifier and retrieval residuals, ancillary data including relative humidity (RH), ozone optical depth, stratospheric aerosol optical depth, and retrieval flags. The land surface data include hemispherical directional reflectance factor, bihemispherical reflectance (i.e., albedo), bidirectional reflectance factor, directional hemispherical reflectance, BRF model parameters, FPAR, and terrain-referenced view and illumination angles. Ocean data include water-leaving equivalent reflectance	*Standard products/parameters:* • Aerosol parameters • Land surface parameters • Ocean surface parameters *Associated ancillary products:* • Aerosol Climatology Product (ACP) • Ancillary Geographic Product • Ancillary Radiometric Product

	and phytoplankton pigment concentration.	
MIS-06	***3 - Global Radiation Product:*** This Level 3 global gridded product is derived from parts of MIS-04, and will be developed post-launch. It contains a statistical summary of spectral top-of-atmosphere BRF for various subregion classifications; and a statistical summary of spectral expansive albedos for several sky classifications.	Gridded products are planned within a year after launch, but are not available yet.
MIS-07	***3 - Global Cloud Product:*** This Level 3 global gridded product is derived from parts of MIS-04, and will be developed post-launch. It contains a statistical summary of altitude-binned scene classifiers.	Gridded products are planned within a year after launch, but are not available yet.
MIS-08	***3 - Global Aerosol Product:*** This Level 3 global gridded product is derived from parts of MIS-05, and will be developed post-launch. It contains a statistical summary of column aerosol 555 nm optical depth, and a monthly aerosol compositional type frequency histogram.	Gridded products are planned within a year after launch, but are not available yet.
MIS-09	***3 - Global Surface Product:*** This Level 3 global gridded product is derived from parts of MIS-05, and will be developed post-launch. It contains a statistical summary of directional hemispherical reflectance (DHR), photosynthetically active spectral region (DHR-PAR); a statistical summary of DHR, for near-infra-red band (DHR-NIR); a statistical summary of fractional absorbed photosynthetically active radiation (FPAR); a statistical summary of DHR-based normalized difference vegetation index (NDVI); and a statistical summary for land surface BRF model parameters, classified into six vegetated and one non-vegetated types.	Gridded products are planned within a year after launch, but are not available yet.
MIS-10	***1B2 - Ancillary Geographic Product (AGP):*** This contains terrain data, generated from a high-resolution DEM, referenced to the WGS84 referenced ellipsoid and mapped onto an SOM grid. It is an archival product generated once preflight at the MISR SCF, but which can be distributed to the scientific community as an aid in interpreting MISR retrievals. The AGP is used as input to Level 1B2 and Level 2 processing. Its contents include latitude, longitude, scene elevation (average and standard deviation), topographic shadow and obscuration mask, surface-normal zenith angle, and a land/ocean/inland water/ephemeral water/coastline mask. All parameters are given on 1.1-km centers.	*Standard products/parameters:* Not applicable *Associated ancillary products:* Not applicable
MIS-11	***1B1 - Ancillary Radiometric Product (ARP):*** This contains coefficients and data variables which are used in the Level 1B1 processing. Updated ARP parameters include the sensor radiometric calibration coefficients, uncertainties in calibration, signal-to-noise ratios, pixel data quality indicators, and quality assessment threshold parameters. Static ARP parameters include spectral response parameters, point-spread-functions (PSF), field-of-view, passband-weighted solar irradiance values, and PAR integration weights. The ARP is regenerated periodically at the MISR SCF to update the instrument performance report. The ARP is used as input to Level 1B1 as well as Level 2 processing.	*Standard products/parameters:* Not applicable *Associated ancillary products:* Not applicable

MIS-12	***2AS - Ancillary Climatology Product (ACP):*** This is generated once, at the MISR SCF, with possible infrequent updates. It is used for interpolation of the aerosol data contained in MIS-05. The ACP contains the physical and optical properties that define common atmospheric aerosol types. The parameters reported in the ACP include an aerosol model identifier (name, number, and composition); a water activity identifier (hygroscopic or not, and if so, how hydrophilic); a partial shape identifier (spherical, polyhedral, or irregular); a grid of relative humidity values for which all optical properties have been calculated; particle size distribution parameters; particle density (volume-weighted for mixtures); complex index of refraction; scattering and extinction cross-section; single scattering albedo; scattering anisotropy parameter; and phase function. It also includes the definition of the aerosol mixtures to be used during generation of MIS-05, along with climatological likelihood parameters for these mixtures.	*Standard products/parameters:* Not applicable *Associated ancillary products:* Not applicable

