

Earth Observing System (EOS)

Tropospheric Emission Spectrometer (TES)

Science Data Processing

Standard and Special Observation

Data Products Specifications

Author: Scott Lewicki

Version 7.0 (Science Software Release 7.0)

D-22993

March 17, 2005

JPL

Jet Propulsion Laboratory
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1. INTRODUCTION

1.1 Identification

This is the Data Products Specification (DPS) for the JPL Tropospheric Emission Spectrometer (TES) Project.

1.2 Overview

This document provides the detailed contents and formats for the TES Standard and Special Observation Data Products produced at launch.

1.3 Document Scope

This document provides specifications for all of the TES standard data products identified in the ICD between ECS and SIPS (423-41-57-10, Volume 10) and TES special observation data products. This document provides a source of requirements to Framework for supporting the listed data types and data objects. This document provides a source of requirements to the subsystems for the contents and formats of the standard data products.

1.4 Method

This document provides the detailed contents and formats for the TES standard and special observation data products produced at launch. At that time it represents a baseline to the version of the products. Any changes to the contents or formats of the products after that time cannot occur without an update and re-release of this document

1.5 Controlling Documents

1. JPL D-17961 Level 2 Subsystem Software Requirements
2. 423-41-64 ESDIS Project Requirements for EOS Instruments Team Science Team Science Data Processing Systems, 07-03-2001 (latest version found at http://spsosun.gsfc.nasa.gov/ESDIS_Pub.html)
3. 420-TP-022-001 Release 6A Implementation Earth Science Data Model for the ECS Project, May 2000 (latest version can be found at <http://edhs1.gsfc.nasa.gov/>)
4. NCAR Doc#: SW- NCA-079 HDF-EOS Aura File Format Guidelines
5. 423-41-57-10 Interface Control Document (ICD) between the EOSIDS Core System (ECS) and the Science Investigator-led Processing System (SIPS), Volume 10: Tropospheric Emission Spectrometer (TES) ECS Data Flows
6. JPL D-17962 Level 1B Subsystem Software Requirements

1.6 Reference Documents

- | | |
|--------------------|--|
| 7. JPL D-13017 | TES Experiment Implementation Plan |
| 8. JPL D-13214 | TES Software Management Plan |
| 9. JPL D-8501 | Software Management Policies and Requirements for EOS Flight Experiments |
| 10. JPL D-11294 | TES Scientific Objectives & Approach, Goals and Requirements |
| 11. JPL D-19450 | Ground System Requirements |
| 12. JPL D-15522 | Science Software Requirements |
| 13. JPL D-1538 | TES Command and Telemetry Handbook |
| 14. 175-TP-510-001 | HDF-EOS Interface Based on HDF5, Volume 1: Overview and Examples |

1.7 Applicable Documents

- | | |
|-------------------------|---|
| 15. HAIS 205-CD-002-001 | Software Developer's Guide to Preparation, Delivery, Integration and Test with ECS, draft version, January 1995 |
| | EOS Reference Handbook, NASA Goddard Space Flight Center |
| 16. 194-207-SE1-001 | System Design Specification for the ECS Project, Hughes Applied Information Systems, June 1994 |
| 17. 423-16-01 | Data Production Software and Science Computing Facility Standards and Guidelines, EOSDIS, October 1996 |

2. OVERVIEW OF FILE STRUCTURE FOR TES SCIENCE DATA PRODUCTS

2.1 TES Products in Native HDF 5 Format

The TES standard and special observation data products at Level 1B will be implemented in Native HDF5 format.

2.1.1 HDF 5 Data Types

The HDF 5 library provides a number of datatypes with the naming convention, `H5T_arch_base`, where *arch* is an architecture name and *base* is a programming type name. The architecture (name) used by the TES ESDT product files is NATIVE. The NATIVE architecture is by design the most portable and contains C-like datatypes for the machine on which the library was compiled. These NATIVE type names are defined with the prefix “H5T_” in the HDF C library and are grouped together in the C++ class “PredType” in the HDF 5 C++ API. In this document only the prefix NATIVE and the type are listed.

Table 2-1 below shows an example of how a 32 bit integer type maps to the HDF 5 APIs and how it is listed in this document.

Table 2-1: Mapping of 32-bit Integer to HDF5 APIs

| HDF 5 API | HDF 5 C++ API | Listing in this Document |
|------------------|------------------------|--------------------------|
| H5T_NATIVE_INT32 | PredType::NATIVE_INT32 | NATIVE_INT32 |

2.2 TES Products in HDF-EOS5 Format

TES will be using the HDF-EOS5 file format to store the scientific standard and special observation products at Level 2. The HDF-EOS extension to the HDF5 library provides the capability to incorporate swath mapping of the global survey data as well as compression and complex datatype usage.

2.3 Versioning of TES Products

For standard product granules versioning information has four types and is reported in four places:

1. End of standard product filename (and the ECS Metadata object LocalGranuleID for Level 2). Numbers capturing format changes and reruns/reprocessing.
2. ECS Metadata object LocalVersionID. Has format: "Executable Name: Clearcase Label"
3. ECS Metadata object PGEVersion. Release number, e.g. “R6.1”.
4. Production History. Text block in standard product file.

2.3.1 Versioning in Filenames

The versioning issue covers two major aspects reflecting changes in the name of a data file:

- 1) Data file format changes.
- 2) Data file content changes (coming from reruns or reprocessing)

The following naming conventions should be used to denote changes due to file format/content changes:

*<file name>*_Fff_cc...

where:

F = File Format placeholder
ff = 2-digit version number reflecting file Format changes
cc = 2-digit version number reflecting file Content changes

The following ground rules must be observed:

- 1) The two sets of identifiers may be incremented independent of each other.
- 2) The start default value for each set is 01.
- 3) Neither set can ever revert back to 01 and must always be incremented throughout the file span of the file.
- 4) The value of each set must always be incremented by 1.

The following are the definitions for Format and Content changes of any data file:

Format change:

- 1) Data type changes (new or redefined)
- 2) New/deleted/renamed data fields/structures
- 3) Dimension changes of data fields/structures

The basic rule defining a Format change is any change that must be reflected in the Data Products Specification (DPS), and therefore requires a DPS update. These DPS updates will be disseminated via change pages and captured in Clearcase, with complete releases of a new DPS version at certain time intervals.

Content change:

- 1) Data file created during a PGE re-run with a different set of input files or different environment.
- 2) Data file reprocessing where contents are updated for completeness or better accuracy/algorithm improvement.

The purpose of the content versioning number is only to reflect a particular run version, not the version of the TES science software used during the run. However, the implication would be that any re-processing run of the same PGE using a different input file set would generate product files with new contents, thus indicated by a new value for the cc field of the products' names.

3. LEVEL 1B STANDARD AND SPECIAL OBSERVATION PRODUCTS

3.1 Overview

At Level 1B, TES produces two standard products captured in two ESDTs: TL1BN for nadir-viewed data and TL1BL for limb-viewed data. For Special Observations, there are two “products” one for Low Resolution and one for High Resolution.

The primary data stored within the L1B nadir and limb products are spectra and noise-equivalent spectral radiance (NESR) data. In addition, the standard product files contain geolocation, engineering, production history, and data quality information.

Each L1B standard and special observation product is implemented as four files (one per Focal Plane) each using the native HDF 5 file format. HDF 5 files have a default extension of “.h5”. The ECS Local Granule ID (filename) for a L1B standard product is constructed using the following template:

TES-Aura_L1B-<view>_FP<FP>_r<run id>-o<orbit number>_<version id>.h5

The table below lists each of the TES L1B standard products.

Table 3-1: TES L1B Standard Products

| ESDT Short Name | ECS File Type | Collection Summary | File Names |
|-----------------|---------------|--------------------|--|
| TL1BN | HDF 5 | TES Aura L1B Nadir | TES-Aura_L1B-Nadir_FP1A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-Nadir_FP1B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-Nadir_FP2A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-Nadir_FP2B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 |
| TL1BL | HDF 5 | TES Aura L1B Limb | TES-Aura_L1B-Limb_FP1A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-Limb_FP1B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-Limb_FP2A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-Limb_FP2B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 |

The table below lists each of the TES L1B special observation products.

Table 3-2: TES L1B Special Observation Products

| Name | ECS File Type | File Names |
|---------------------------------------|---------------|--|
| Special Observation – Low Resolution | HDF 5 | TES-Aura_L1B-SO-Low_FP1A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-SO-Low_FP1B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-SO-Low_FP2A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-SO-Low_FP2B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 |
| Special Observation – High Resolution | HDF 5 | TES-Aura_L1B-SO-High_FP1A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-SO-High_FP1B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-SO-High_FP2A_rnnnnnnnnnn-onnnnn_Fff_cc.h5 TES-Aura_L1B-SO-High_FP2B_rnnnnnnnnnn-onnnnn_Fff_cc.h5 |

Where the string rnnnnnnnnnn represents the ten-digit Run ID, the string onnnnn represents the starting five-digit Absolute Orbit number, the substring “Fff_cc” represents a version ID which is used to keep track of file format changes (see Section 2.3.1).

Note: TES data acquisition begins at the South Pole apex crossing, and subsequent orbits worth of data begin from there for the L1B granules. The Absolute Orbit number in the file name above is the same as the Aura orbit number at the time of the South Pole apex crossing.

For Special Observations, there is the potential for multiple products within a single orbit. These will be differentiated by Run Number. Special Observations which span multiple orbits, i.e. cross the South Pole apex, will be split into separate files.

3.2 Nadir or Low Resolution Observations

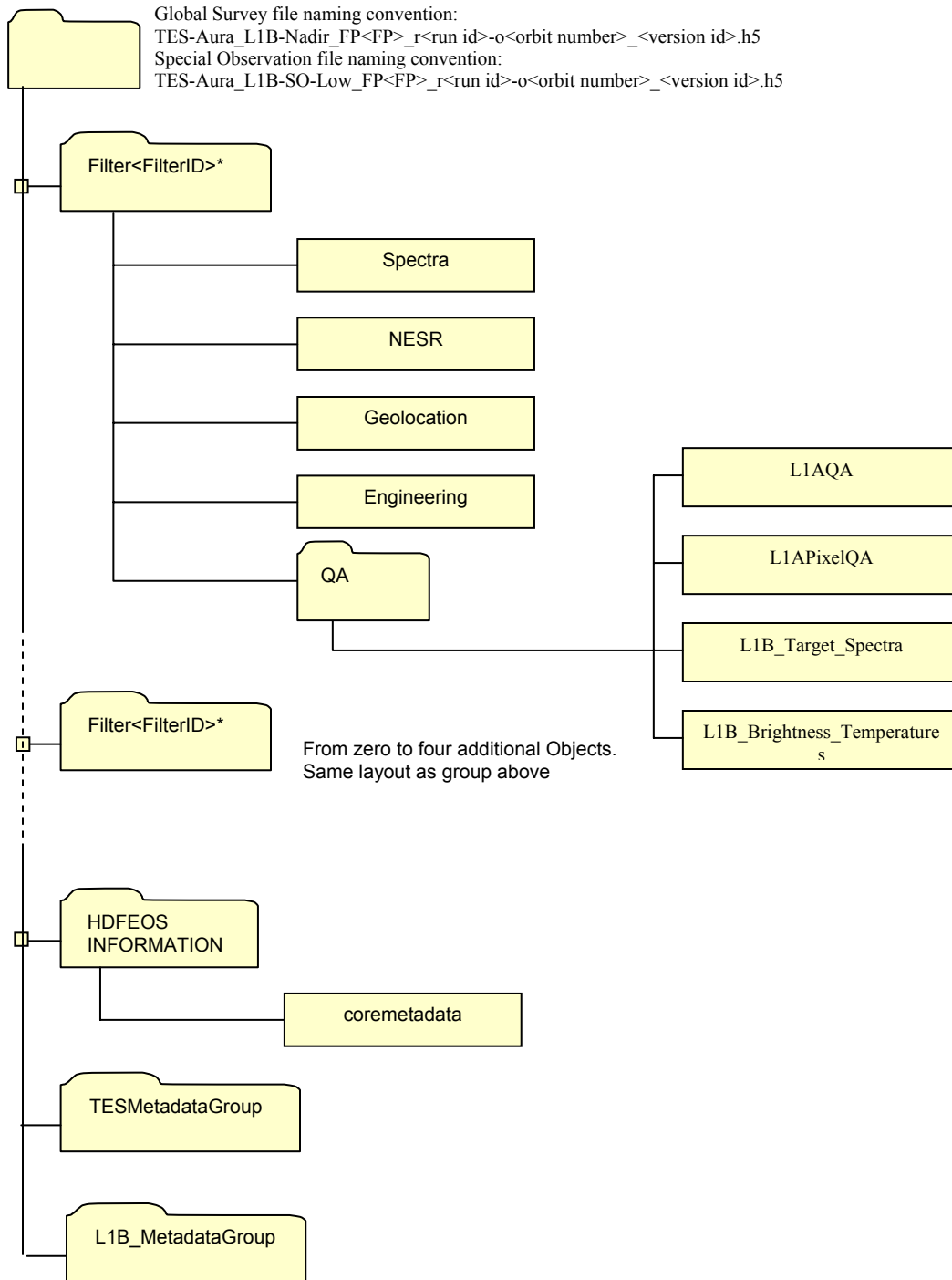
The Nadir standard product consists of four files, where each file is composed of the Global Survey Nadir observations from one of four focal planes for a single orbit. The number of observations within an orbit is fixed for a Global Survey, but that number may change if the configuration of the Global Survey is changed.

