PCS Section 3.3.3 Terra ASTER Processing and Algorithm Version History Document

Purpose: This document fulfills the requirements outlined in the NASA Earth Science Data Preservation Content Specification (PCS) Section 3.3.3: Processing and Algorithm Version

PCS 3.3.3 Requirement	Addressed in ASTER PGE History Document
Processing & product version history	Timeline of ASTER PGE, Radiometric Calibration database (DB) updates from 2016–2024, including version numbers (e.g., 3.4, 3.4-3_9), and product-version updates from 2005-2025.
Which versions were used	Each entry lists release dates (e.g., Oct 2019, Jul 2020) if available).
Why new versions were introduced	Narrative notes describe drivers: anomaly fixes (2017 TIR), orbit correction (2024), ancillary data updates (MOD07, MERRA-2), toolkit changes, etc.
What improvements were made	Each entry highlights enhancements: fallback mechanisms, radiometric DB version upgrades, SILCAST v3.0 for DEMs, elevation handling, geoid referencing, etc.
Ancillary, input, or calibration history	References to input changes (NCEP/GDAS, AURAOMI, MOD07, MERRA-2) and calibration updates (radiometric DB).
Traceability of inputs & methods	Document ties each PGE upgrade to improvements in inputs, calibration, or processing environment, ensuring provenance is documented.
Source code & file-level metadata	PGEs are tracked within DAAC operations; file-level metadata already records the PGE version used (not restated in narrative but ensured operationally).
Maintenance of historical versions	Notes when “final” PGEs were promoted (e.g., S4PM Lite installations). Older versions are retained internally per DAAC practice.

Introduction

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument has been one of NASA's longest-running sources of moderate-resolution multispectral data since its launch on Terra in December 1999. To maintain the quality and consistency of its data products, ASTER's processing system relies on Product Generation Executables (PGEs)—software modules that convert raw satellite observations into higher-level science products such as reflectance, emissivity, temperature, and digital elevation models.

The ASTER Team in Japan created and maintains the Level-1 processing software which creates at-satellite radiance products from the raw instrument data. This document primarily covers Level-2 product generation, which uses Level-1B radiance products as input for higher-level geophysical retrievals.

Over the past two-plus decades of operation, ASTER has applied regular updates to its PGEs and its Radiometric Calibration Coefficients (RCCs) to address instrument drift, evolving atmospheric inputs, changes in orbital/illumination conditions, and expanding user requirements.

The historical record for these updates comes from two sources:

Pre-2016 information is reconstructed from LP DAAC public announcements and dataset release notices, which documented major early-mission milestones such as emissivity database releases, cloud-mask reassessments, and foundational calibration or processing adjustments.

2016–2025 information is derived from internal PGE operational logs, which provide precise version numbers, release dates, and the technical motivations behind each change.

Taken together, these sources provide a unified history of ASTER processing evolution. The following summary integrates both eras, offering a timeline and narrative of PGE and RCC updates that highlights how each adjustment contributed to long-term data quality, usability, and scientific reliability.

May 2005: Addition of NCEP/TOVS as Atmospheric Correction

National Center for Environmental Prediction/TIROS Operational Vertical Sounder (NCEP/TOVS) Ozone data were introduced as an ancillary input for ASTER Level 2 on-demand products, providing an additional option for column ozone correction alongside Climatology. When TOVS data acquired on or after April 18, 2005 contained instrument errors, fallback to Climatology ensured continuous and reliable processing. This update expanded atmospheric correction capabilities and reinforced the consistency of ASTER Level 2 products.

May 2006: LP DAAC Offers New ASTER Level-1B On-Demand Data Sets

LP DAAC implemented on-demand ASTER Level-1 processing, allowing users to request updated Level-1A and Level-1B data for any scene in the archive. This new approach applied the most current geometric and radiometric correction coefficients, improving the accuracy of inputs

used for higher-level products. All Level-1 and higher-level products were delivered via FTP-Pull, simplifying user access across the full ASTER archive.

May 2006: LP DAAC Offers ASTER Digital Elevation Model (DEM) Products Using New Production Software

LP DAAC implemented new ASTER DEM production software that replaces both the former relative and absolute DEM processes and no longer requires user-supplied ground control points (GCPs). The update was driven by growing demand, a significant order backlog, and observed accuracy issues in the earlier relative DEMs. The new system automatically produces 30-meter GeoTIFF DEMs at much higher throughput—often 50 or more per day—while meeting or exceeding the accuracy specifications defined in the ASTER DEM ATBD. With this transition, absolute DEMs are no longer offered due to low demand and variable GCP quality, and users may notice some differences in automatically generated products (e.g., unedited water bodies or cloudy areas), though overall accuracy and production efficiency are improved.