2.4 Further attributes of MISR products:

Product granularity

MISR products are generated with the following granularity:

- **Swath-based products:** All of the Level 1 and Level 2 Global Mode (GM) MISR products, which comprise the bulk of the science products, are generated on a swath basis. That is, each granule covers the daylit side of the Earth for a single orbit. Level 1A and Level 1B1 products use the HDF EOS swath format. Level 1B2 and Level 2 products, being based on the Space Oblique Mercator map projection, use a special form of the HDF EOS grid format called the "stacked block" format, in which the swath is divided into 180 blocks, each being 2048 pixels across-track and 512 lines along-track in 1 x 1 (275 m) resolution in the SOM projection. The 180-block length accommodates the northerly and southerly extremes of swath length corresponding to the northern and southern summers respectively.
- **Scene-based products:** All of the Local Mode (LM) MISR products are on a single scene basis, where one LM scene is a 300-km along-track science data set with all cameras set to the highest resolution.
- **Orbit-based products:** MISR engineering data is transmitted from the instrument continuously, and are processed in whole-orbit granules to form the Level 1A engineering data product. The boundary between adjacent orbits is the dark-side equator crossing.
- **Event-based products:** The Level 1A products associated with calibration sequences, and with opening and closing of the instrument shutter mechanism, are each processed on a single-event basis.
- **Gridded products:** The Level 3 global products are planned to conform with the standard set by the Science Working Group for the AM Platform (SWAMP), and will be binned into 1 x 1 degree grid cells and accumulated over time periods corresponding to calendar months, with 64,800 grid cells covering the globe.

Geographic subsetting

The swath-based products (described in the previous subsection) are very large. Many users will be interested only in those parts of the swath that cover their region of interest. Such users may not have the facilities to handle data available in only gigabyte-sized chunks. Because of this, subsetting of the swath-based products is planned. Subsetting is currently under development, and will be available for users within the first year of the mission.

Initially, subsetting will be for the HDF EOS grid format products (Level 1B2 and higher) on a block-by-block basis.

Parameter-based subsetting

Users may wish to select particular parameters from a MISR product rather than obtaining the entire file. This capability is planned to be availableduring the first year of the mission.

2.5 Product ordering strategy:

The files that constitute MISR data products are referred to by file designators called Earth Science Data Types (ESDTs). A table of ESDTs is given just below in this document (Table C). The ESDT is the smallest breakdown of a product that can be ordered by the user, and most products consist of multiple ESDTs. Users will thus find themselves ordering a collection of MISR ESDTs. As the collections may not be automated, the following table gives an indication of how the ESDTs are grouped for typical collections. Individual users, especially those with specialist knowledge of MISR, may desire to order different collections from those shown here. However, the intention here is to present the most typical case.

It should be noted that while the Ancillary Products are part of various product collections, it is usually necessary to order the Ancillary Products only once because they change infrequently.

In Table C there are numbered columns for each typical product collection, which are:

Collection No. (columns of Table C)	Product ID	Description of collection
1	N/A	Level 0 data. Only specialist users or other MISR data processers are expected to required this.
2	MIS-01C	Level 1A calibration/mechanism data. Required only for MISR instrument calibration.
3	MIS-01E	Level 1A engineering data.
4	MIS-01	Level 1A science data. This contains swath-based information with Global Mode and Local Mode data intermingled. These two modes are not separated until Level 1B1.
5	MIS-02	Level 1B1 radiometric data, Global Mode swaths
6	MIS-02	Level 1B1 radiometric data, Local Mode scenes
7	MIS-03	Level 1B2 georectified imagery, Global Mode swaths
8	MIS-03	Level 1B2 radiometric camera-by-camera cloud mask, Global Mode swaths
9	MIS-03	Level 1B2 georectified imagery, Local Mode scene
10	MIS-03	Level 1B2 radiometric camera-by-camera cloud mask, Local Mode scene
11	MIS-04	Level 2TC stereo-derived cloud product
12	MIS-04	Level 2TC albedo product
13	MIS-05	Level 2AS aerosol/surface product
14	N/A	QA files