The Low Resolution special observation product also consists of four files, where each file is composed of special observations from one of four focal planes. A special observation product is of an undetermined length and may be smaller than an orbit or larger.

The filter position for a given focal plane is in the L1B-specific metadata. This filter position determines the dimensions of the filter group objects for each file.

3.2.1 Structure of Nadir File

The structure of each of the Nadir or Low Resolution files contains groups for ECS (HDFEOS INFORMATION) and TES-specific metadata (including Production History) and groups for the data corresponding to specific filters. The data objects within each of these groups are shown in the figure below.



*Where <FilterID> for Nadir for the Filter Plane 1A file can be one of the following: 1A1, 1A2, 1A3, 1A4, or 1A5; for the Filter Plane 1B file can be 1B1 or 1B2; for the Filter Plane 2A file can be 2A1, 2A2, 2A3, or 2A4; and for the Filter Plane 2B file will be 2B1.

3.3 Limb or High Resolution Observations

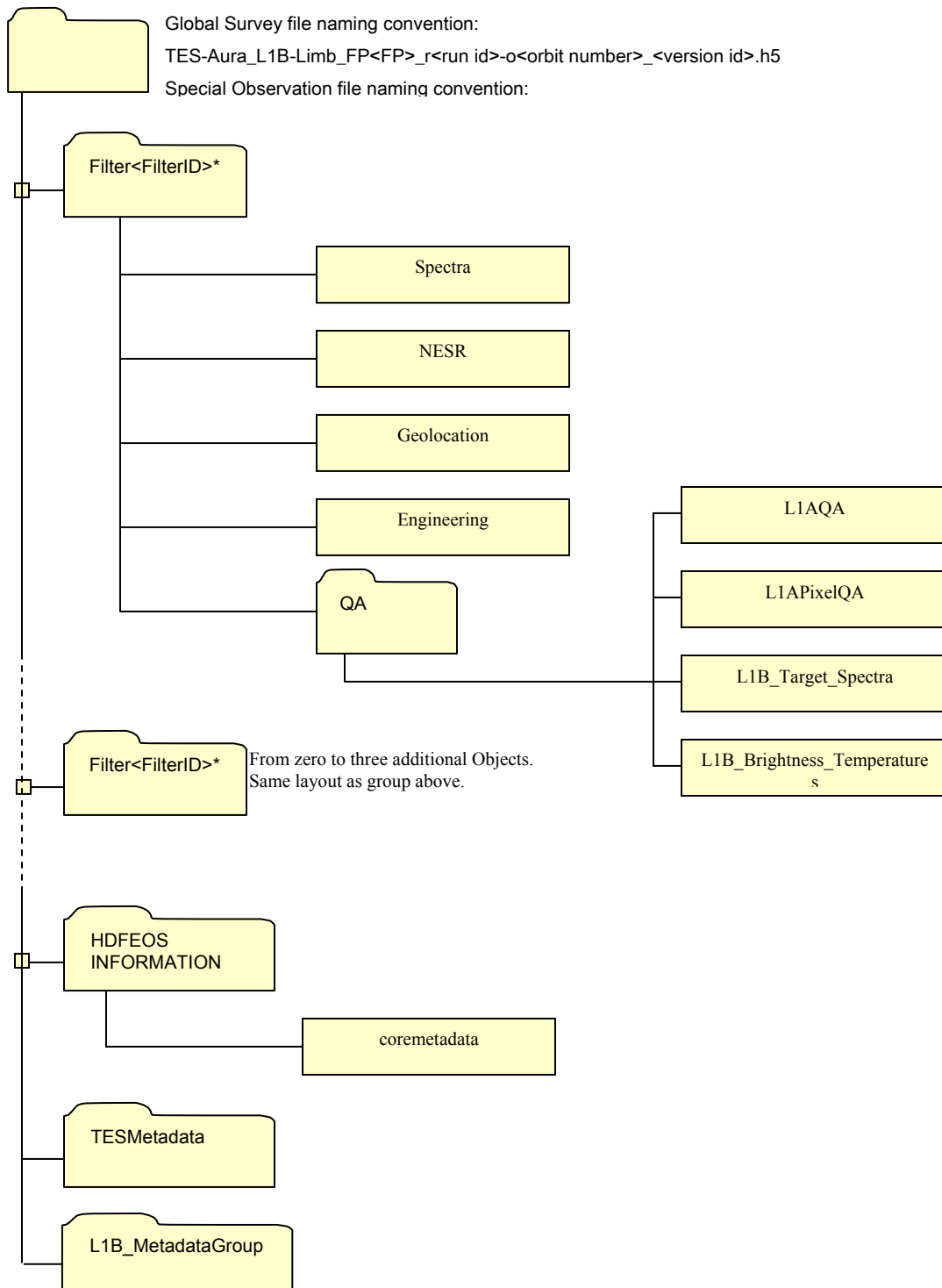
The Limb standard product consists of four files, where each file is composed of the Global Survey Nadir observations from one of four focal planes for a single orbit. The number of observations within an orbit is fixed for a Global Survey, but that number may change if the configuration of the Global Survey is changed.

The High Resolution special observation product also consists of four files, where each file is composed of special observations from one of four focal planes. A special observation product is of an undetermined length and may be smaller than an orbit or larger.

The filter position for a given focal plane is in the L1B-specific metadata. This filter position determines the dimensions of the filter group objects for each file.

3.3.1 Structure of Limb File

The structure of each of the Limb or High Resolution files contains groups for ECS (HDFEOS INFORMATION) and TES-specific metadata (including Production History) and groups for the data corresponding to specific filters. The data objects within each of these groups are shown in the figure below.



*Where <FilterID> for Limb for the Filter Plane 1A file can be one of the following: 1A1 or 1A2; for the Filter Plane 1B file can be 1B1 or 1B2; for the Filter Plane 2A file can be 2A1, 2A2, 2A3, or 2A4; and for the Filter Plane 2B file will be 2B1.

3.4 Spectra and NESR Data

Each product captures data in four focal planes for each observation. These focal planes are 1A, 1B, 2A, and 2B. For each of these focal planes there are sixteen pixels, 0 through 15. These pixels return 32-bit float data. Along with the spectra data, NESR data has the same characteristics, ranging from pixels 0 through 15 returning 32-bit float data. See tables below for all values and definitions of the sixteen pixels in each of the four focal planes. Each focal plane/filter position has a different number of samples for each spectrum.

Table 3-3: Spectra Data Type Definition

| Data Name | Data Description | Units | Data Range | Size | Type | HDF 5 Type |
|-----------|---------------------------|---|---|------|-------|--------------|
| Spectra | Spectrum radiance sample. | W/cm ² /sr/cm ⁻¹ | -10 ⁻⁴ – 10 ⁻⁴ (fill= -999.) | 32 | float | NATIVE_FLOAT |

Table 3-4: NESR Data Type Definition

| Data Name | Data Description | Units | Data Range | Size | Type | HDF 5 Type |
|-----------|--|---|---|------|-------|--------------|
| NESR | Noise equivalent spectral radiance sample. | W/cm ² /sr/cm ⁻¹ | -10 ⁻⁵ – 10 ⁻⁵ (fill= -999.) | 32 | float | NATIVE_FLOAT |

Table 3-5: Focal Plane Data Dimensions

| Dimension Name | Dimension Description | Dimension Size |
|---------------------|--|----------------|
| TES_pixel_dim | Number of pixels in a TES focal plane. | 16 |
| Observations_dim | Number of sequences. | variable |
| Spectra_Samples_dim | Number of samples for Spectra & NESR | configurable |

Dimensions are implemented in the file in “C” order, i.e. last dimension is the fastest.

Table 3-6: Focal Plane Spectra Dataset

| Dataset Name | Dataset Description | Dimension List | Data Type |
|--------------|---|--|---------------|
| Spectra | Contains spectra data for all sixteen pixels in the focal plane for a nadir or a limb scan. | TES_pixel_dim Observations_dim Spectra_Samples_dim | Spectrum_type |

Table 3-7: Focal Plane NESR Dataset

| Dataset Name | Dataset Description | Dimension List | Data Type |
|--------------|--|--|-----------|
| NESR | Contains NESR data for all sixteen pixels in the focal plane for a nadir or a limb scan. | TES_pixel_dim Observations_dim Spectra_Samples_dim | NESR_type |

3.5 Geolocation Data

For the Nadir-viewing product files (Low or High resolution), the geolocation is calculated from the boresight. For the Limb-viewing product files (Low or High resolution), the geolocation is calculated from the tangential height.

Table 3-8: Geolocation Dataset

| Dataset Name | Dataset Description | Dimension List | Data Type |
|--------------|--|------------------|------------------|
| Geolocation | Contains geolocation data for each sequence. | Observations_dim | Geolocation_type |

Table 3-9: Geolocation Dataset Dimensions

| Dimension Name | Dimension Description | Dimension Size |
|-------------------|-------------------------|----------------|
| Observationss_dim | Number of observations. | variable |

The Geolocation Dataset is implemented as a compound data type (for each Observations_dim) with the following definition.

