

Version 1.1

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# Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Version 4 Product User Guide November 2025

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## Executive Summary

This document provides the User Guide for all ASTER Version 4 Final Collections. It supplements the JPL ASTER User's Handbook and other previous ASTER User Guides by providing new information on the ASTER (Version 4) Final Collections included in the final processing campaign.

## Version Log History

<b>Revision</b>	<b>Date Updated</b>	<b>Prepared By</b>	<b>Description</b>
Draft	February 2025	Karen Yuan	Draft of ASTER Version 4 User Guide
Version 1.0	April 2025	Karen Yuan	Added QA and additional Metadata Information
Version 1.1	September 2025	Karen Yuan	Updated Section 8: Improvements

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# 1. Introduction

## 1.1 ASTER Overview

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a multispectral imaging mission launched aboard NASA's Earth Observing System (EOS) Terra Platform on December 18, 1999. It has been acquiring Earth observations for over 25 years. ASTER captures data across a wide spectral range, from visible to thermal infrared, using 14 spectral bands with high spatial, spectral, and radiometric resolution. The spectral band passes are shown in Table 1.1. The wide spectral region is covered by three telescopes:

- Three Visible and Near Infrared Radiometer (VNIR) bands with a spatial resolution of 15 meters (m)
- Six Short Wave Infrared Radiometer (SWIR) bands with a spatial resolution of 30 m and
- Five Thermal Infrared Radiometer (TIR) bands with a spatial resolution of 90 m.

Each subsystem has a nadir-pointing telescope, and the VNIR subsystem has an additional backward pointing telescope that captures stereo imagery in the near infrared spectral band (band 3B). Each ASTER acquisition (scene) covers an area of 60 x 60 km. ASTER is a partnership between NASA, Japan's Ministry of Economy, Trade and Industry (METI), the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, and Japan Space Systems (J-spacesystems). The Land Processes Distributed Active Archive Center (LP DAAC) ingests, archives, processes, and distributes ASTER data.

**Table 1.1: ASTER Spectral Bands**

Subsystem	Band No.	Spectral Range ( $\mu\text{m}$ )	Spatial Resolution
VNIR	1	0.52 - 0.60	15 m
VNIR	2	0.63 - 0.69	15 m
VNIR	3N	0.78 - 0.86	15 m
VNIR	3B	0.76 - 0.86	15 m
SWIR	4	1.600 - 1.700	30 m
SWIR	5	2.145 - 2.185	30 m
SWIR	6	2.185 - 2.225	30 m
SWIR	7	2.235 - 2.285	30 m
SWIR	8	2.295 - 2.365	30 m
SWIR	9	2.360 - 2.430	30 m
TIR	10	8.125 - 8.475	90 m
TIR	11	8.475 - 8.825	90 m
TIR	12	8.925 - 9.275	90 m
TIR	13	10.25 - 10.95	90 m
TIR	14	10.95 - 11.65	90 m

## 1.2 ASTER Final Processing Campaign Overview

As the Terra satellite approaches its decommissioning phase, the LP DAAC, in collaboration with the ASTER Science Team, is reprocessing the entire ASTER archive using improved atmospheric inputs for Level 2 (L2) Product Generation Executables (PGEs) and updated Landsat Collection 2 Ground Control Points (GCPs) and Digital Elevation Models (DEMs) to

improve geolocation accuracy and temporal consistency. ASTER L1T utilizes the GCPs and DEMs for precision terrain correction. On January 24, 2025, the LP DAAC started the ASTER Final Processing Campaign. The goal of the final processing campaign is to produce static collections (referred to as Version 4) of eleven selected ASTER products (see Table 2.1) for the entire ASTER archive of acquisitions (scenes). Following the completion of the ASTER final processing campaign, the LP DAAC will no longer provide on-demand product generation, and users will be directed to access the final Version 4 full collections. The objective of this User Guide is to provide information on the ASTER Version 4 products included in the final processing campaign.