Table C: Typical collections of files for product ordering

Data set designator (ESDT)	Data set long name	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MI2LME	MISR Level 1B2 Local Mode Ellipsoid Radiance Data									x					
MI2LM	MISR									x					

T	Level 1B2 Local Mode Terrain Radiance Data													
MI1AC	MISR Level 1A Calibration Data		x											
MI1AENG1	MISR Level 1A Engineering Data File Type 1			x										
MI1AMOT	MISR Level 1A Motor Data		x											
MI1ANAV	MISR Level 1A Navigation Data			x										
MI1AOBC	MISR Level 1A On-Board Calibration Data		x											
MI1B1	MISR Level 1B1 Radiance Data					x								
MI1B2E	MISR Level 1B2 Ellipsoid Data							x						
MI1B2T	MISR Level 1B2 Terrain Data							x						
MIB1LM	MISR Level 1B1 Local Mode Radiance Data						x							
MIL1A	MISR Level 1A CCD Science Data, all cameras				x									
MIL2AS	MISR												x	

AE	Level 2 Aerosol parameters													
MIL2ASLS	MISR Level 2 Land Surface parameters												x	
MIL2ASOS	MISR Level 2 Ocean Surface parameters												x	
MIL2TCAL	MISR Level 2 Top of Atmosphere/Cloud Albedo parameters											x		
MIL2TCCL	MISR Level 2 Top of Atmosphere/Cloud Classifier parameters										x			
MIL2TCST	MISR Level 2 Top of Atmosphere/Cloud Stereo parameters										x			
MIANCAGP	MISR Ancillary Geometric Product							x	x	x	x	x	x	x	
MIANCARP	MISR Ancillary Radiometric Product		x		x									
MIANACP	MISR Aerosol Climatology Product												x	
MIB2GEOP	MISR Geometric Parameters							x	x	x	x	x	x	x
MIRCCM	MISR Radiometric Camera-by-Camera								x					

	Cloud Mask														
MISQA	MISR Quality Assessment Data														x

2.6 Files included in standard data products

The following table includes all the file designators (ESDTs) for the MISR standard products and ancillary products. Each product includes one or more of these files, as explained above.

Table D: MISR product data Sets

Designator (ESDT)	Data Set Long Name	Description	Format
MB2LME	MISR Level 1B2 Local Mode Ellipsoid Radiance Data	Ellipsoid projected TOA parameters for the single local mode scene, resampled to WGS84 ellipsoid.	HDF-EOS Grid
MB2LMT	MISR Level 1B2 Local Mode Terrain Radiance Data	Terrain-projected TOA radiance for the single local mode scene, resampled at the surface and topographically corrected.	HDF-EOS Grid
MI1AC	MISR Level 1A Calibration Data	Level 1A calibration data in DN. The data numbers have been commuted from 12-bit numbers to 16-bit, byte aligned half-words.	HDF-EOS Swath
MI1AENG1	MISR Level 1A Engineering Data File Type 1	Reformatted Annotated Level 1A product for the camera engineering data, which represents indicators of sampled measurements.	HDF
MI1AMOT	MISR Level 1A Motor Data	Output for the Level 1A Motor data.	HDF-EOS Swath
MI1ANAV	MISR Level 1A Navigation Data	Reformatted Annotated Level 1A Product for the Navigation Data, which contains samples of the *Terra* Platform position and attitude data.	HDF-EOS Swath
MI1AOBC	MISR Level 1A On-Board Calibration Data	Contains the output for the Level 1A On-Board Calibration Data.	HDF-EOS Swath
MI1B1	MISR Level 1B1 Radiance Data	The Level 1B1 Product containing the DNs radiometrically-scaled to radiances with no geometric resampling.	HDF-EOS Swath
MI1B2E	MISR Level 1B2 Ellipsoid Data	Contains the ellipsoid projected TOA radiance, resampled to WGS84 ellipsoid corrected.	HDF-EOS Swath
MI1B2T	MISR Level 1B2 Terrain Data	Contains the terrain projected TOA radiance, resampled at the surface and topographically corrected.	HDF-EOS Swath
MIB1LM	MISR Level 1B1 Local Mode Radiance Data	Contains the DNs radiometrically scaled to radiances with no geometric resampling.	HDF-EOS Swath
MIL1A	MISR Level 1A CCD Science Data, all cameras	The Reformatted Annotated Level 1A product of the CCD science data. The data numbers (DN) have been commuted from 12-bit numbers to 16-bit byte aligned half-words.	HDF-EOS Swath
MIL2ASAE	MISR Level 2 Aerosol parameters	Contains aerosol optical depth and	HDF-EOS Grid