Table 3-10: Geolocation Data Type Definition: Geolocation_type

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|--------------------------|---|-----------------|-------------------|------|---------------|
| Time_of_Geolocation | Time of ZPD (Zero Path Difference) | TAI 93 time | | 64 | NATIVE_DOUBLE |
| Geolocation_Failed | Failure indicator. False = 0 True = 1 If True, the following data fields will be set to zero or are suspect. | N/A | 0..1 | 8 | NATIVE_INT8 |
| OrbitAscendingFlag | Ascending node = 1 Descending node = 0 | N/A | 0..1 | 8 | NATIVE_INT8 |
| Path_Number | Aura Path Number | N/A | 1..233 | 8 | NATIVE_UINT8 |
| PCS_QA_Poor_Percentage | Percent data interpolated | N/A | 0..100 | 8 | NATIVE_INT8 |
| DPREP_QA_Poor_Percentage | Percent data interpolated | N/A | 0..100 | 8 | NATIVE_INT8 |
| Orbit_Inclination_Angle | Orbit Inclination Angle | Decimal degrees | 0..180 | 64 | NATIVE_DOUBLE |
| Latitude | Ground boresight location | Decimal degrees | ±90.0 | 64 | NATIVE_DOUBLE |
| Longitude | Ground boresight location | Decimal degrees | ±180.0 | 64 | NATIVE_DOUBLE |
| Elevation | Ground boresight elevation | Meters | -1000..100,000 | 32 | NATIVE_FLOAT |
| Horizontal_Uncertainty | Uncertainty in geolocation horizontal position | Meters | -100,000..100,000 | 32 | NATIVE_FLOAT |
| Elevation_Uncertainty | Uncertainty in geolocation elevation | Meters | -1000..100,000 | 32 | NATIVE_FLOAT |
| Latitude_Footprint_1 | Geo-location in geodetic coordinates of the four corners of the footprint. Nadir footprint determined by field of view of pixels. Limb footprint is ±60 km track, ±12 km crosstrack from surface expression | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_2 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_3 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|------------------------------|--|-----------------|----------------|------|---------------|
| Latitude_Footprint_4 | of boresight tangent point. Latitude_Footprint_1=LowerLeft Latitude_Footprint_2=LowerRight Latitude_Footprint_3=UpperRight Latitude_Footprint_4=UpperLeft | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_1 | Geo-location in geodetic coordinates of the four corners of the footprint. Nadir footprint determined by field of view of pixels. Limb footprint is ±60 km track, ±12 km crosstrack from surface expression of boresight tangent point Longitude_Footprint_1=LowerLeft Longitude_Footprint_2=LowerRight Longitude_Footprint_3=UpperRight Longitude_Footprint_4=UpperLeft | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_2 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_3 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_4 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| SurfaceElevation | Average elevation over the footprint | Meters | -1000..100,000 | 32 | NATIVE_FLOAT |
| SurfaceElevStandardDeviation | Standard deviation of elevation over the footprint | Meters | -1000..100,000 | 32 | NATIVE_FLOAT |
| Min_Elev_Footprint | Lowest elevation over the footprint | Meters | -1000..100,000 | 32 | NATIVE_FLOAT |
| Max_Elev_Footprint | Greatest elevation over the footprint | Meters | -1000..100,000 | 32 | NATIVE_FLOAT |
| Surface_Type_Footprint | From DEM, 1=Fresh Water, 2=Salt Water, 3=Land, 4=Mixed (not 100% of FW, SW, or Land) | Enumerated | 1..4 | 8 | NATIVE_INT8 |
| Day_Night_Flag_Target | 0=Night (False), 1=Day (True) | T/F | 0..1 | 8 | NATIVE_INT8 |
| Day_Night_Flag_SC | 0=Night (False), 1=Day (True) | T/F | 0..1 | 8 | NATIVE_INT8 |
| LocalSolarTime | Local Mean Solar Time (hours from midnight) | Hours | 0.0..24.0 | 32 | NATIVE_FLOAT |
| TES_Bsight_Azimuth | TES boresight (LOS) azimuth angle relative to the local north at SC | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| TES_Bsight_Azimuth_Uncert | Uncertainty in TES boresight azimuth angle | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| TESBoresightNadirAngle | TES boresight (LOS) nadir angle relative to the local nadir at SC | Decimal degrees | 0..90 | 64 | NATIVE_DOUBLE |
| TES_Bsight_Nadir_Uncert | Uncertainty in TES boresight nadir angle | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Grd_Trk_TES_Bsight_Azimuth | TES boresight (LOS) azimuth angle relative to the local ground track | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| SpacecraftAzimuth | TES boresight (LOS) azimuth angle relative to the local north at the geolocation | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| SpacecraftZenith | TES boresight (LOS) zenith angle relative to the local zenith at the geolocation | Decimal degrees | 0..180 | 64 | NATIVE_DOUBLE |
| Tgt_Sun_Azimuth | Solar azimuth angle relative to the local north at the geolocation | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| Tgt_Sun_Zenith_Angle | Solar zenith angle relative to the local zenith at the geolocation | Decimal degrees | 0..180 | 64 | NATIVE_DOUBLE |
| SolarAzimuthAngle | Solar azimuth angle relative to the local north at spacecraft point at ZPD time | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| SolarZenithAngle | Solar zenith angle relative to the local zenith at spacecraft point at ZPD time | Decimal degrees | 0..180 | 64 | NATIVE_DOUBLE |
| MI_Mirror_Sun_Angle | Angle between M1 mirror normal and the sun | Decimal degrees | 0..180 | 64 | NATIVE_DOUBLE |
| SpacecraftLatitude | Geodetic latitude | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|----------------------------|--|-----------------|-------------------|------|---------------|
| SpacecraftLongitude | Geodetic longitude | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| SpacecraftAltitude | Geodetic spacecraft altitude (w/ respect to geoid) | Meters | -1000..10,000,000 | 64 | NATIVE_DOUBLE |
| Doppler_Shift | Relative frequency shift due to Doppler effect. | N/A | | 64 | NATIVE_DOUBLE |
| Resolved_SC_Position_X | From ground corrected ephemeris | meters | ±8,000,000 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Position_Y | From ground corrected ephemeris | meters | ±8,000,000 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Position_Z | From ground corrected ephemeris | meters | ±8,000,000 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Velocity_X | From ground corrected ephemeris | meters/sec | ±10,000.0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Velocity_Y | From ground corrected ephemeris | meters/sec | ±10,000.0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Velocity_Z | From ground corrected ephemeris | meters/sec | ±10,000 .0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Quaternion_Q1 | From ground corrected ephemeris | N/A | -1.0...1.0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Quaternion_Q2 | From ground corrected ephemeris | N/A | -1.0...1.0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Quaternion_Q3 | From ground corrected ephemeris | N/A | -1.0...1.0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Quaternion_Q4 | From ground corrected ephemeris | N/A | -1.0...1.0 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Attitude_Pitch | From ground corrected attitude | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Attitude_Roll | From ground corrected attitude | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Attitude_Yaw | From ground corrected attitude | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Pitch_Rate | From ground corrected attitude | deg/sec | ±0.3 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Roll_Rate | From ground corrected attitude | deg/sec | ±0.3 | 64 | NATIVE_DOUBLE |
| Resolved_SC_Yaw_Rate | From ground corrected attitude | deg/sec | ±0.3 | 64 | NATIVE_DOUBLE |
| PCS_Track | PCS track resolver position at time of ZPD | Decimal degrees | | 64 | NATIVE_DOUBLE |
| PCS_Crosstrack | PCS crosstrack resolver position at time of ZPD | Decimal degrees | | 64 | NATIVE_DOUBLE |

3.6 Engineering Data

Table 3-11: Engineering Dataset

| Dataset Name | Dataset Description | Dimension List | Data Type |
|--------------|----------------------------|------------------|------------------|
| Engineering | Contains engineering data. | Observations_dim | Engineering_type |

Table 3-12: Engineering Dataset Dimensions

| Dimension Name | Dimension Description | Dimension Size |
|------------------|-------------------------|----------------|
| Observations_dim | Number of observations. | variable |

The Engineering Dataset is implemented as a compound data type (for each Observation_dim) with the following definition.

Table 3-13: Engineering Dataset Type Definition: Engineering_type

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|-----------------------|--|-------|---|------|---------------|
| Scan | Scan number in sequence. | n/a | >0 | 8 | NATIVE_INT8 |
| Sequence | Sequence number in run. | n/a | >0 | 16 | NATIVE_INT16 |
| Time_of_Observation | Time of ZPD (Zero Path Difference) | TAI93 | | 64 | NATIVE_DOUBLE |
| Filter_Identification | Optical Filter Identification | | For FP1A: “1”, “2”, “3”, “4”, or “5” For FP1B: “1” or “2” For FP2A: “1”, “2”, “3”, or “4” For FP2B: “1” | 8 | NATIVE_CHAR |
| ADC_Enabled | Analog to Digital sampling | --- | 0 = enabled 1 = off | 16 | NATIVE_INT16 |
| Elect_Filter | Filter Center Frequency | kHz | For FP1A: 0 = 8.8 kHz, 1 = 9.8, 2 = 10.7, 3 = 11.5, 4 = 12.4, 5 = DC For FP1B: 0 = 4.0, 1 = 4.4, 5 = DC For FP2A: 0 = 5.1, 1 = 6.0, 2 = 6.9, 3 = 7.7, 5 = DC For FP2B: 0 = 3.3, 5 = DC | 32 | NATIVE_FLOAT |
| Fringe_Clock_Divisor | Sets ADC Sampling Rate | --- | 8..15 | 16 | NATIVE_INT16 |
| AT_Index | Indicator as to whether the Filter Wheel is at a pre-determined index point. | | 0, 1 | 8 | NATIVE_INT8 |

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|------------------------------|--|-------|--|------|--------------|
| Filter_Wheel_Index | Filter Wheel Index position | --- | For FP1A: 0 = 1A4, 7 = 1A5, 6 = 1A1, 5 = 1A2, 4 = 1A3 For FP1B: 5 = 1B2, 4 = 1B1 For FP2A: 1 = 2A4, 0 = 2A1, 7 = 2A3, 6 = 2A2 For FP2B: 3 = 2B1 | 16 | NATIVE_INT16 |
| Signal_Chain_Gain | Mapping from signal chain (1A, 1B, 2A, 2B) to a gain factor. | --- | 0.5, 1.0, 2.0, 4.0, 32.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Detector_Temp | Measurement of a given focal plane detector temperature. | K | 60 – 361 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Observation_Type | TES Defined Scans | | 1..40 | 16 | NATIVE_INT16 |
| ICS_Scan_Direction | Arm scan direction: 0 = reverse 1 = forward | | “0”, “1” | 8 | NATIVE_CHAR |
| Blackbody_Wall_Temp_#1 | Blackbody Wall Temperature #1 from the Calibration Subsystem Electronics board. | K | 213 – 349 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Blackbody_Wall_Temp_#2 | Blackbody Wall Temperature #2 from the Calibration Subsystem Electronics board. | K | 213 – 349 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Cold_Reference_Plate_Temp_#1 | Cold Reference Plate Temperature #1 from the Operational Support Electronics board. | K | 160 – 361 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Cold_Reference_Plate_Temp_#2 | Cold Reference Plate Temperature #2 from the Operational Support Electronics board. | K | 160 – 361 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Beamsplitter_Temp_#1 | Beamsplitter Temperature #1 from the Operational Support Electronics board. | K | 160 – 361 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Beamsplitter_Temp_#2 | Beamsplitter Temperature #2 from the Operational Support Electronics board. | K | 160 – 361 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Foreoptics_Temp | Foreoptics Temperature from the Engineering Data Interface board. | K | 168 – 359 Fill = -999.0 | 32 | NATIVE_FLOAT |
| M1_Mirror_Temp | M1 Mirror Temperature from the Positioning Control Subsystem electronics board. | K | 173 – 364 Fill = -999.0 | 32 | NATIVE_FLOAT |
| M2_Mirror_Temp | M2 Mirror Temperature from the Positioning Control Subsystem electronics board. | K | 198 – 359 Fill = -999.0 | 32 | NATIVE_FLOAT |
| Calibration_SS_Resistor_1 | Provides the measurement data for Calibration Subsystem Calibration Resistor 1 from the Calibration Subsystem Electronics board. | Ohms | Fill = -999.0 | 32 | NATIVE_FLOAT |

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|---------------------------|--|-------|---------------|------|--------------|
| Calibration_SS_Resistor_2 | Provides the measurement data for Calibration Subsystem Calibration Resistor 2 from the Calibration Subsystem Electronics board. | Ohms | Fill = -999.0 | 32 | NATIVE_FLOAT |
| OSE_Resistor_1 | Provides the measurement data for OSE Calibration Resistor 1 from the Operational Support Electronics board. | Ohms | Fill = -999.0 | 32 | NATIVE_FLOAT |
| OSE_Resistor_2 | Provides the measurement data for OSE Calibration Resistor 2 from the Operational Support Electronics board. | Ohms | Fill = -999.0 | 32 | NATIVE_FLOAT |

3.7 Quality Assessment (QA) Data

Quality data consists of quality flags for the scan level and quality flags for all sixteen pixels in each focal plane. Each focal plane will contain this set of quality data.

QA data are placed in the following groups. Within each group are datasets listed in subsequent tables.

