MISR Level 1 Products Quality Statement
July 31, 2002

Quality Designator:

- Validated (GP_GMP, GRP_TERRAIN, GRP_ELLIPSOID, FM_SCI, RP_GM,RP_LM)
- Beta (GRP_RCCM-land)
- Provisional (GRP_RCCM-ocean)

MISR maturity level definitions

This statement applies to MISR Level 1 Products with a production date of July 31, 2002, or later until such time as further improvements to MISR software or ancillary inputs are made. See the Versioning Page for an in-depth explanation of the differences between various MISR product versions. Quality statements covering earlier time periods may be accessed through links at the bottom of this page.

The MISR Level 1 software which generated these products is believed to be functioning quite well except where noted below. This statement lists known problems with Level 1 Products and clarifies issues which have confused some users.

Geometric Parameters (a.k.a GP_GMP, MIB2GEOP) (from MISR PGE7) (Validated)

There are no known problems with the current release of PGE7 software. Analysis of isolated case studies indicates that the software is meeting all of its requirements.

The Geometric Parameters exhibit one algorithmic quirk which has surprised some users. Solar zenith and azimuth angles near the swath edge occasionally appear to jump around. This inconsistency is the result of an intentional choice of algorithm whereby solar angles are computed at the mean time at which MISR cameras viewed the ground point in question. Adjacent points are not always visible to the same set of cameras. This can cause a bias in solar angle towards cameras which acquired that point.

L1B2 Terrain (a.k.a. GRP_TERRAIN_GM, MI1B2T) (from MISR PGE1) (Validated)
L1B2 Ellipsoid (a.k.a. GRP_ELLIPSOID_GM, MI1B2E) (from MISR PGE1) (Validated)

This portion of the list is lengthy, so the sub-headings are listed for quick reference.

RADIOMETRIC CALIBRATION

The MISR calibration team has been involved in an on-going effort to both validate and make incremental improvements to the radiometric accuracy of the Level 1B data products. Because the uncertainties in these products are well understood, those produced after April 15, 2002, are given the quality designation of "Validated." Thorough descriptions of calibration uncertainties for current and older products can be found on the Calibration Page. The uncertainties at this time are listed below.

- The ***absolute uncertainty*** in MISR radiances is estimated to be within 7% (1 sigma level of confidence). The next upgrade to the Level 1B software will reduce scene-dependent effects and the absolute radiometric uncertainty to 4%.
- ***Camera and band-relative uncertainties*** are within 2%
- ***Pixel-relative uncertainties*** are within 0.5%. Although this error is small, it is sufficient to observe vertical striping in selected scenes, such as highly contrast-enhanced images of uniform snow, ocean, and desert regions.
- ***Early mission data*** (February - March, 2000) have increased uncertainties. During this time period, the MISR radiometric response was rapidly changing, due to an initial instrument on-orbit settling effect. This change has been noticed in most other on-orbit sensors, and is generally attributed to the browning of the optics in the space environment. Thus, products generated with ARP T002 may contain radiometric errors as large as 10%.

Although MISR radiometric accuracy is predictable over uniform scenes, improvements are anticipated to remove scene-dependent effects. These have been attributed to point-spread-function (PSF), ghost-image, L1B2 resampling, illumination level, and detector non-uniformity of response effects. These effects typically reduce contrast by a few percent; however, in extreme cases radiometric error can increase to about 25% for dark ocean targets (< 10 W m-2 micron-1 sr-1) with bright areas in the camera field-of-view. Because the MISR absolute radiometric scale was established over Nevada desert test sites, and believed accurate to within 4%, radiometric error increases over targets that are more extensive in size. As an example, the radiometric error for Sahara desert sites, which fill MISR camera fields-of-view, increases to 7% uncertainty. Specific examples of scene-dependent effects are given in the table below. A Level 1B correction algorithm for ghost-image and PSF effects is planned for the next product upgrade in October of 2002.