## 2. Data Products

ASTER Version 4 includes 11 products (as opposed to the 16 products found in Version 3). The selection of products for the final version was made based on usage, scientific merit, and feedback from the ASTER Science Team.

**Table 2.1: ASTER Version 4 Products**

Product Name	Shortname	File Format
ASTER L1A Reconstructed Unprocessed Instrument Data	AST_L1A	HDF-EOS2
ASTER L1B Registered Radiance at the Sensor	AST_L1B	HDF-EOS2
ASTER L1T Precision Terrain Corrected Registered At-Sensor Radiance	AST_L1T	COG
ASTER L2 Surface Emissivity	AST_05	COG
ASTER L2 Surface Reflectance VNIR and SWIR	AST_07	COG
ASTER L2 Surface Reflectance VNIR and Crosstalk Corrected SWIR	AST_07XT	COG
ASTER L2 Surface Kinetic Temperature	AST_08	COG
ASTER L2 Surface Radiance VNIR and SWIR	AST_09	COG
ASTER L2 Surface Radiance TIR	AST_09T	COG
ASTER L2 Surface Radiance VNIR and Crosstalk Corrected SWIR	AST_09XT	COG
ASTER Digital Elevation Model	AST14DEM	COG

## 3. Data Characteristics

The following tables (3.1-3.3) show example L2 collection, granule, and SDS characteristics.

**Table 3.1: Example L2 Collection (AST\_05) Characteristics**

Characteristic	Description
Collection	ASTER
DOI	10.5067/ASTER/AST_05.004
File Size	~9 MB
Temporal Resolution	Varies
Temporal Extent	2000-03-04 to Present
Spatial Extent	Global
Coordinate System	Universal Transverse Mercator (UTM)
Datum	World Geodetic System (WGS84)
File Format	Cloud-optimized GeoTIFF (COG)
Geographic Dimensions	~60 km x 60 km

**Table 3.2: Example L2 Product (AST\_05) Granule Characteristics**

Characteristic	Description
Number of Science Dataset (SDS) Layers	5
Columns/Rows	700 / 800
Pixel Size	90 m

**Table 3.3: Example L2 Product (AST\_05) SDS Layer Characteristics**

SDS Name	Description	Units	Data Type	Fill Value	No Data Value	Valid Range	Scale Factor
TIR_Band10	90 meter resolution TIR Band 10 (8.125 to 8.475 $\mu\text{m}$ )	N/A	16-bit unsigned integer	N/A	N/A	0 to 65535	0.001
TIR_Band11	90 meter resolution TIR Band 11 (8.475 to 8.825 $\mu\text{m}$ )	N/A	16-bit unsigned integer	N/A	N/A	0 to 65535	0.001
TIR_Band12	90 meter resolution TIR Band 12 (8.925 to 9.275 $\mu\text{m}$ )	N/A	16-bit unsigned integer	N/A	N/A	0 to 65535	0.001
TIR_Band13	90 meter resolution TIR Band 13 (10.25 to 10.95 $\mu\text{m}$ )	N/A	16-bit unsigned integer	N/A	N/A	0 to 65535	0.001
TIR_Band14	90 meter resolution TIR Band 14 (10.95 to 11.65 $\mu\text{m}$ )	N/A	16-bit unsigned integer	N/A	N/A	0 to 65535	0.001

For collection, granule, and science dataset (SDS) characteristics for all eleven of the ASTER Version 4 products, please visit the [Product Dataset Landing Pages](#).

## 4. File Naming Conventions

ASTER filenames (i.e., the local granule ID) follow a naming convention which provides useful information regarding the specific product.