Table 3-14: QA Groups

| Group Name | Datasets Description | Dimension List |
|-----------------------------|--|---|
| L1AQA | Contains quality datasets for all sixteen pixels in each focal plane for a scan within a sequence. | Observations_dim |
| L1APixelQA | Contains L1A quality datasets for each pixel in a specific filter for an observation | TES_pixel_dim Observations_dim |
| L1B_Target_Spectra | Contains L1B Target Spectra datasets | TES_pixel_dim Observations_dim |
| L1B_Brightness_Temperatures | Contains L1B Brightness Temperatures datasets | TES_pixel_dim (limb only) Observations_dim |

Table 3-15: QA Datasets Dimensions

| Dimension Name | Dimension Description | Dimension Size |
|------------------|--|----------------|
| TES_pixel_dim | Number of pixels in a TES focal plane. | 16 |
| Observations_dim | Number of observations. | variable |

The following is a list of the L1A QA datasets.

Table 3-16: L1AQA Group Datasets

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|---|---|-------|---|------|-------------|
| L1A_Ifgm_Dropout_Occurred | Missing packet | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_Time_Date_Error_Occurred | Error in header | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_Sequence_Error_Occurred | Error in run, sequence, scan | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_Filter_Seq_Error_Occurred | Filter wheel position not as expected | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_SC_Attitude_Out_Of_Spec | Attitude not as expected | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_ICs_Direction_Out_Of_Sequence | ICS Scan direction not as expected | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_ICs_Speed_Variation_Out_Of_Specification | ICS speed variation over spec | N/A | 0..2 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_BB_Temperature_Out_Of_Specification | Black body temperatures out of spec | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_Cold_Ref_Plate_Temperature_Out_Of_Specification | Cold Reference Plate temperature out of spec. | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_Engineering_Temperatures_Out_Of_Specification | Any High Rate PRT not specified | N/A | 0..2 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_Channel_Shift | Indicates detected telemetry channel shift | N/A | 0=no shift -1...-15=shift Not Processed=9 | 8 | NATIVE_INT8 |

The following is a list of the L1A Pixel QA datasets. They are dimensioned Observations_dim x TES_pixel_dim.

Table 3-17: L1APixelQA Group Datasets

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|---------------------------|------------------------|-------|--------------------------------------|------|-------------|
| L1A_Spike_Occurred | 10x neighboring values | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_DN_Overflow_Occurred | DN > tolerance | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |
| L1A_DN_Underflow_Occurred | DN < tolerance | N/A | True=1 False=0 Not Processed=9 | 8 | NATIVE_INT8 |

For the following tables, Flags have the definition:

-1 = the error/quality measurement and check was not performed.

0 = the error/quality measurement was done, and the measurement did not exceed tolerance (SUCCESS).

+1 = the error/quality measurement was done, and the measurement exceeded tolerance (FAILURE).

The following datasets in L1B Target Spectra Quality are dimensioned Observations_dim x TES_pixel_dim.

Table 3-18: L1B_Target_Spectra Group Quality Datasets

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|------------------------------------|--|-------|----------------------------------|------|--------------|
| L1B_Zero_Padding | the ratio of zero padding size to the FFT size | N/A | 0.0-1.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Zero_Padding_Flag | | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_Missing_Cal_Table_Flag | at least one calibration table is missing | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_Cal_Table_Quality_Flag | at least one calibration table has <i>suspicious</i> quality | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_Phase_Alignment | the chi-square of the imaginary of calibration ratio is too large | N/A | >= 0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Phase_Alignment_Flag | | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_Absolute_Radiance_Mean_BT | The mean of the absolute value of real target spectra after radiometric calib. | | >=0; 10^{-5} Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Absolute_Radiance_Mean_BT_Flag | | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_NESR_Mean | NESR mean between full in-band range (full power points) | | >= 0; 10^{-6} Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_NESR_Mean_Flag | | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_Imaginary_RMS | target spectrum imaginary RMS between half power points | | >= 0; 10^{-6} | 32 | NATIVE_FLOAT |
| L1B_Imaginary_RMS_Flag | | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|--------------------------|--|-------|----------------------------|------|--------------|
| L1B_Imaginary_Mean | target spectrum imaginary mean between half power points | | +/-10 ⁻⁷ | 32 | NATIVE_FLOAT |
| L1B_Imaginary_Mean_Flag | | N/A | -1,0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_General_Quality_Flag | See notes below | N/A | 0,+1 Not Processed=9 | 8 | NATIVE_INT8 |
| L1B_General_Error_Flag | See notes below | N/A | 0,+1 Not Processed=9 | 8 | NATIVE_INT8 |

L1B_General_Quality_Flag and L1B_General_Error_Flag are binary flags they are set to 0 (good) or 1 (bad).

L1B_General_Error_Flag set equal to 1 means that at some processing step an error was detected, and the spectrum was dropped. A spectrum with its L1B_General_Error_Flag set to 1 will not appear in the final product.

L1B_General_Quality_Flag set equal to 1 means that the spectrum may have some quality problem. A spectrum that just has some quality problem does appear in final L1B product.

The following datasets in L1B Nadir Brightness Temperatures are dimensioned only by Observations_dim.

Table 3-19: L1B_Brightness_Temperatures Group Datasets for Nadir

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|------------------------------|---|-------|--|------|--------------|
| L1B_Nadir_BT_11 | Average brightness temperature in band 11 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Nadir_BT_12 | Average brightness temperature in band 12 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Nadir_BT_8 | Average brightness temperature in band 8 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Nadir_BT_5 | Average brightness temperature in band 5 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Nadir_BT_10 | Average brightness temperature in band 10 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_N_Interpixel_Vari_BT10 | Measure of variation in BT-10 across all pixels | | | 32 | NATIVE_FLOAT |
| L1B_N_Ipix_Var_Exceeded_BT10 | Nadir scene interpixel variability exceeded threshold | N/A | -1 = Test not performed, 0 = False, 1 = True | 8 | NATIVE_INT8 |
| L1B_N_Interpixel_Vari_BT11 | Measure of variation in BT-11 across all pixels | | | 32 | NATIVE_FLOAT |
| L1B_N_Ipix_Var_Exceeded_BT11 | Nadir scene interpixel variability exceeded threshold | N/A | -1 = Test not performed, 0 = False, 1 = True | 8 | NATIVE_INT8 |

The following datasets in L1B Limb Brightness Temperatures are dimensioned Observations_dim x TES_pixel_dim.

Table 3-20: L1B_Brightness_Temperatures Group Datasets for Limb

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|----------------|---|-------|--------------------------------|------|--------------|
| L1B_Limb_BT_11 | Average brightness temperature in band 11 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Limb_BT_12 | Average brightness temperature in band 12 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Limb_BT_8 | Average brightness temperature in band 8 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Limb_BT_5 | Average brightness temperature in band 5 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |
| L1B_Limb_BT_10 | Average brightness temperature in band 10 | | -100.0—1000.0 Fill = -999.0 | 32 | NATIVE_FLOAT |

3.8 L1 ECS and TES-specific Metadata

3.8.1 Introduction

As with all ESDTs, TES ESDTs contain metadata that describes specific attributes about the data or the quality of data contained in the ESDT. Some of the basic metadata items are required by EOSDIS. These data items commonly include basic identification information and other generic information about the particular ESDT. These data items are referred to as ECS Inventory Metadata. In addition to ECS Inventory Metadata, TES ESDTs contain additional metadata more specific to the TES program. The TES-specific metadata has been subdivided into four subcategories based on the uniqueness of its origin and identification:

- | | |
|---|---|
| 1. TES Production History | Production History Metadata |
| 2. TES-Common | Metadata common to all TES ESDTs |
| 3. TES-L1B-Common | Metadata common to all Level 1B ESDTs |
| 4. TES-L1B- <i>observation specific</i> | Metadata unique to a particular ESDT subtype. |

TES common metadata are fairly generic to the entire family of TES ESDTs or to TES L1B products. TES-L1B-*observation specific*, as described by name, are unique to a particular family of L1 ESDTs.

3.8.2 ECS Inventory Metadata

The ECS Inventory Metadata is implemented in the HDF file as text block named coremetadata within a group named HDFEOS INFORMATION.

Table 3-21: ECS Inventory Metadata

| Data Layer Name | Data Description | TES Validates | Type ¹ | Source |
|-------------------------------|--|---------------|-------------------|--------|
| AssociatedInstrumentShortName | Instrument short name supplied by TES project. | TES | VA20 | MCF |
| AssociatedPlatformShortName | Platform short name supplied by EOS project. | Aura | VA20 | MCF |
| AssociatedSensorShortName | Sensor short name supplied by TES project. | FTS | VA20 | MCF |
| OperationMode | Mode of operation of the instrument. | Routine | VA20 | MCF |

¹ Data types and Source given are specified in document [3] in paragraph 1.5

| Data Layer Name | Data Description | TES Valid | Type ¹ | Source |
|-------------------------------|---|---|-------------------|--------|
| ShortName | This name will identify the ESDT short name associated with the collection or granule. | (set in MCF file) | A8 | MCF |
| VersionID | Version identifier of the ESDT data collection. | (set in MCF file) | SI | MCF |
| ProductionDateTime | The date and time a specific granule was produced by PGE. | YYYY-MM-DDT HH:MM:SS.SSSZ | DT | TK |
| SizeMBECSDDataGranule | The size attribute will indicate the volume of data contained in the granule. | | F10 | DSS |
| LocalVersionID | Local version identifier for PGE defined granule versions. Takes the form “executable name: Clearcase label” | | VA60 | PGE |
| InputPointer | Description of location of Production History information. | “Production History block at: /TESMetadataGroup/ProductionHistory” | VA255 | PGE |
| ParameterName | Scope of quality flags. For tests, refers to entire granule | Granule | A40 | PGE |
| ScienceQualityFlag | The granule level flag applying generally to the granule and specifically to parameters at the granule level. | Passed Being Investigated Inferred Passed Suspect Failed Not Investigated Inferred Failed | VA25 | DP |
| ScienceQualityFlagExplanation | A text explanation of the criteria used to set the ScienceQualityFlag including thresholds or other criteria. | (Free text) | VA255 | DP |
| RangeBeginningDate | The year, month, and day when the temporal coverage period being described began. | YYYY-MM-DD | DT | PGE |
| RangeBeginningTime | The first hour, minute, and second of the temporal coverage period being described. | HH:MM:SS | T | PGE |
| RangeEndingDate | The last year, month, and day when the temporal coverage period being described. | YYYY-MM-DD | DT | PGE |
| RangeEndingTime | The last hour, minute, and second of the temporal coverage period being described. | HH:MM:SS | T | PGE |
| PGEVersion | The Release of the PGE software: e.g. “R6.1” | | A10 | PGE |

3.8.3 Production History Metadata

The Production History Metadata is implemented as a single text block and written to the HDF file as a file level attribute. The Production History text block contains information about the L1 PGE and the running execution of the PGE to produce ESDT standard products. Static information in the text block describes the elements that make up the PGE like build configuration, support files and database table population. Dynamic information describes all the running parameters involved in a PGE execution for a specific RUN ID. This information is captured for both pre and post execution of the L1 Product PGE.

Table 3-22: L1 Production History

| History Data | Data Description | Size (K) | State |
|-----------------------|--|----------|---------|
| ECS | Toolkit file for input/output file specification | 23 | Dynamic |
| Environment Variable | SIPS environment variables | 5 | Dynamic |
| Fetch | SIPS fetch list from archived | 5 | Dynamic |
| SIPS PCF | SIPS-specific PCF file for PGE processing | 3 | Dynamic |
| Workspace List (PRE) | File listing in SIPS PGE workspace prior to PGE execution | 5 | Dynamic |
| Workspace List (POST) | File listing in SIPS PGE workspace following PGE execution | 5 | Dynamic |

| | | | |
|-----------------------------|--|------|---------|
| Runtime | CPU and Wallclock PGE run time | 0.1 | Dynamic |
| Control Definition | Framework Parameter Definition File for output files | 1 | Static |
| Control Parameter | Framework Parameter Specification File for output files | 0.02 | Static |
| Control Parameter (Runtime) | Framework Parameter specified in the command line of the PGE | 0.02 | Dynamic |
| TimeStamp | RUN ID begin date and end date timestamp | 0.05 | Dynamic |
| README | README file that describes production history context | 1 | Static |
| PGE Version | PGE version information | 0.2 | Static |
| PGE specific configurations | TBD | TBD | TBD |

3.8.4 TES-Common Metadata

Metadata shown below is common to all TES files.