		particle type, with associated atmospheric data.	
MIL2ASLS	MISR Level 2 Land Surface parameters	Contains information on load directional reflectance properties, albedos (spectral and PAR-integrated), FPAR, associated radiation parameters and terrain-referenced geometric parameters.	HDF-EOS Grid
MIL2ASOS	MISR Level 2 Ocean Surface parameters	Contains water-leaving equivalent reflectance and phytoplankton pigment concentration over tropical ocean.	HDF-EOS Grid
MIL2TCAL	MISR Level 2 Top of Atmosphere/Cloud Albedo parameters	Contains local, restrictive, and expansive albedo, with associated data.	HDF-EOS Grid
MIL2TCCL	MISR Level 2 Top of Atmosphere/Cloud Classifier parameters	Contains the Angular Signature Cloud Mask (ASCM), Regional Cloud Classifiers, Cloud Shadow Mask, and Topographic Shadow Mask, with associated data.	HDF-EOS Grid
MIL2TCST	MISR Level 2 Top of Atmosphere/Cloud Stereo parameters	Contains the Stereoscopically Derived Cloud Mask (SDCM), cloud winds, Reflecting Level Reference Altitude (RLRA), with associated data.	HDF-EOS Grid
MIANCAGP	MISR Ancillary Geometric Product	This file consists primarily of terrain data on a SOM Grid. It has 233 parts, corresponding to the 233 repeat orbits of the *Terra* spacecraft.	HDF-EOS Grid
MIANCARP	MISR Ancillary Radiometric Product	Comprises 4 files covering instrument characterization data, preflight calibration data, in-flight calibration data, and configuration parameters.	HDF-EOS Grid
MIANACP	MISR Aerosol Climatology Product	This product is 1) the microphysical and scattering characteristics of pure aerosol upon which routine retrievals are based; 2) mixtures of pure aerosol to be compared with MISR observations; and 3) likelihood value assigned to each mode geographically.	Binary
MIB2GEOP	MISR Geometric Parameters	Contains the geometric parameters which measure the sun and view angles at the reference ellipsoid.	HDF-EOS Grid
MIRCCM	MISR Radiometric Camera-by-Camera Cloud Mask	Contains the radiometric camera-by-camera cloud mask. It is used to determine whether a scene is classified as clear or cloudy.	HDF-EOS Grid
MISBR	MISR Browse Data	This is the browse data associated with a particular granule. (Although its purpose is as search tool in the on-line user interface, it is designed such that it can be a separately orderable product if so required by the user.)	HDF-EOS Grid
MISQA	MISR Quality Assessment Data	This is the quality information associated with a particular granule.	ASCII

2.7 Ancillary data sets:

The following table includes all the file designators (ESDTs) for the ancillary data sets used in generating MISR standard products and ancillary products. As explained above, these files are not designed specifically for distribution but may be available on request except for a few cases that are restricted.