October 2006: SWIR Crosstalk-Corrected products

LP DAAC released a new suite of ASTER SWIR crosstalk-corrected products for Level 2 surface reflectance and radiance. These products addressed sensor crosstalk issues in SWIR bands while maintaining the original VNIR data, improving the fidelity of SWIR measurements for downstream applications.

February 2007: Release of New ASTER Level-3 Orthorectified Image Products

LP DAAC introduced on-demand ASTER Level-3 orthorectified products, generated from Level-1A data and DEM created from the same scene. Two suites were released: AST14OTH, providing orthorectified, calibrated radiance images for all 15 ASTER bands (including 3B), and AST14DMO, which delivers both the scene-derived DEM and the full set of 15 orthorectified Level-1B radiance images as a combined multi-file product.

August 2007: Water Detection Option in DEM Production Software

ASTER DEM software introduced a selectable water detection option. The default “water on” setting produced reliable DEMs in most scenarios, while the “water off” option allowed users to mitigate misclassification in scenes with high-altitude dark objects, such as shadows or black rocks. This addition provided greater flexibility and improved DEM accuracy across diverse terrain.

June 2008: GeoTIFF Option for Level-1 and Level-2 products

S4PM 5.4.3 introduced the ability to generate Level-1 and Level-2 ASTER products in GeoTIFF format, alongside the default HDF. Metadata and ancillary files were also provided in plain text, streamlining data access and usability for a broader range of applications.

January 2010: Cloud Cover and DEM Software Updates

A new method for assessing scene cloud cover was implemented, improving the accuracy of metadata values for both historical and newly acquired imagery. Concurrently, ASTER DEM software was upgraded to enhance horizontal resolution and water body detection, reducing the minimum detectable water body from 12 to 1 sq km. These improvements ensured higher-quality DEM outputs for scientific and operational applications.

October 2011: Release of ASTER GDEM Version 2

ASTER released the Global Digital Elevation Model Version 2 (GDEM V2), offering substantial improvements over Version 1. Increased stereo pair coverage and algorithm refinements, including water masking and bias correction, enhanced horizontal and vertical accuracy, reduced artifacts, and provided more realistic representation over water bodies. This release strengthened ASTER's role as a key global elevation dataset.

February 2012: Release of the North American ASTER Land Surface Emissivity Database (NAALSED)

LP DAAC released the North American ASTER Land Surface Emissivity Database (NAALSED), a seasonal emissivity and land surface temperature product derived from ASTER observations collected from 2000–2010 during leaf-on periods. The 100-m, 1°x1° tiles include temperature means and standard deviations, emissivity layers, NDVI, and ancillary information such as observation counts and elevation. This release provided regional, high-resolution emissivity resources for North American applications.

May 2012: Level-1 Software Update

ASTER Level-1 processing software was updated with Geometric Correction Database v3.02. This update improved geolocation for thermal infrared night observations, ensuring greater consistency and accuracy across Level-1 radiance products.

April 2014: Release of the ASTER Global Emissivity Dataset (GED)

LP DAAC released the ASTER Global Emissivity Dataset (GED), an expanded global emissivity product derived from ASTER observations over multiple continents, with additional regions scheduled for completion later that year. GED provided 100-m and 1-km emissivity tiles in 1°x1° format, accessible via multiple data clients. This dataset superseded the earlier NAALSED product by offering broader spatial coverage and standardized emissivity retrievals.

April 2015: Addition of L1T Precision Terrain-Corrected Product

ASTER Level 1 Precision Terrain-Corrected Registered At-Sensor Radiance (AST_L1T) products were introduced, providing rapid access to GIS-ready data including HDF-EOS granules, full-resolution GeoTIFF composites, and associated metadata. The AST_L1T products established a consistent processing baseline that supported subsequent Level-1 and higher-level product generation.

2016–2017: Infrastructure Upgrades and TIR Anomaly Fix

The earliest upgrade from this period focused on infrastructure stability rather than major algorithmic changes.

2016 (S4PM-5.4_15): A new Priority Graphical User Interface was deployed, along with several new virtual and physical machines to strengthen processing capacity. This ensured that ASTER data continued to be generated reliably as system demand grew.

2017 (S4PM-5.4_18): Due to abnormal signatures in thermal bands, L1T PGEs were updated to improve accuracy and consistency of L1T thermal infrared products for downstream scientific use. While modest compared to later milestones, these updates were essential for maintaining continuity and scientific trust in ASTER products during its second decade in orbit.

2019: Introduction of PGE v3.4 and Radiometric DB v3.16

The next major upgrade came in October 2019, marking one of the most significant milestones in ASTER's processing history.