Table 3-23: TES-Common Metadata

| Data Layer Name | Data Description | Units | Data Range | Size | HDF5Type | Source |
|-----------------------|---|-------|------------|------|---------------|--------|
| InstrumentName | TES | ---- | | | NATIVE_CHAR | MCF |
| ProcessLevel | L1B,L2,L3,etc. | ---- | | | NATIVE_CHAR | MCF |
| TAI93AtOzOfGranule | | ---- | | | NATIVE_DOUBLE | PGE |
| GlobalSurveyNumber/ID | Run ID | ---- | 0.. | 64 | NATIVE_INT64 | PGE |
| GranuleMonth | Month granule was produced (from ECS MD RangeBeginningDate) | | 1-12 | 8 | NATIVE_INT | PGE |
| GranuleDay | Day granule was produced (from ECS MD RangeBeginningDate) | | 1-31 | 8 | NATIVE_INT | PGE |
| GranuleYear | Year granule was produced (from ECS MD RangeBeginningDate) | | | | NATIVE_INT | PGE |
| SurveyMode | Type of survey, e.g., Global or Special | | | | NATIVE_CHAR | MCF |
| PGEVersion | Release of PGE software: e.g. "R6.1" | | | | NATIVE_CHAR | MCF |

3.8.5 TES-L1B-Common Metadata

Metadata shown below is common to all TES L1B files.

The metadata item L1B_Data_Missing is calculated in the following way:

First, compute total_scans for the file, so for nadir scan is 144 and limb is 216, then compute row_count that is in L1B_tgt_spectra_quality tables. then compute difference between them and multiply it with 4 (number of focal planes) and 16 (number of pixels) and then add error_count found in General_error_flag, which is count of 1's in that file and then divide this number to total_scans * 4 * 16 and multiple by 100.

As code it looks like:

L1B_Data_Missing =

```
(((total_scans - row_count) * NUM_FOCAL_PLANE * TES_PIXEL_DIM) + error_count) * 100
/ ((total_scans * NUM_FOCAL_PLANE * TES_PIXEL_DIM));
```

Table 3-24: TES-L1B-Common Metadata

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|---------------------------|--|-------|------------|------|---------------|
| Run_Counter | | | | 32 | NATIVE_INT32 |
| Orbital_Path_ID | | | 1..233 | 8 | NATIVE_UINT8 |
| Absolute_Orbit_Number | | | | 32 | NATIVE_INT32 |
| Time_Of_Observation_Start | TAI time, for first observation in file | | | 64 | NATIVE_DOUBLE |
| Time_Of_Observation_End | TAI time, for last observation in file | | | 64 | NATIVE_DOUBLE |
| Geolocation_Data_Missing | No geolocation for observation count | | | 16 | NATIVE_INT16 |
| IceContamination | Ice contamination exceeded threshold. | N/A | 0,1 | 8 | NATIVE_INT |
| L1A_Data_Missing | Sum of missing scans and bad quality scans (per pixel) written as a percentage of the total number of scans for all focal planes at Level 1A | N/A | 0..100.0 | 32 | NATIVE_FLOAT |
| L1B_Data_Missing | Sum of missing scans and bad quality scans (per pixel) written as a percentage of the total number of scans for all focal planes at Level 1B | N/A | 0..100.0 | 32 | NATIVE_FLOAT |
| Command_Seq_ID | Command Sequence (Run) ID | N/A | | 32 | NATIVE_INT32 |

3.8.6 TES-L1B-Nadir Metadata

Metadata shown below is present only in TES L1B Nadir files.

Table 3-25: TES-L1B-Nadir Metadata

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|-----------------|---------------------|-------|------------|------|---------------|
| Start_Frequency | Start Frequency | | 500 - 3200 | 64 | NATIVE_DOUBLE |
| Delta_Frequency | Frequency step size | | .01 - .1 | 64 | NATIVE_DOUBLE |

3.8.7 TES-L1B-Limb Metadata

Metadata shown below is present only in TES L1B Limb files.

Table 3-26: TES-L1B-Limb Metadata

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|-----------------|---------------------|-------|------------|------|---------------|
| Start_Frequency | Start Frequency | | 500 - 3200 | 64 | NATIVE_DOUBLE |
| Delta_Frequency | Frequency step size | | .01 - .1 | 64 | NATIVE_DOUBLE |

3.8.8 TES-L1B-SO-Low Metadata

Metadata shown below is present only in TES L1B SO Low-Resolution files.

Table 3-27: TES-L1B-SO-Low Metadata

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|------------------|----------------------------|-------|--------------------|------|---------------|
| Start_Frequency | Start Frequency | | 500 - 3200 | 64 | NATIVE_DOUBLE |
| Delta_Frequency | Frequency step size | | .01 - .1 | 64 | NATIVE_DOUBLE |
| Observation_View | Specify Nadir or Limb view | n/a | 'Nadir', 'Limb' | | NATIVE_CHAR |

3.8.9 TES-L1B-SO-High Metadata

Metadata shown below is present only in TES L1B SO High-Resolution files.

Table 3-28: TES-L1B-SO-High Metadata

| Data Name | Data Description | Units | Data Range | Size | HDF 5 Type |
|------------------|----------------------------|-------|--------------------|------|---------------|
| Start_Frequency | Start Frequency | | 500 - 3200 | 64 | NATIVE_DOUBLE |
| Delta_Frequency | Frequency step size | | .01 - .1 | 64 | NATIVE_DOUBLE |
| Observation_View | Specify Nadir or Limb view | n/a | 'Nadir', 'Limb' | | NATIVE_CHAR |

4. LEVEL 2 STANDARD AND SPECIAL OBSERVATION PRODUCTS

4.1 Overview

The TES Level 2 (L2) subsystem generates information pertaining to the abundance of trace gases in the troposphere from analysis of spectra generated from the TES Level 1B subsystem. These spectra are evaluated by L2 using modeling algorithms collectively referred to as *retrieval*. An iterative process, retrieval compares an observed spectra to a modeled spectra, determines their similarity/dissimilarity, and the modifies the modeled spectra. Nominally, the retrieval process is repeated until the modeled spectra matches the observed spectra within certain tolerances. In addition to retrieving information pertaining to the distribution of trace atmospheric gases, L2 retrieves temperature information for the sampled atmosphere. The “retrieved” information is stored for later generation of L2 Products.

Before L2 can generate its products, the retrieval process is completed for all target scenes comprising a global survey or Special Observation run. A Global Survey consists of 16 consecutive orbits at the start of a two-day cycle. A Special Observation run may be less than one orbit or span multiple orbits. There can be more than one Special Observation run in a single orbit.

Once all retrievals are performed, L2 products are produced. While each retrieval yields information pertaining to several trace molecules (and temperature), L2 products include information for one molecular species (or temperature) for an entire global survey or Special Observation run. Data are oriented in this fashion to facilitate science evaluations where only one or a minimal set of atmospheric gases are involved.

4.1.1 Standard Products

L2 standard data products are segregated by observation type (limb and nadir) to minimize the use of fill data. For nadir observations, TES L2 standard products are produced for the following molecular species: H₂O, O₃, CH₄, CO, AtmT (atmospheric temperature). For limb observations, L2 standard products include more molecular species: H₂O, O₃, CH₄, CO, NO₂, HNO₃, and AtmT. See Table 4-1.

Table 4-1: View and Species Types

| Species | H2O | O3 | CH4 | CO | NO2 | HNO3 | AtmT |
|--------------------|-----|----|-----|----|-----|------|------|
| Nadir Swath Object | X | X | X | X | | | X |
| Limb Swath Object | X | X | X | X | X | X | X |

To minimize the duplication of information among all these standard products, an additional standard product, termed an TES L2 Ancillary Data product, will be generated as well. All TES L2 standard products report this information along a uniform UARS pressure grid ordered from ground to space.

To facilitate sharing data products between all Aura platform science teams, the organization of the L2 Standard Data Products conforms to specifications dictated in the [HDF-EOS Aura File Format Guidelines](#) (Craig, et al). These guidelines lay down the basic file format and data format specifications for all L2 standard products. While the specific referenced document should be checked for details, the guidelines specify that all L2 standard products should be generated using HDF-EOS V5.x formatting specifications. All data are to be reported as “swath” data objects. The Local Granule ID is a unique identifier for locally produced granules that are then sent to the ECS for archive. The Local Granule ID is also the filename of the standard data product produced by Level 2.

The L2 standard product files are implemented using the HDF-EOS 5 file format. HDF-EOS 5 files have a default extension of “.he5”. The ECS Local Granule ID (filename) for a L2 standard product is constructed using the following template:

TES-Aura_L2-<species>-<view>_r<run id>_<version id>.he5

Table 4-2: EOS Aura TES Standard Products (Level 2)

| ESDT Short Name | ECS File Type | Collection Summary | Local Granule ID ^a |
|-----------------|---------------|--|---|
| TL2H2ON | HDF-EOS | TES/Aura L2 H2O Nadir | TES-Aura_L2-H2O-Nadir_rnnnnnnnnnn_Fff_cc.he5 |
| TL2H2OL | HDF-EOS | TES/Aura L2 H2O Limb | TES-Aura_L2-H2O-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2O3N | HDF-EOS | TES/Aura L2 O3 Nadir | TES-Aura_L2-O3-Nadir_rnnnnnnnnnn_Fff_cc.he5 |
| TL2O3L | HDF-EOS | TES/Aura L2 O3 Limb | TES-Aura_L2-O3-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2CH4N | HDF-EOS | TES/Aura L2 CH4 Nadir | TES-Aura_L2-CH4-Nadir_rnnnnnnnnnn_Fff_cc.he5 |
| TL2CH4L | HDF-EOS | TES/Aura L2 CH4 Limb | TES-Aura_L2-CH4-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2CON | HDF-EOS | TES/Aura L2 CO Nadir | TES-Aura_L2-CO-Nadir_rnnnnnnnnnn_Fff_cc.he5 |
| TL2COL | HDF-EOS | TES/Aura L2 CO Limb | TES-Aura_L2-CO-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2NO2L | HDF-EOS | TES/Aura L2 NO2 Limb | TES-Aura_L2-NO2-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2HNO3L | HDF-EOS | TES/Aura L2 HNO3 Limb | TES-Aura_L2-HNO3-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2ATMTN | HDF-EOS | TES/Aura L2 Atmospheric Temperatures Nadir | TES-Aura_L2-ATM-TEMP-Nadir_rnnnnnnnnnn_Fff_cc.he5 |
| TL2ATMTL | HDF-EOS | TES/Aura L2 Atmospheric Temperatures Limb | TES-Aura_L2-ATM-TEMP-Limb_rnnnnnnnnnn_Fff_cc.he5 |
| TL2ANC | HDF-EOS | TES/Aura L2 Ancillary Data | TES-Aura_L2-ANCILLARY_rnnnnnnnnnn_Fff_cc.he5 |

a. Where rnnnnnnnnnn corresponds to the run_id and Fff_cc is the file version number (see Section 2.3.1).

As mentioned above, each TES L2 standard product reports information in a standardized data organization, the swath. Each swath element is bounded by (1) the number of observations in a global survey and (2) a predefined set of pressure levels representing slices through the atmosphere.

The organization of data within the swath object is based on a superset of the UARS pressure levels used to report concentrations of trace atmospheric gasses. The reporting grid is the same pressure grid used for modeling. There are 87 reporting levels from 1211.53 hPa, which allows for very high surface pressure conditions, to 0.1 hPa, about 65 km. In addition, the nadir and limb products will report values directly at the surface when possible or at the observed cloud top level. Thus in the Standard Product files each nadir and limb observation can potentially contain estimates for the concentration of a particular molecule at 88 different pressure levels within the atmosphere. However, for almost all retrieved profiles, the highest pressure levels are not observed due to a surface at lower pressure or cloud obscuration. For pressure levels corresponding to altitudes below the cloud top or surface, where measurements were not possible, a fill value will be applied.