Table 1. Sources of scene-dependent effects

PSF effects refer to scene-contrast reductions due to local scene inhomogeneity. The radiometry of one pixel is affected in proportion to the contrast difference and proximity of another pixel. This is a camera optical effect, and is measurable for objects that are within 6 km crosstrack distance of each other. The downtrack PSF effect is believed to be negligible.
Ghost-images refer to the reduction in image contrast due to scene inhomogeneity on the scale of the camera field-of-view. Although in-focus ghost-images have been observed, they are radiometrically insignificant except where a bright primary image has a secondary ghost which falls on a dark target. (The secondary ghost has been measured to be 0.3% of the primary image). More significant is the reduction in contrast due to the broad-scale out-of-focus secondary images. These effects have been estimated to be 2% of the average scene brightness. As with PSF, this effect results in the reduction of the reported radiance of bright targets, and an increase in the reported radiance of dark targets.
L1B2 resampling is implemented by bilinear interpolation, and thus errors in this process are a function only of a sample's radiance value as compared to that of its immediate neighbors.
Illumination-level dependent errors are attributable to the goodness-of-fit of camera response data to a mathematical equation. The MISR cameras are described as having a quadratic relationship between incident radiance and camera output. For radiance levels less than 2% in equivalent reflectance, this assumption is valid to within 5% uncertainty. The error is considered negligible for larger input signals.
Detector uniformity of response errors occur when a set of detector elements are non-uniform in response (10% non-uniformity or greater), are image inhomogeneous scenes, and are DN-averaged as part of the on-board data compression (Global Mode) algorithm. Only a dozen detector regions (out of 13,000 such pixel blocks) are non-uniform, and these are identified by data quality indicators in the products. For conditions where bright scenes are adjacent to dark scenes, an additional radiometric error of 6% may result in pixel regions where the Data Quality Indicator level is given a value of 2.

GEORECTIFICATION and COREGISTRATION

MISR Level 1B2 products exhibit acceptable georectification and coregistration accuracy. In the nominal case, the expected mean geolocation error across all cameras is below 60 meters. Standard deviations range between 100 meters (Nadir camera) and 300 meters (D cameras). Exceptions exist, but the most evident problem in older data, the Da camera mis-registration, has been corrected for the time period August 2000 - July 2001. Degraded georectification accuracy should be expected of data acquired by the Da camera outside of this time period. Also, all camera data acquired near the time of occasional spacecraft maneuvers is of degraded accuracy. See the Georectification Page for more details, including a link to the list of degraded orbits.

It is possible that the registration accuracy of future Da camera data will fluctuate. However, both georectification accuracy and the ability to automatically assess georectification accuracy will be improved as soon as MISR Level 1 software is enhanced to take advantage of navigation correction by means of image matching against a specially prepared ancillary dataset. When implemented, this image matching process is expected to fix any new Da Camera mis-registration.

EXCEPTIONS/ANOMALIES

- **GAPS** The raw MISR data contains occasional gaps. These gaps usually consist of a few lost lines. Straight lines of raw data are resampled to gentle curves in the SOM map projection. Radiances in the gap regions are filled in with pre-defined fill values. Gaps then usually look like narrow, curved, bright, horizontal stripes in the L1B2 image. There is at least one small gap in almost every swath. In rare cases, data gaps of many lines have been observed.
- **INSTRUMENT OUT-OF-SYNC** The MISR instrument tends to go out-of-sync momentarily if the data rate from the hardware exceeds the real-time flight computer's capacity to write data out. This condition can occur whenever a change of camera state is commanded. Image lines acquired while the MISR instrument was out-of-sync may contain sporadic fill and/or repeats of previous lines. The resulting image contains a brief vertical smear across the swath. Normally, this phenomenon only lasts for a handful of lines. In order to avoid geolocation errors, fill values are inserted in the line time fields in these regions. In the worst cases, a 1-line registration error can be generated in a multi-line region of the Level 1 data.
- **TERRAIN TOPOGRAPHIC OBSCURATION** The line-of-sight between an off-nadir camera and a ground point is sometimes blocked by a topographic feature, such as a mountain. In such cases, fill values are reported instead of radiances in the terrain product. Large patches of obscuration fill can be seen in the D cameras over mountainous regions.
- **TERRAIN OCEAN FILL** Blocks which encompass no land at all get entirely filled with ocean-fill values in the terrain product. Terrain algorithms are wasteful over ocean since height variation is negligible there. The Ellipsoid product already contains radiances for these blocks. If ocean blocks are required, blocks from the Ellipsoid product may be substituted.

ELLIPSOID COLOR BROWSE

The Nadir, single-band L1A browse product has been replaced with a new Ellipsoid-based color product. The new browse product is generated for all 9 cameras at 2.2 km resolution (sub-sampled). MISR Red, Green and Blue bands are used to create the color image, which is intentionally clipped and gamma-stretched in order to make cloud, ocean and land features visible. The jpeg compression is performed at 75% quality, which means that compression artifacts are occasionally visible.

L1A CCD (a.k.a. FM_SCI, MIL1A) (from MISR PGE1) (Validated)

The MISR Level 1A product is a reformatted version of the raw L0 data packet stream from the spacecraft. In this format, the CCD Data Numbers (DNs) may be viewed as an unregistered image with data quality indicators occupying the two low-order bits. By design, L1A does not differ greatly from the raw data except that gaps are filled in with appropriate fill values.