PGE v3.4: This release incorporated MOD07_L2 atmospheric profiles into the processing chain, enhancing atmospheric correction accuracy. Prior to this, ASTER relied primarily on Assimilation model data from NCEP or simpler fallback datasets, which could introduce regional or seasonal biases.

Auto-Fallback Capability: Recognizing that atmospheric inputs are not always consistently available, this version introduced a hierarchical fallback system. If MOD07_L2 was unavailable, PGEs could revert to secondary inputs or climatology, ensuring uninterrupted product generation.

Radiometric Calibration DB v3.16: To support the new PGEs, an updated calibration database was deployed. This refined radiometric coefficients to reflect instrument drift and maintain fidelity in reflectance and radiance products after nearly 20 years in orbit.

Combined, these updates enhanced the scientific accuracy of ASTER Level 1 products through improved radiometric calibration and atmospheric correction, while also strengthening operational robustness and ensuring continuous product generation in the event of missing ancillary inputs.

2020–2021: Incremental Refinements and Ancillary Expansion

Following the 2019 milestone, updates in 2020 and 2021 concentrated on refinements and expanded ancillary inputs.

July 2020 (S4PM-5.4_21): Adjustments were made to elevation handling and resampling methods in Level-1B products. These improvements corrected spatial alignment issues and ensured consistency in geolocation.

June 2021 (S4PM-5.4_25): A key radiometric change was the implementation of RCC v5 in the L1A+ PGE. This update refined calibration coefficients to address long-term instrument sensitivity drift. The release also introduced an on-demand processing option for AST_L1T.031, giving users greater flexibility.

September 2021 (S4PM-5.4_26): Another major advancement was the integration of Aura Ozone Monitoring Instrument (OMI) ozone inputs, adding a new dimension to atmospheric correction. This broadened ASTER's ancillary dataset options, complementing MOD07 and improving accuracy for atmospheric absorption corrections. Additionally, the processing Toolkit was upgraded to TK5.2.20, ensuring compatibility with evolving infrastructure.

By the end of 2021, ASTER PGEs supported multiple ancillary sources and had undergone two calibration database refinements, ensuring radiometric accuracy while expanding user options.

2022–2023: System Modernization

April 2022 (S4PM-5.4_27): Updates were made for the new Earth Observing System Data and Information System (EOSDIS) Core System (ECS) hardware, and a DOI (Digital Object Identifier) was added to the L1T PGE, strengthening traceability for research and publications.

November 2023 (S4PM-5.4_28): A complete rebuild was conducted for Rocky8 OS environments, ensuring compatibility with updated computing platforms. This type of system modernization was crucial for extending mission lifetime in the face of changing IT ecosystems. Although less visible to data users, these infrastructure changes kept ASTER's processing system resilient and positioned it for future updates.

2024: Adoption of MERRA-2 and PGE v3.4-3_9

April 2024 (S4PM-5.4_30): PGE v3.4-3_8 was released to fix issues with restricted AST_L1A granules, which had limited data availability for certain users.

December 2024 (S4PM-5.4_31): The release of PGE v3.4-3_9 marked the full adoption of MERRA-2 reanalysis data as the preferred ancillary atmospheric input. This aligned ASTER with the broader Earth science community, which increasingly relies on reanalysis products for consistency and long-term climate studies. Importantly, the fallback hierarchy was formalized: if MERRA-2 was unavailable, PGEs would revert to MOD07 → GDAS → Climatology.

October 2024 (S4PM-5.4_32): Infrastructure adjustments were made to update the path to ENVI/IDL dependencies within multiple PGEs.

With these changes, ASTER entered a new phase where ancillary inputs are modern, fallback pathways are robust, and system dependencies are aligned with current computational environments.

Conclusion

The complete history of ASTER PGE and Radiometric Calibration DB updates from 2005 through 2025 illustrates the dual priorities of scientific accuracy and operational sustainability. Pre-2016 updates established new product types, improved baseline processing, and expanded ancillary inputs. Post-2016 changes focused on infrastructure resilience and correcting instrument anomalies, while subsequent updates enhanced radiometric calibration, ancillary integration, and modernized computing environments. After more than two decades in orbit, ASTER continues to deliver high-quality, calibrated, and scientifically relevant data through progression of software and calibration updates. This timeline underscores the importance of continuous maintenance and innovation in keeping long-term Earth observation missions viable.

Note on Validation and Quality Assurance

Every change to the ASTER PGEs and RCCs undergoes systematic testing, validation, and regression analysis before being promoted to operations at the LP DAAC. This includes validation against legacy test cases, calibration reference points, and cross-comparisons with prior product versions. Only after passing validation are updated PGEs and calibration databases used for production data, ensuring continuity, accuracy, and scientific reliability.