For example, the filename AST\_L1B\_00409252001185202\_20250213043112.hdf indicates:

AST\_L1B – Product Shortname

004 – Collection Version

09252001 – Calendar Date of Acquisition (MMDDYYYY)

185202 – Hours, Minutes, and Seconds of Acquisition (HHMMSS)

20250213 – Calendar Date of Processing (YYYYMMDD)

043112 – Hours, Minutes, and Seconds of Processing (HHMMSS)

.hdf – File Format (HDF4)

For products delivered as cloud-optimized GeoTIFFs: the filename  
AST\_05\_00409252001185202\_20250213043757\_SRE\_TIR\_B10.tif indicates:

AST\_05 – Product Shortname  
004 – Collection Version  
09252001 – Calendar Date of Acquisition (MMDDYYYY)  
185202 – Hours, Minutes, and Seconds of Acquisition (HHMMSS)  
20250213 – Calendar Date of Processing (YYYYMMDD)  
043757 – Hours, Minutes, and Seconds of Processing (HHMMSS)  
SRE – Surface Emissivity  
TIR – Thermal Infrared  
B10 – Band Number  
.tif – Cloud-Optimized GeoTIFF (COG) File Format

#### 4.1 ASTER Product Long Name

The ASTER Product Long Name (i.e., Collection-Level) convention provides useful information regarding the product.

In this example, ASTER L1B Registered Radiance at the Sensor V004 indicates:

ASTER: Instrument/Sensor  
L1B: Processing Level  
Registered Radiance at the Sensor: Geophysical Parameter  
V004: Collection or Version

#### 4.2 File Structure and Metadata

##### 4.2.1 HDF-EOS2 File Structure and Metadata

The AST\_L1A.004 and AST\_L1B.004 products are distributed using HDF-EOS2 file format. Data from each of ASTER's 15 bands are stored within subgroups for the applicable sub-system (VNIR, SWIR, TIR). Each HDF metadata file contains the following attributes: Ancillary Data, Cloud\_Coverage\_Data, coremetadata.0, productmetadata.0, productmetadata.1, productmetadata.s, productmetadata.t, productmetadata.v, StructMetadata.0, StructMetadata.1; SWIR, TIR, and VNIR.

- **Ancillary Data** includes the following data: primary\_header, secondary\_header, flag\_byte, time\_conversion, velocity, position, attitude\_angle, and attitude\_rate. This information is used as control data for extracted image data.
- **Cloud Coverage Data** contains cloud coverage for the scene.
- **coremetadata.0** contains inventory metadata.
- **productmetadata.0** contains generic metadata.
- **productmetadata.1** contains GDS generic metadata, which includes header information.

- **productmetadata.s** contains product specific metadata and attributes for SWIR.
- **productmetadata.t** contains product specific metadata and attributes for TIR.
- **productmetadata.v** contains product specific metadata and attributes for VNIR.
- **StructMetadata.0** contains categories of the HDF data object for VNIR and SWIR.
- **StructMetadata.1** contains categories of the HDF data object for TIR.

**Table 4.1: Standard metadata for all ASTER products**

Group/Object Name	Type	Description
ShortName	string	The short name for information that identifies a dataset: 'ASTL1A'
SizeMBDataGranule	double	The volume of data contained in the granule. Unit: Mbytes
ProductionDateTime	datetime	Generation date and time of this Level 1A product.
PlatformShortName	string	'AM-1' fixed.
InstrumentShortName	string	'ASTER' fixed.
WestBoundingCoordinate	double	Western-most coordinate of the scene expressed in longitude.
NorthBoundingCoordinate	double	Northern-most coordinate of the scene expressed in geodetic latitude.
EastBoundingCoordinate	double	Eastern-most coordinate of the scene expressed in longitude.
SouthBoundingCoordinate	double	Southern-most coordinate of the scene expressed in geodetic latitude.
TimeOfDay	string	format: hhmmssd...dZ
CalendarDate	string	format: YYYYMMDD
FutureReviewDate	string	The date of the nearest planned QA peer review in the future. format: YYYYMMDD
ScienceReviewDate	string	The date of the last QA peer review. format: YYYYMMDD
QAPercentMissingData	double	The percentage of missing data in the scene. Unit: %
QAPercentOutofBoundsData	double	The percentage of out of bounds data in the scene. Unit: %
QAPercentInterpolatedData	double	The percentage of interpolated data in the scene. Unit: %
ReprocessingActual	string	States what reprocessing has been performed on this granule. {'not reprocessed', 'reprocessed once', 'reprocessed twice', 'reprocessed n times'}
PGEVersion	string	The version of PGE
ProcessingLevelID	string	The classification of the science data processing level: '1A'
MapProjectionName	string	The type of map projection used: 'N/A'