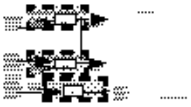
Table E: MISR ancillary data sets

Designator (ESDT)	Data Set Long Name	Description	Format
MIRFOI	MISR Reference Orbit Images	Unresampled MISR Imagery (Radiometric Product - L1B1) associated with the Projection Parameters. An ROI is a composite of several orbit passes in order to reduce the cloud cover.	HDF-EOS Swath
MIANCSSC	MISR Cloud Screening Surface Classification	Contains the MISR Cloud Screening Classification Data Set used in Level 2 processing.	HDF-EOS Grid
MIANSMT	MISR Simulated MISR Ancillary Transfer	Produced by the MISR SCF and shipped to the DAAC for generating Level 2 products.	HDF-EOS Grid
MIANTASC	MISR Terrestrial Atmosphere and Surface Climatology	Produced by the MISR SCF and shipped to the DAAC for generating Level 2 products.	HDF-EOS Grid
MIANTOAC	MISR Tropical Ocean Atmosphere Correction	Data set used as an ancillary input file to the Level 2 processing.	Binary
MIASH	MISR Angular Signature Histogram	Data set used in Level 2 processing.	HDF-EOS Grid
MIAST1	MISR Angular Signature Threshold - Biweekly File	Used in Level 2 processing. Biweekly updated file.	Binary
MIAST2	MISR Angular Signature Threshold - Seasonal File	Used in Level 2 processing. Seasonal updated file.	Binary
MIAST3	MISR Angular Signature Threshold - Static File	Used in Level 2 processing. Static file.	Binary
MIANAZM	MISR Azimuthal Model Data Set	Contains the azimuthal model data set.	HDF-EOS Grid
MIANLDBM	MISR Ancillary Land Biome Data Set	Consists of a Land Surface Classification by Biome Types.	HDF-EOS Grid
MIANPP	MISR Projection Parameters	The image coordinates which relate SOM map projection grid centers (275m resolution) to the Reference Orbit Imagery. (This data is restricted.)	HDF-EOS Grid
MIANRCCH	MISR Radiometric Camera-by-Camera Histogram Data Set	Contains histogram hits associated with a particular orbit and camera to be added to the Radiometric Camera-by-Camera Histogram Data Set.	HDF-EOS Grid
MICNFG	MISR Configuration File	Configuration constants for all PGEs.	ASCII
MIRCCT	MISR Radiometric Camera-by-Camera Threshold Data Set File	Contains the radiometric camera-by-camera threshold data set.	Binary
MISANCGM	MISR Camera Geometric Model	A parametric model describing the internal geometry of the nine cameras relative to the spacecraft frame of reference.	ASCII

2.8 Processing details:

For those who are interested in or need to know greater detail, here are two diagrams that give graphical illustrations of the

complete associations between individual MISR standard products and the respective ancillary data sets and ancillary data products. Select the left hand thumbnail to see a full-sized diagram of the Level 1 file relationships. Select the right-hand thumbnail to see a full-sized diagram of the Level 2 file relationships. Note that there is no illustration for Level 3 as these products are still under development.



2.9 Input/Output Media:

Data will be made available to the user via 8mm tape or by FTP (see Data Access section below).

2.10 Proprietary Status:

There is no proprietary status for the data sets currently on-line at the Langley DAAC, except for certain restricted data sets of non-NASA origin, as indicated above.

3. Data Access:

The MISR data is accessible by contacting the NASA Langley DAAC.

The EOS Data Gateway system will serve as the main search and order service for the EOSDIS Core System (ECS) which is being built to accommodate the tremendous amount of data expected from the new series of EOS instruments.

The EOS Gateway allows users to search science data holdings, retrieve high-level descriptions of data sets and detailed descriptions of the data inventory, view browse images, and place orders for data products.

Search methods are available to aid the user in obtaining the desired data. A general search is made by specifying geographic areas of interest along with either geophysical parameter, data set name, or sensor name. Three different search types provide increasingly detailed information about the science data available through the system. A directory search provides summary information about EOSDIS data sets. This type of search accesses the Global Change Master Directory (GCMD), a multidisciplinary database of information about Earth science data. A guide search provides detailed descriptions about data sets, data sources, instruments, projects, and data centers; it may include algorithm descriptions and calibration information. The inventory search gives descriptions of specific observations or collections of observations of data (granules) that are available from a data center.

The Gateway system includes a coverage map which is a graphical representation of the geographic coverage of selected data observations (data granules).

A browse function is also included which allows the user to view data (possibly reduced in resolution) as an aid for selecting many of the products available from the data centers. Such data may be viewed in the EOS Data Gateway interface or retrieved via File Transfer Protocol (FTP).

The order function allows the user to select the desired data processing options and media, and allows the user to specify contact, billing, and shipping addresses.