Finally, other data are included with estimates for molecular concentration. Some of these data such as precision estimates are reported at the same density as the data points, while other information defines an aspect of a target scene’s characteristics in a single data value

4.1.2 Special Observation Products

L2 Special Observation data products are also segregated by observation type (limb and nadir) to minimize the use of fill data.

The L2 Special Observation files are also implemented using the HDF-EOS 5 file format. HDF-EOS 5 files have a default extension of “.he5”. The filename for a L2 Special Observation product is constructed using the following template:

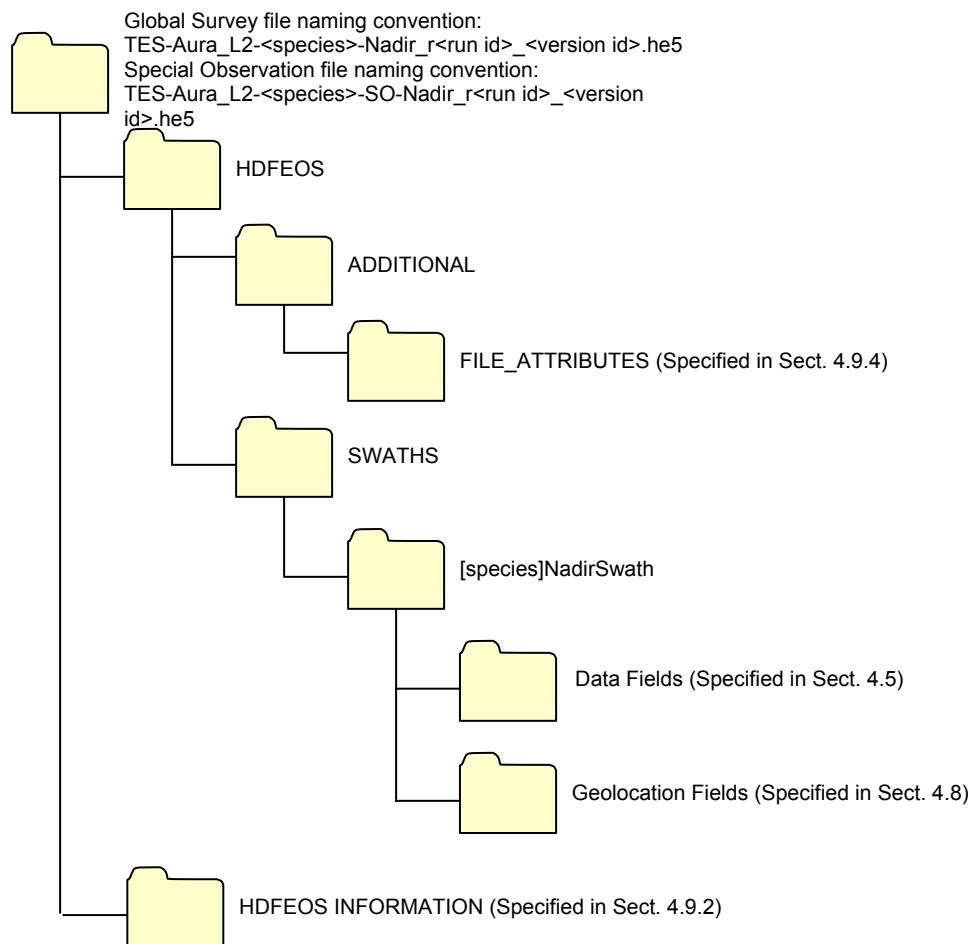
TES-Aura_L2-<species>-SO-<view>_r<run id>_<version id>.he5

At this time, it is not known which species will be reported for Special Observation runs processed through Level 2 beyond those shown above for Standard Products.

As above for Standard Products, each TES L2 Special Observation product reports information in a standardized data organization, the swath. Each swath element is bounded by (1) the number of observations in a Special Observation run and (2) a predefined set of pressure levels representing slices through the atmosphere as described above.

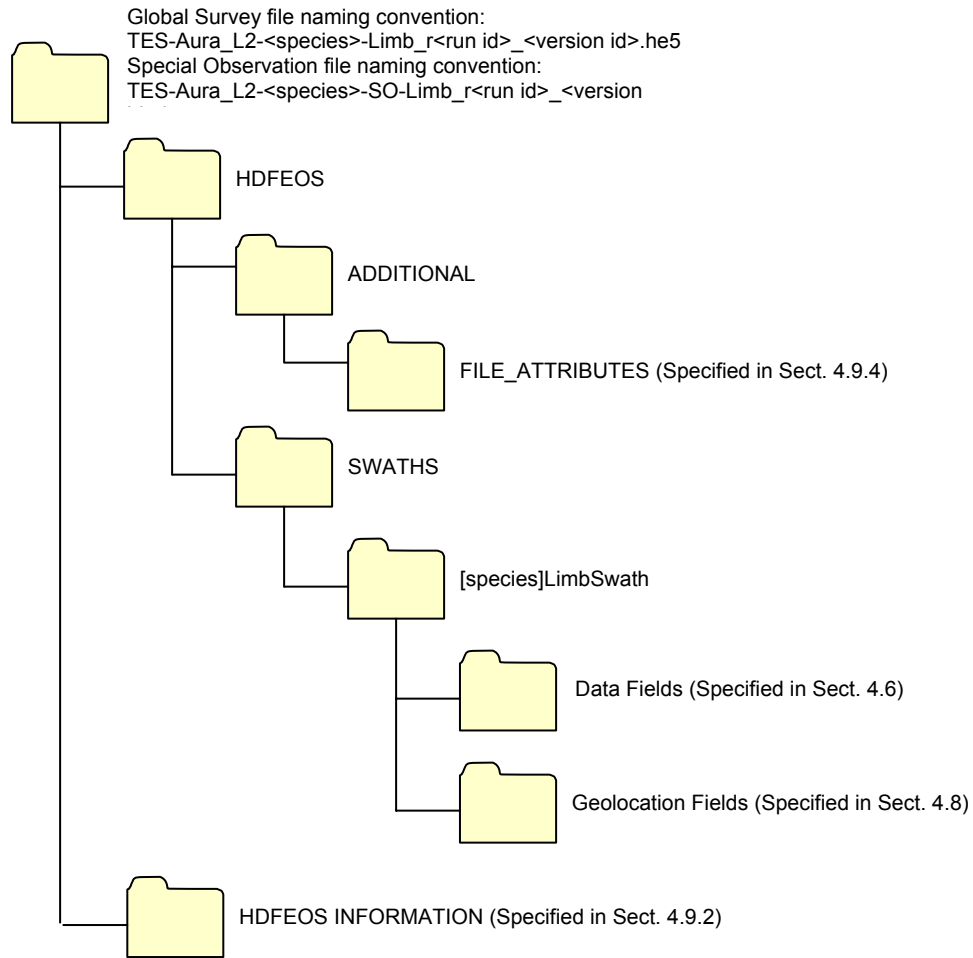
4.2 Nadir File Structure

The file structure of each nadir standard or special observation product is depicted in the figure below. In addition to the swath object (described above), each nadir standard product also contains descriptive metadata. The organization and layout of metadata conforms to HDF-EOS guidelines. First, an ECS Metadata block, metadata that includes a set of mandatory data describing attributes about the standard product is found at the beginning of every standard product. TES-specific metadata follows the ECS metadata. These metadata fields are used to describe TES specific details. Some of these data will be common among all TES products, some common only to TES Level 2 products, and some specific only to Nadir L2 products.



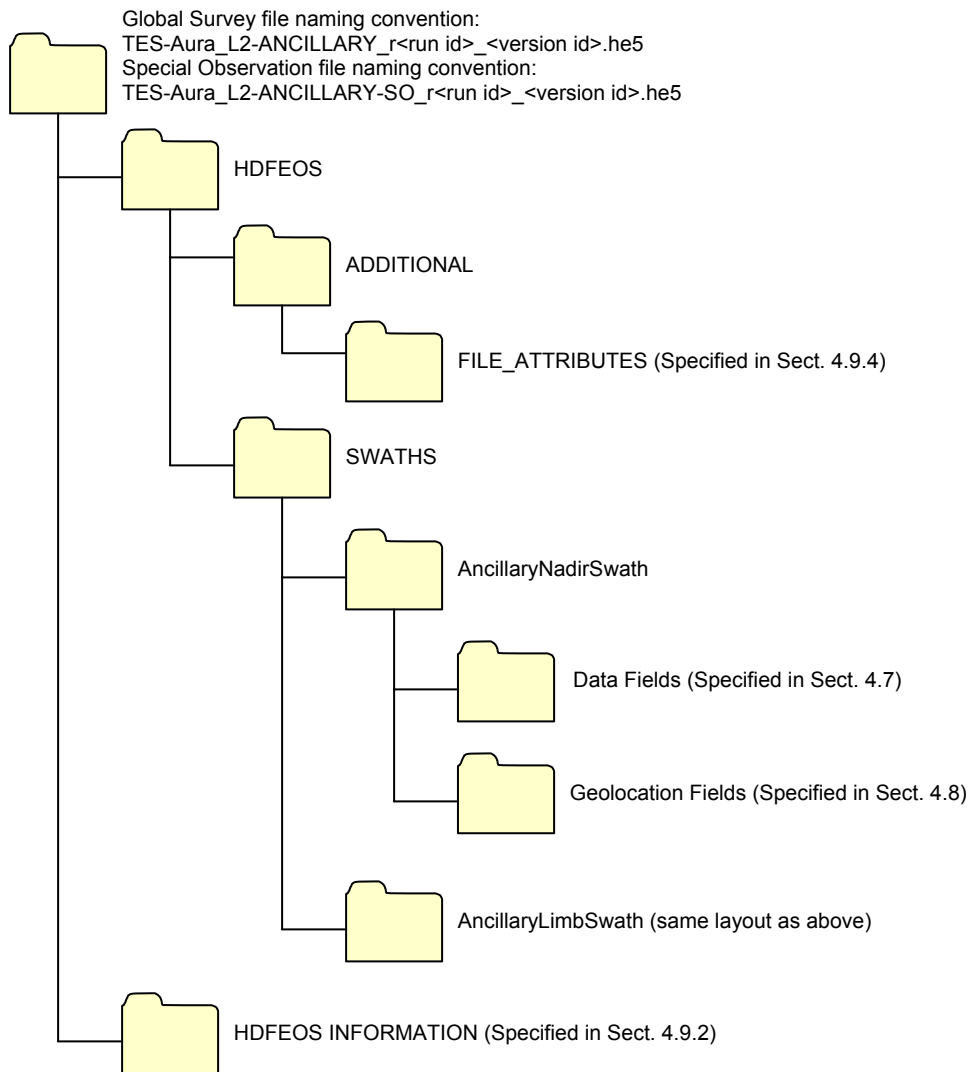
4.3 Limb File Structure

Similar in structure to the Nadir data product above, the Limb or High-Resolution product consists of both metadata and a swath data object (see figure below).



4.4 Ancillary File Structure

There are a number data items common to both Nadir and Limb observations that are consistent for all species for a given global survey or Special Observation run. Rather than replicate these items repeatedly with each file, these data items have been incorporated into a single file termed the TES L2 Ancillary Data product. Thus, the Ancillary product would be required as a partner to any L2 nadir or limb product. See figure below.



4.5 Nadir Data Fields

The Nadir Data Fields consist of primary data fields, which are VMR or temperature profiles and other data dimensioned by time and pressure levels, and the associated data fields, which are only dimensioned by time.