#### 4.2.2 Cloud-Optimized GeoTIFF File Structure and Metadata

Nine of the ASTER Version 4 products, including AST\_L1T.004, AST\_05.004, AST\_07.004, AST\_07XT.004, AST\_08.004, AST\_09.004, AST\_09T.004, AST\_09XT.004, and AST14DEM.004 are distributed using COG file format. Each ASTER granule contains a COG file for each available band along with one or two QA data plane layers depending on the

product, along with global attributes and dataset specific attributes such as the ancillary fallback sequence pertaining to the granule. The product metadata file has been converted to JSON format with the same attributes available as those from the HDF-EOS2 metadata descriptions listed above.

**Table 4.2: An example of a list of ASTER COG files for an AST\_05.004 granule.**

Filename
AST_05_00409242022201425_20241107123346_SRE_TIR_B10.tif
AST_05_00409242022201425_20241107123346_SRE_TIR_B11.tif
AST_05_00409242022201425_20241107123346_SRE_TIR_B12.tif
AST_05_00409242022201425_20241107123346_SRE_TIR_B13.tif
AST_05_00409242022201425_20241107123346_SRE_TIR_B14.tif
AST_05_00409242022201425_20241107123346_SRE_TIR_QA_DataPlane.tif
AST_05_00409242022201425_20241107123346_SRE_TIR_QA_DataPlane2.tif

## 5. ASTER Processing Levels

- **Level-1A (L1A):** Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (e.g., platform ephemeris) computed and appended but not applied to L0 data.
- **Level-1B (L1B):** L1A data that have been processed to sensor units (at-sensor radiance).
- **Level-2 (L2):** Derived geophysical variables at the same resolution and location as Level-1 source data.
- **Level-3 (L3):** Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.

## 6. Algorithm Description

Please refer to the Algorithm Theoretical Basis Document (ATBDs) available on each [ASTER V4 Dataset Landing Page](#) for additional information on processing methodologies and algorithms used to generate ASTER Level 1, Level 2, and Level 3 products. The ATBDs describe the algorithms, input data, and processing steps used to generate the final products in detail. Section 8 of this document includes a description of the improvements made to the L1-L3 algorithms used to produce the Version 4 ASTER products.

## 7. Quality

Quality assurance of ASTER products are performed in a two pronged approach, which are generated within product generation software. First, QA parameters are calculated and results are reported in the metadata. Summary of QA statistics include: QAPERCENTMISSINGDATA, QAPERCENTOUTOFBOUNDSDATA, QAPERCENTCLOUDCOVER, and QAPERCENTINTERPOLATEDDATA. Second, each ASTER product contains one or two QA Data Plane datasets, depending on the product. The QA Data Plane provides a pixel-level quality analysis. Each pixel will be marked as Good, Bad, Suspect and its cloudiness is noted. The second QA Data Plane is optional and its structure depends on the product level.

See the [ASTER Higher Level Data Product Quality Assessment Plan](#) for product specific QA Data Plane information.

## 8. Improvements

### 8.1 Level 2 Atmospheric Ancillary Inputs

Several ASTER Level 2 (L2) products require additional atmospheric inputs to retrieve geophysical variables at the surface. These products include surface emissivity (AST\_05), surface reflectance in VNIR and SWIR (AST\_07 and AST\_07XT), surface kinetic temperature (AST\_08), and surface radiance in VNIR, SWIR, and TIR (AST\_09, AST\_09T, and AST\_09XT). To generate these products, the LP DAAC utilizes the Science Scalable Scripts-based Science Processor for Missions (S4PM) Lite framework, which executes the Level 2 Product Generation Executables (PGEs).