Data Center Location:

Langley Atmospheric Science Data Center
NASA Langley Research Center

Contact Information:

User and Data Services Office
NASA Langley Research Center Atmospheric Science Data Center
Mail Stop 157D
Hampton, Virginia 23681-2199
U.S.A.
Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: support-asdc@earthdata.nasa.gov

Associated Costs:

Currently, there is no cost associated with this data.

4. Principal Investigator Information:

Investigator(s) Name and Title:

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Mail Stop 169-237
Pasadena, California 91109
U.S.A.

Please direct inquiries to NASA Langley User Services: support-asdc@earthdata.nasa.gov

5. Submitting Investigator Information:

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Jet Propulsion Laboratory
Mail Stop 169-237
Pasadena, California 91109
U.S.A.

Please direct inquiries to NASA Langley User Services: support-asdc@earthdata.nasa.gov

6. References:

Here are several references to papers that give an instrument overview and an introduction to the aerosol and surface retrievals.

- Diner, D.J., J.C. Beckert, T.H. Reilly, C.J. Bruegge, J.E. Conel, R. Kahn, J.V. Martonchik, T.P. Ackerman, R. Davies, S.A.W. Gerstl, H.R. Gordon, J-P. Muller, R.B. Myneni, R.J. Sellers, B. Pinty, and M.M. Verstraete (1988). Multiangle Imaging SpectroRadiometer (MISR) description and experiment overview. IEEE Trans. Geosci. Rem. Sens., Vol. 36, pp 1072-1087.
- Martonchik, J.V., D.J. Diner, R. Kahn, T.P. Ackerman, M.M. Verstraete, B. Pinty, and H.R. Gordon (1988). Techniques for the retrieval of aerosol properties over land and ocean using multi-angle imaging, IEEE Trans. Geosci. Rem. Sens., VOl. 36, pp 1212-1227.
- Martonchik, J.V., D.J. Diner, B. Pinty, M.M. Verstraete, R.B. Myneni, Yu. Knyazikhin, and H.R. Gordon (1988). Determination of land and ocean reflectance, radiative, and biophysical properties using multi-angle imaging, IEEE Trans. Teosci. Rem. Sens., Vol. 36, pp 1266-1281.

A complete list of references can be found on the MISR Publications page.

7. Glossary and Acronyms:

EOSDIS Acronyms (PDF).

ACP - Ancillary Climatology Product
ARP - Ancillary Radiometric Product
ASCM - Angular Signature Cloud Mask
BRF - Bidirectional Reflectance Factor
CCD - Charge-Coupled Device
CM - Calibration Mode
DAAC - Distributed Active Archive Center
DEM - Digital Elevation Model
DHR - Directional Hemispherical Reflectance
DN - Data Number

ECS - EOSDIS Core System
EOS - Earth Observing System
EDOS - Earth Observing System Data and Operations System
EOSDIS - Earth Observing System Data Information System
ESE - Earth Science Enterprise
FPAR - Fraction of Photosynthetically Active Radiation
FTP - Fire Transfer Protocol
GCMD - Global Change Master Directory
GM - Global Mode
GRP - Georectified Radiance Product
HDF - Hierarchical Data Format
IFOV - Instantaneous Field-of-View
JPL - Jet Propulsion Laboratory
LaRC - Langley Research Center
LM - Local Mode
MISR - Multi-angle Imaging SpectroRadiometer
NASA - National Aeronautics and Space Administration
NDVI - Normalized Difference Vegetation Index
NIR - Near-InfraRed
PAR - Photosynthetically Active spectral Region
PGE - Product Generation Executable
PP - Projection Parameters
PSF - Point Spread Function
RCCM - Radiometric Camera-by-camera Cloud Mask
RH - Relative Humidity
RLRA - Reflecting Level Reference Altitude
ROI - Reference Orbit Image
SCF - Science Computing Facility
SDCM - Stereoscopically Derived Cloud Mask
SOM - Space-Oblique Mercator
SWAMP - Science Working Group for the AM Platform
TOA - Top of Atmosphere

8. Document Information:

- **Document Creation Date:** June 1999
- **Document Revision Date:** June 2000
- **Document Review Date** June 1999
- **Document ID:**
- **Document Curator:** Langley Atmospheric Science Data Center
  User and Data Services Office
  Telephone: (757) 864-8656
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  E-mail: support-asdc@earthdata.nasa.gov
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