Each Data Field will be annotated using HDF-EOS Local Attributes which are listed in the table below. Data Field Attributes are a feature which can be useful in annotating plots as well as describing the data product to input routines. These attributes will be set via calls to `he5_swrlattr` (`HE5_SWwritelocattr` for C users).

| Attribute Name | Attribute Description | Size | HDF-EOS 5 Type |
|-----------------------|---|------|-------------------------|
| MissingValue | Contains the value for missing data. 32 float : -999.0 64 double: -999.0 32 int : -999 8 int : -99 | | Same type as Data Field |
| Title | For labeling a plot or axis. | | NATIVE_CHAR |
| Units | Labeling units (for labeling color bars, converting between units, etc). | | NATIVE_CHAR |
| UniqueFieldDefinition | Describes if definition of field is shared with other Aura Instruments ("Aura-Shared", "X-Specific", where X=Instrument Name, "X-Y[-Z]-Shared" where X,Y, and optional Z are instrument names (in alphabetical order) | | NATIVE_CHAR |

4.5.1 Nadir Primary Data Fields

The table below shows the swath data dimensions. The pressure levels as shown in this table are the 87 pressure levels plus one surface level as described in the Overview (Section 4.1).

All nadir swath data fields are based on a unified data structure and are used to report results of retrievals of spectra received from the L1B subsystem. The VMR data for the particular species of interest is the primary data element of each swath data layer. It is accompanied by various indices of error that help in evaluating the quality of the retrieval.

Table 4-3: Primary Data Dimensions Definitions

| Dimension Name | Valid Value (Description) |
|----------------|---------------------------------|
| nLevels | 88 pressure levels |
| nTimes | Number of reported observations |

Table 4-4: Nadir Primary Data Fields

| Data Field Name / Title * | Data Descriptions | Units | Data Range | Size | HDF-EOS 5 Type |
|-----------------------------|---|-------------|------------|------|----------------|
| [species] | VMR data or temperature data (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |
| [species]Precision | Square-roots of diagonal elements the measurement error covariance (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |
| TotalError | Square-roots of diagonal elements the output total error covariance (includes smoothing error, systematic error, and measurement error) (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |
| [species]VerticalResolution | Estimate of vertical resolution using the FWHM of averaging kernels (dim nLevels x nTimes) | km | | 32 | NATIVE_FLOAT |
| ConstraintVector | Constraint vector used in the retrieval (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |

| Data Field Name / Title * | Data Descriptions | Units | Data Range | Size | HDF-EOS 5 Type |
|----------------------------|---|------------------------------------|--------------|------|----------------|
| AveragingKernel | Retrieval sensitivity (dim nLevels x nLevels x nTimes) | N/A | | 32 | NATIVE_FLOAT |
| TotalErrorCovariance | Sum of measurement, systematic, and smoothing error covariances (dim nLevels x nLevels x nTimes) | VMR ² or K ² | | 32 | NATIVE_FLOAT |
| MeasurementErrorCovariance | Propagated measured radiance noise (dim nLevels x nLevels x nTimes) | VMR ² or K ² | | 32 | NATIVE_FLOAT |
| SystematicErrorCovariance | Propagated retrieval systematic errors (dim nLevels x nLevels x nTimes) | VMR ² or K ² | | 32 | NATIVE_FLOAT |
| Pressure | List of the 88 Pressure Levels used (dim nLevels x nTimes) | hPa | 0.001-1300.0 | 32 | NATIVE_FLOAT |
| Altitude | Derived altitude for each pressure level (dim nLevels x nTimes) | meters | 0-70000 | 32 | NATIVE_FLOAT |

* Where [species] equals H2O, O3, CH4, CO, or Temperature

Ideally, species and associated precision and quality measures will be populated for all Target Scenes in the global survey. However, there will be times where completing retrievals will not be possible. The causes will be varied and might be due to bad spectra (based on evaluation by L1B), excessive cloud cover, or the retrieval was not performed for scheduling or other administrative reasons. Regardless of the cause for missing data, certain swath data fields will be set to a fill value according [HDF-EOS Aura File Format Guidelines](#). Additionally, cloud cover may prevent retrieval down to the Earth’s surface, resulting in partial retrievals. When such cases occur, pressure layers will contain fill values when no data exists.

4.5.2 Nadir Associated Data Fields

The table below provides the associated data dimensions. The data items shown in the following tables are also included in the Swath Data as Associated Data:

Table 4-5: Associated Data Field Dimensions Definitions

| Dimension Name | Valid Value (Description) |
|----------------|---------------------------------|
| nTimes | Number of reported observations |

Table 4-6: Nadir Associated Data Fields

| Data Fields Name / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|--------------------------|---|--------|----------------|------|----------------|
| Scan_Averaged_Count | Number of scans averaged into a single target scene (dim nTimes) | N/A | 1-40 | 8 | NATIVE_INT8 |
| CloudTopHeight | Elevation of inferred cloud top (species independent) (dim nTimes) | Meters | 0 – 70,000 | 32 | NATIVE_FLOAT |
| CloudTopPressure | Pressure of inferred cloud top (species independent) (dim nTimes) | hPa | 1300.0 – 0.001 | 32 | NATIVE_FLOAT |
| SurfaceTemperature | Retrieved surface temperature (species independent) (dim nTimes) | K | 150.0 - 350 | 32 | NATIVE_FLOAT |

| Data Fields Name / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|--------------------------------|--|-----------------------|--|------|----------------|
| SurfaceTempError | Error in retrieved surface temperature (species independent) (dim nTimes) | K | 0.0 – 20.0 | 32 | NATIVE_FLOAT |
| TotalColumnDensity | Total column amount computed from the retrieved profile (dim nTimes) | Molec/cm ² | 0 – 10 ²⁸ | 32 | NATIVE_FLOAT |
| TotalColumnDensityError | Error in total column amount computed from total error covariance (dim nTimes) | Molec/cm ² | 0 – 10 ²⁸ | 32 | NATIVE_FLOAT |
| SpeciesRetrievalConverged | Indicates whether the non-linear least squares solver converged to a minimum. True=1, False=0 (dim nTimes) | N/A | 0 or 1 (Boolean) | 8 | NATIVE_INT8 |
| DeviationVsRetrievalCovariance | Deviation vs. Retrieval Covariance (dim nTimes) | | -10000.0 – 10000.0 | 32 | NATIVE_FLOAT |
| RadianceResidualMean | Mean of the model and data radiance difference (per species). (dim nTimes) | | -1000.0 – 1000.0 | 32 | NATIVE_FLOAT |
| RadianceResidualRMS | RMS of model and data difference (dim nTimes) | | 0.0 – 100.0 | 32 | NATIVE_FLOAT |
| RadianceResidualMax | Maximum absolute difference between model and data (dim nTimes) | | -10000.0 – 10000.0 | 32 | NATIVE_FLOAT |
| NumberIterPerformed | Actual number of iterations performed (dim nTimes) | Integer | Small number, typically < 8 and could be 0 | 8 | NATIVE_INT8 |
| MaxNumIterations | Maximum number of iterations allowed for convergence (dim nTimes) | N/A | <100 | 8 | NATIVE_INT8 |
| DegreesOfFreedomForSignal | Number of independent parameters for the profile (trace of the averaging kernel) (dim nTimes) | N/A | 0.0—1000.0 | 32 | NATIVE_FLOAT |
| InformationContent | Relative decrease in error volume with respect to a priori (dim nTimes) | N/A | -100.0—1000.0 | 32 | NATIVE_FLOAT |

4.6 Limb Data Fields

Like the Nadir Data Fields, the Limb Data Fields consist of the primary data fields, which are VMR or temperature profiles and other data dimensioned by time and pressure levels, and the associated data fields, which are only dimensioned by time.

Each Data Field will be annotated using HDF-EOS Local Attributes which are listed in the table below. Data Field Attributes are a feature which can be useful in annotating plots as well as describing the data product to input routines. These attributes will be set via calls to `he5_swwrlattr` (`HE5_SWwritelocattr` for C users).

| Attribute Name | Attribute Description | Size | HDF-EOS 5 Type |
|-----------------------|---|------|-------------------------|
| MissingValue | Contains the value for missing data. 32 float : -999.0 64 double: -999.0 32 int : -999 8 int : -99 | | Same type as Data Field |
| Title | For labeling a plot or axis. | | NATIVE_CHAR |
| Units | Labeling units (for labeling color bars, converting between units, etc). | | NATIVE_CHAR |
| UniqueFieldDefinition | Describes if definition of field is shared with other Aura Instruments ("Aura-Shared", "X-Specific", where X=Instrument Name, "X-Y[-Z]-Shared" where X,Y, and optional Z are instrument names (in alphabetical order) | | NATIVE_CHAR |

4.6.1 Limb Primary Data Fields

All swath data fields are based on a unified data structure and are used to report results of retrievals of spectra received from the L1B subsystem. The VMR data for the particular species of interest is the primary data element of each swath data layer. It is accompanied by various indices of error that help in evaluating the quality of the retrieval.

Ideally, species and associated precision and quality measures will be populated for all Target Scenes in the global survey. However, there will be times where completing retrievals will not be possible. The causes will be varied and might be due to bad spectra (based on evaluation by L1B), excessive cloud cover, or the retrieval was not performed for scheduling or other administrative reasons. Regardless of the cause for missing data, certain swath data fields will be set to a fill value according to the [HDF-EOS Aura File Format Guidelines](#). Additionally, cloud cover may prevent retrieval down to the Earth’s surface, resulting in partial retrievals. When such cases occur, pressure layers will contain fill values when no data exists.

Table 4-7: Primary Data Fields Dimensions Definitions

| Dimension Name | Valid Value (Description) |
|----------------|---------------------------------|
| nLevels | 88 pressure levels |
| nTimes | Number of reported observations |

Table 4-8: Limb Primary Data Fields

| Data Field Name / Title * | Data Descriptions | Units | Data Range | Size | HDF-EOS 5 Type |
|---------------------------|--|----------|------------|------|----------------|
| [species] | VMR data or temperature data (for retrieved temperature) (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |
| [species]Precision | Square-roots of diagonal elements of the measurement error covariance (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |
| TotalError | Square-roots of diagonal elements of the output total error covariance (includes smoothing error, systematic error, and measurement error) (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |

| Data Field Name / Title * | Data Descriptions | Units | Data Range | Size | HDF-EOS 5 Type |
|-----------------------------|---|------------------------------------|--------------|------|----------------|
| [species]VerticalResolution | Estimate of vertical resolution using the FWHM of averaging kernels (dim nLevels x nTimes) | km | | 32 | NATIVE_FLOAT |
| ConstraintVector | Constraint vector used in the retrieval (dim nLevels x nTimes) | VMR or K | | 32 | NATIVE_FLOAT |
| AveragingKernel | Retrieval sensitivity (dim nLevels x nLevels x nTimes) | N/A | | 32 | NATIVE_FLOAT |
| TotalErrorCovariance | Sum of measurement, systematic, and smoothing error covariances (dim nLevels x nLevels x nTimes) | VMR ² or K ² | | 32 | NATIVE_FLOAT |
| MeasurementErrorCovariance | Propagated measured radiance noise (dim nLevels x nLevels x nTimes) | VMR ² or K ² | | 32 | NATIVE_FLOAT |
| SystematicErrorCovariance | Propagated retrieval systematic errors (dim nLevels x nLevels x nTimes) | VMR ² or K ² | | 32 | NATIVE_FLOAT |
| Pressure | List of the 88 Pressure Levels used (dim nLevels x nTimes) | hPa | 0.001-1300.0 | 32 | NATIVE_FLOAT |
| Altitude | Derived altitude for each pressure level (dim nLevels x nTimes) | meters | 0-70000 | 32 | NATIVE_FLOAT |

* Where [species] equals H2O, O3, CH4, CO, NO2, HNO3, or Temperature

4.6.2 Limb Associated Data Fields

The table below provides the associated data dimensions. The data items shown in the following tables are also included in the Swath Data as Associated Data:

Table 4-9: Associated Data Field Dimensions Definitions

| Dimension Name | Valid Value (Description) |
|----------------|---------------------------------|
| nTimes | Number of reported observations |