L1B1 (a.k.a. RP_GM, MI1B1) (from MISR PGE1) (Validated)
L1B1 Local Mode (a.k.a. RP_LM, MI1B1LM) (from MISR PGE1) (Validated)

The MISR Level 1B1 product has been radiometrically corrected, but it has not been registered. The quality of L1B1 radiances is equivalent to that of L1B2 radiances discussed above, except that L1B1 pixels correspond directly to instrument CCD detector samples. The instrument out-of-sync condition can temporarily corrupt the times reported with MISR L1B1 lines.

The L1B1 Local Mode product consists of the L1B1 output acquired when the MISR instrument is put into Local Mode in which all nine cameras view a scene at 275 m resolution in all four bands.

RCCM (a.k.a. GRP_RCCM, MIRCCM) (from MISR PGE1) ANCHOR#rccm1END(Provisional: RCCM over Ocean and Glitter Mask) (Beta Quality: RCCM over Land)

The cloud mask produced during Level 1 processing is called the RCCM (Radiometric Camera-by-camera Cloud Mask). It is one of three independent cloud masks generated from MISR data. The other two cloud masks are produced at Level 2 and are called the ASCM (Angular Signature Cloud Mask) and the SDCM (Stereo Derived Cloud Mask).

The RCCM algorithm applies traditional spectral and spatial measures to data from each MISR camera in order to produce separate cloud masks for each camera. These measures and the threshold procedures are completely different for the two processing paths: ocean and land. For this reason, ocean and land may carry different quality statements. Another field, the Glitter Mask, is included in the RCCM product for the sake of convenience.

Over ocean, the RCCM employs a static threshold procedure. The static thresholds are a function of the sun-view geometry and have been fine-tuned several times since launch. Several tests have been performed to bring the quality of the **RCCM over ocean** from Beta to **Provisional Quality**:

- Visual inspection of several hundred orbits has revealed very good performance of the cloud mask.
- Cloud fraction vs. view angle statistics gathered from approximately 1300 orbits have revealed overall good performance of the cloud mask, with the ability to single out problem scenes for further visual analysis.
- A Level 3 diagnostic clear sky RGB map has revealed a uniform ocean background, with the expected brightening over the sun-glint edge of the swath, and browning over thick aerosol regions (e.g., Sahara dust off the west coast of Africa.)

Although overall performance looks good for the RCCM over ocean, it does suffer from the traditional problems encountered with spectral/spatial cloud masks:

- Very thin clouds may go undetected.
- Thick aerosol layers may at times be classified as cloud.
- Cloud detection over strong sun-glint regions may at times be a problem.
- Sea ice is often classified as cloud.
- Shallow waters near coast lines can cause clear skies to be classified as cloud.

The **RCCM over land** is designed to use completely dynamic thresholds. However, at this time, the dynamic threshold procedure is not in place. Instead, a static set of thresholds is currently being used. This static threshold dataset was developed pre-launch using 10 consecutive days of AVHRR data. Its intention was simply to act as a placeholder for the thresholds generated using the dynamic threshold procedure. Its overall performance is not suitable for scientific use. As such, it remains **Beta Quality**. It has been deduced by visual inspection of ~10 orbits that reasonable performance is only observed over vegetated land.

The Glitter Mask indicates regions of the data that may contain sun-glint. As of February 5, 2002, the sun-glint cone angle was increased from 30 degrees to 40 degrees in order to mask some of the weaker glint that was observed in the imagery. The Glitter Mask is currently of Provisional Quality.

See also:

- Statement dated April 15, 2002 for MISR Level 1 Products from April 15, 2002 to July 26, 2002;
- Statement dated February 05, 2002 for MISR Level 1 Products from February 05, 2002 to April 14, 2002;
- Statement dated December 03, 2001 for MISR Level 1 Products from December 03, 2001 to February 4, 2002;
- Statement dated September 27, 2001 for MISR Level 1 Products from September 27, 2001 to December 02, 2001;

- Statement dated March 30, 2001 for MISR Level 1 Products from March 30, 2001 to September 26, 2001;
- Statement dated February 16, 2001 for MISR Level 1 Products from December 21, 2000 to March 29, 2001;
- Statement dated August 24, 2000 for MISR Level 1 Products from August 1 to December 20, 2000;
- Statement dated June 15, 2000 for MISR Level 1 Products from June 1 to July 31, 2000.