Modern-Era Retrospective analysis for Research and Applications, Versions 2 ([MERRA-2](#)), produced by NASA's Global Modeling and Assimilation Office (GMAO), is the new primary source of atmospheric input data for ASTER L2 Version 4 products. MERRA-2 is a global atmospheric reanalysis product that integrates both satellite observations and ground-based measurements. The dataset provides three-hourly profiles of temperature, water vapor, pressure, and ozone at a spatial resolution of roughly 50 kilometers. Because of its temporal frequency, spatial detail, and scientific validation, MERRA-2 provides consistent ASTER atmospheric corrections compared to earlier input sources. MERRA-2 observations are available for the entire ASTER temporal extent, meaning that the entire ASTER Version 4 product archives are all generated using the same auxiliary data source.

When MERRA-2 data are not available—for example, due to latency in recently acquired observations—the processing system uses fallback inputs in a defined sequence. The first alternative is the Global Data Assimilation System (GDAS), also referred to historically as NCEP/GDAS. It provides six-hourly global atmospheric model outputs. If neither MERRA-2 nor GDAS are available, monthly climatology profiles are used as the final fallback option. This sequence ensures that ASTER Level 2 products can continue to be generated without interruption even when the preferred data source is not accessible.

The ancillary atmospheric inputs are applied within the MODerate resolution atmospheric TRANsmission (MODTRAN) radiative transfer model to account for the influence of the atmosphere on ASTER-observed radiances. In the case of the AST\_05 Surface Emissivity product, the corrected radiances are subsequently processed with the Temperature and Emissivity Separation (TES) algorithm to derive surface emissivity and kinetic temperature. The TES algorithm has not been modified during this update.

Users can determine which atmospheric input source was applied to a particular granule by reviewing the product metadata. The OPERATIONALQUALITYFLAGEXPLANATION field provides this information. If MERRA-2 was used, the field states “All requested inputs are used.” If not, the metadata specifies whether GDAS or climatology provided the fallback inputs. While both fallback sources are scientifically valid, they may introduce subtle scene-level differences, particularly near cloud edges or in areas of complex surface–atmosphere interactions.

In summary, ASTER Level 2 products are generated using a structured atmospheric input framework that prioritizes MERRA-2 first, followed by GDAS, and then climatology as a final fallback. This approach provides robust and consistent data processing while the adoption of MERRA-2 enhances the overall stability and standardization of ASTER surface retrievals.

## **8.2 Collection 2 Ground Control Points and Input DEMs**

The ASTER Level 1T (AST\_L1T) product is a precision terrain-corrected dataset that provides geodetically accurate, orthorectified radiance at the sensor. Development of this product was initiated in response to recommendations from the Terra Senior Review, which identified the need for orthorectified Level 1 data products to support consistent time-series analyses and facilitate interoperability with data from other remote sensing instruments such as Landsat.

ASTER L1T processing begins with ASTER Level 1A input data and applies Landsat-derived geometric algorithms, including systematic correction, resampling, precision grid generation, and geometric verification. The resulting product is a radiometrically calibrated, geodetically aligned, precision terrain-corrected image suitable for scientific and operational applications.

For the ASTER L1T Final Collection (V004), the auxiliary datasets that support orthorectification—Landsat-based Ground Control Points (GCPs) and Digital Elevation Models (DEMs)—were upgraded from Collection 1 (C1) to Collection 2 (C2). This transition ensures compatibility with the current USGS Landsat Collection 2 archive and improves both horizontal and vertical accuracy. The ASTER Level 1T processing logic itself remains unchanged.

In Collection 2, the Landsat GCP dataset was re-baselined against the European Space Agency’s Sentinel-2 Global Reference Image. This update significantly enhances geodetic control and spatial consistency, reducing co-registration error (CE90) from approximately 26 meters in C1 to less than 10 meters in C2—a nearly 60% improvement in horizontal alignment for Landsat C2 observations.

The DEM inputs in C2 were also modernized, replacing older Shuttle Radar Topography Mission (SRTM)-based layers with a composite elevation product derived from multiple high-resolution sources. These include NASADEM, ArcticDEM, Canadian DEM (CDEM), Alaska National Elevation Database (AK\_NED), Sweden–Norway–Finland DEM (SNF), Norwegian Polar Institute DEM (NPI), Greenland Ice Sheet Mapping Project DEM (GIMP), and Radarsat Antarctic Mapping Project DEM (RAMP). The integrated global DEM mosaic features void-filling, artifact reduction, and improved seam matching, producing smoother elevation transitions across tile boundaries while maintaining the native 3-arc-second resolution.

Landsat validation against benchmarks such as ICESat-2 and National Geodetic Survey (NGS) control points demonstrates regional root mean square error (RMSE) values of 1–4 meters. In high-relief terrain, vertical accuracy improvements of up to 35 meters have been observed—representing more than a twofold improvement compared to Landsat Collection 1 datasets<sup>1</sup>.

While no similar validation have yet been completed for ASTER, these refinements should enhance the precision of orthorectification and terrain correction in AST\_L1T ensuring more reliable geolocation for time-series studies and multi-sensor integration.

<sup>1</sup>Franks, S.; Storey, J.; Rengarajan, R. The New Landsat Collection-2 Digital Elevation Model. *Remote Sens.* 2020, 12, 3909. <https://doi.org/10.3390/rs12233909>.

### **8.3 Cloud-Optimized GeoTIFF (COG) File Format**

Along with auxiliary dataset improvements, ASTER Version 4 products (except AST\_L1A and AST\_L1B) have transitioned from the legacy HDF-EOS2 format to Cloud Optimized GeoTIFF (COG). This change is part of NASA's broader shift toward cloud-native geospatial standards, aimed at improving accessibility, interoperability, and usability.

The cloud-optimized file format, paired with all ASTER Version 4 products being made available in NASA's Earthdata Cloud, offer a new era of efficient ASTER data access. Each granule is now delivered as a set of per-band COGs with the following characteristics:

- Per-band delivery: Each file contains one spectral band (VNIR, SWIR, or TIR).
- Georeferencing: Products are provided in UTM projection (WGS84 datum).
- Optimized structure: Internal tiling and pyramids allow rapid subsetting and multi-resolution visualization.
- Compression: DEFLATE compression reduces storage requirements without affecting data quality.
- Metadata: Each granule includes STAC-compliant JSON metadata describing acquisition, processing level, band properties, and spatial geometry.
- Raster values remain radiometrically calibrated and corrected with standard GeoTIFF/COG metadata tags defining scale, offset, and nodata values.

## 9. Known Issues

During a software upgrade, the QAPERCENTINTERPOLATEDDATA value found in .met files for L1A and L1B were inconsistent and outside of the valid range for those that were processed using the previous software version. After some additional testing and in consultation with the ASTER Science Team, it was determined that the QAPERCENTINTERPOLATEDDATA value did not have any impact on the science data. Therefore, the value has been set at 0 and nullified.

Additionally, during L2 PGE validation testing, it was observed that L2 products that are on the international date line / anti-meridian have incorrect bounding coordinates for the UTM zone defined in the file metadata.

## 10. Data Access

ASTER Version 4 products are made available by the LP DAAC in the NASA Earthdata Cloud through the [NASA Earthdata Search](#) user interface and programmatically via [NASA's Common Metadata Repository \(CMR\)](#). ASTER Version 4 Data Resources including tutorials for how to access ASTER V4 data using Python can be found on the [ASTER Data Resources NASA GitHub Repo](#).

## 11. Contact Information

LP DAAC User Services

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