Table 4-10: Limb Associated Data Fields

| Data Fields Name / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|--------------------------|---|-----------------------|----------------------|------|----------------|
| CloudTopHeight | Elevation of inferred cloud top (species independent) (dim nTimes) | Meters | 0 – 70,000 | 32 | NATIVE_FLOAT |
| CloudTopPressure | Pressure of inferred cloud top (species independent) (dim nTimes) | hPa | 1300.0 – 0.001 | 32 | NATIVE_FLOAT |
| TotalColumnDensity | Total column amount computed from the retrieved profile (dim nTimes) | Molec/cm ² | 0 – 10 ²⁸ | 32 | NATIVE_FLOAT |
| TotalColumnDensityError | Error in total column amount computed from total error covariance (dim nTimes) | Molec/cm ² | 0 – 10 ²⁸ | 32 | NATIVE_FLOAT |

| Data Fields Name / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|--------------------------------|--|---------|---|------|----------------|
| SpeciesRetrievalConverged | Indicates whether the non-linear least squares solver converged to a minimum. True=1, False=0 (dim nTimes) | | 0 or 1 (Boolean) | 8 | NATIVE_INT8 |
| DeviationVsRetrievalCovariance | Deviation vs. Retrieval Covariance (dim nTimes) | | -10000.0 – 10000.0 | 32 | NATIVE_FLOAT |
| RadianceResidualMean | Mean of the model and data radiance difference (per species). (dim nTimes) | | -1000.0 – 1000.0 | 32 | NATIVE_FLOAT |
| RadianceResidualRMS | RMS of model and data difference (dim nTimes) | | 0.0 – 100.0 | 32 | NATIVE_FLOAT |
| RadianceResidualMax | Maximum absolute difference between model and data (dim nTimes) | | -10000.0 – 10000.0 | 32 | NATIVE_FLOAT |
| NumberIterPerformed | Actual number of iterations performed (dim nTimes) | Integer | Small number typically < 8 and could be | 8 | NATIVE_INT8 |
| MaxNumIterations | Maximum number of iterations allowed for convergence (dim nTimes) | | < 100 | 8 | NATIVE_INT8 |
| DegreesOfFreedomForSignal | Number of independent parameters for the profile (trace of the averaging kernel) (dim nTimes) | N/A | 0.0—1000.0 | 32 | NATIVE_FLOAT |
| InformationContent | Relative decrease in error volume with respect to a priori (dim nTimes) | N/A | -100.0—1000.0 | 32 | NATIVE_FLOAT |

4.7 Ancillary Data Fields

The Ancillary ESDT contains the Associated Data Fields common to all species that were not included in the individual species files. One Ancillary ESDT will be created for each global survey.

Each Data Field will be annotated using HDF-EOS Local Attributes which are listed in the table below. Data Field Attributes are a feature which can be useful in annotating plots as well as describing the data product to input routines. These attributes will be set via calls to `he5_swrlattr` (`HE5_SWwritelocattr` for C users).

| Attribute Name | Attribute Description | Size | Type | HDF-EOS 5 Type |
|-----------------------|---|------|------|-------------------------|
| MissingValue | Contains the value for missing data. 32 float : -999.0 64 double: -999.0 32 int : -999 8 int : -99 | | | Same type as Data Field |
| Title | For labeling a plot or axis. | | char | NATIVE_CHAR |
| Units | Labeling units (for labeling color bars, converting between units, etc). | | char | NATIVE_CHAR |
| UniqueFieldDefinition | Describes if definition of field is shared with other Aura Instruments ("Aura-Shared", "X-Specific", where X=Instrument Name, "X-Y[-Z]-Shared" where X,Y, and optional Z are instrument names (in alphabetical order) | | char | NATIVE_CHAR |

Each Ancillary ESDT will consist of four Ancillary Data swaths, Nadir, Limb 1, Limb 2, and Limb 3. Each Ancillary Data swath will contain the following data items:

Table 4-11: Ancillary Data Dimensions Definitions

| Dimension Name | Valid Value (Description) |
|----------------|---------------------------------|
| nTimes | Number of reported observations |
| nFreq | 103 frequencies |
| nLevels | 88 pressure levels |

Table 4-12: Ancillary Nadir Data Fields

| Ancillary Data Fields / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|-------------------------------|---|------------------|------------------------------|------|----------------|
| SpacecraftLatitude | Geodetic latitude referenced to WGS84 ellipsoid (dim nTimes) | degrees | ± 90.0 | 32 | NATIVE_FLOAT |
| SpacecraftLongitude | Longitude referenced to WGS84 ellipsoid (dim nTimes) | degrees | ± 180.0 | 32 | NATIVE_FLOAT |
| SpacecraftAltitude | Height referenced to WGS84 ellipsoid (dim nTimes) | meters | | 32 | NATIVE_FLOAT |
| OrbitAscendingFlag | True=1, False=0 (dim nTimes) | | 0 or 1 (Boolean) | 8 | NATIVE_INT8 |
| SolarAzimuthAngle | Solar azimuth angle relative to the local north at the geolocation. (From geolocation table) (dim nTimes) | degrees | | 32 | NATIVE_FLOAT |
| PixelsUsedFlag | True=1, False=0 (dim nTimes) | | 64 chars, one for each pixel | 520 | NATIVE_CHAR |
| EmissivityWavenumber | Wavenumber array corresponding to retrieval emissivity points (applies to Nadir only) (dim nFreq x nTimes) | cm ⁻¹ | 600.0 – 3500.0 | 32 | NATIVE_FLOAT |
| LandSurfaceEmissivity | Retrieved surface emissivity for land nadir targets. Fill values for scenes where emissivity not retrieved. (dim nFreq x nTimes) | | 0.0 - 2.0 | 32 | NATIVE_FLOAT |
| LandSurfaceEmissErrors | Errors in retrieved surface emissivity for land nadir targets. Fill values for scenes where emissivity not retrieved. (dim nFreq x nTimes) | | | 32 | NATIVE_FLOAT |
| T_H2OCovariance | Error covariance terms for joint temperature and water retrieval (dim nLevels x nLevels x nTimes) | K*VMR | -4.0 – 4.0 | 32 | NATIVE_FLOAT |
| T_H2OAveragingKernel | Averaging kernel terms for joint temperature and water retrieval (influence of T on H2O) (dim nLevels x nLevels x nTimes) | N/A | -10.0 – 10.0 | 32 | NATIVE_FLOAT |

| Ancillary Data Fields / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|-------------------------------|--|-------|--------------|------|----------------|
| H2O_TAveragingKernel | Averaging kernel terms for joint temperature and water retrieval (influence of H2O on T) (dim nLevels x nLevels x nTimes) | N/A | -10.0 – 10.0 | 32 | NATIVE_FLOAT |
| Filter_Position_1A | Filter position for Focal Plane 1A (dim nTimes) | N/A | 1-5 | 8 | NATIVE_INT8 |
| Filter_Position_1B | Filter position for Focal Plane 1B (dim nTimes) | N/A | 1-2 | 8 | NATIVE_INT8 |
| Filter_Position_2A | Filter position for Focal Plane 2A (dim nTimes) | N/A | 1-4 | 8 | NATIVE_INT8 |
| Filter_Position_2B | Filter position for Focal Plane 2B (dim nTimes) | N/A | 1 | 8 | NATIVE_INT8 |

Table 4-13: Ancillary Limb Data Fields

| Ancillary Data Fields / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|-------------------------------|--|---------|------------------------------|------|----------------|
| SpacecraftLatitude | Geodetic latitude referenced to WGS84 ellipsoid (dim nTimes) | degrees | ± 90.0 | 32 | NATIVE_FLOAT |
| SpacecraftLongitude | Longitude referenced to WGS84 ellipsoid (dim nTimes) | degrees | ± 180.0 | 32 | NATIVE_FLOAT |
| SpacecraftAltitude | Height referenced to WGS84 ellipsoid (dim nTimes) | meters | | 32 | NATIVE_FLOAT |
| OrbitAscendingFlag | True=1, False=0 (dim nTimes) | | 0 or 1 (Boolean) | 8 | NATIVE_INT8 |
| SolarAzimuthAngle | Solar azimuth angle relative to local north at the spacecraft. (dim nTimes) | degrees | | 32 | NATIVE_FLOAT |
| PixelsUsedFlag | True=1, False=0 (dim nTimes) | | 64 chars, one for each pixel | 520 | NATIVE_CHAR |
| RetrievedPointingAngle | Retrieved value of the boresight nadir angles using TES limb spectral radiances. (Limb only) (dim nTimes) | degrees | | 32 | NATIVE_FLOAT |
| RetrievedPointingAngleError | Error of retrieved value of the boresight nadir angles using TES limb spectral radiances. (Limb only) (dim nTimes) | degrees | | 32 | NATIVE_FLOAT |
| T_H2OCovariance | Error covariance terms for joint temperature and water retrieval (dim nLevels x nLevels x nTimes) | K*VMR | -4.0 – 4.0 | 32 | NATIVE_FLOAT |
| T_H2OAveragingKernel | Averaging kernel terms for joint temperature and water retrieval (influence of T on H2O) (dim nLevels x nLevels x nTimes) | N/A | -10.0 – 10.0 | 32 | NATIVE_FLOAT |
| H2O_TAveragingKernel | Averaging kernel terms for joint temperature and water retrieval (influence of H2O on T) (dim nLevels x nLevels x nTimes) | N/A | -10.0 – 10.0 | 32 | NATIVE_FLOAT |
| Filter_Position_1A | Filter position for Focal Plane 1A (dim nTimes) | N/A | 1-5 | 8 | NATIVE_INT8 |
| Filter_Position_1B | Filter position for Focal Plane 1B (dim nTimes) | N/A | 1-2 | 8 | NATIVE_INT8 |

| Ancillary Data Fields / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|-------------------------------|--|-------|------------|------|----------------|
| Filter_Position_2A | Filter position for Focal Plane 2A (dim nTimes) | N/A | 1-4 | 8 | NATIVE_INT8 |
| Filter_Position_2B | Filter position for Focal Plane 2B (dim nTimes) | N/A | 1 | 8 | NATIVE_INT8 |

4.8 Geolocation Fields

The Geolocation Data is used to provide generic geolocation and spacecraft pointing information. This information is included with each species specific ESDT and copied identically into the Ancillary ESDT.

Each Data Field will be annotated using HDF-EOS Local Attributes which are listed in the table below. Data Field Attributes are a feature which can be useful in annotating plots as well as describing the data product to input routines. These attributes will be set via calls to he5_swwrlattr (HE5_SWwritelocattr for C users).

| Attribute Name | Attribute Description | Size | HDF-EOS 5 Type |
|-----------------------|---|------|-------------------------|
| MissingValue | Contains the value for missing data. 32 float : -999.0 64 double: -999.0 32 int : -999 8 int : -99 | | Same type as Data Field |
| Title | For labeling a plot or axis. | | NATIVE_CHAR |
| Units | Labeling units (for labeling color bars, converting between units, etc). | | NATIVE_CHAR |
| UniqueFieldDefinition | Describes if definition of field is shared with other Aura Instruments ("Aura-Shared", "X-Specific", where X=Instrument Name, "X-Y[-Z]-Shared" where X,Y, and optional Z are instrument names (in alphabetical order) | | NATIVE_CHAR |

Each Nadir-viewing species specific ESDT will have one swath containing the Nadir geolocation items below. Each Limb-viewing species specific ESDT will have three swaths containing the Limb 1, Limb 2, and Limb 3 geolocation items below.

Each Ancillary ESDT will consist of four Ancillary Data swaths, Nadir, Limb 1, Limb 2, and Limb 3. Each Ancillary Data swath will contain the following geolocation data items:

Table 4-14: Geolocation Dimensions

| Dimension Name | Valid Value (Description) |
|----------------|---------------------------------|
| nTimes | Number of reported observations |

Table 4-15: Nadir Geolocation Fields

| Geolocation Fields Name / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|---------------------------------|--|-----------------|------------|------|----------------|
| Time | Time (TAI93) of ZPD (Zero Path Difference) (dim nTimes) | sec | | 64 | NATIVE_DOUBLE |
| Latitude | Geodetic Latitude (dim nTimes) | Decimal degrees | ± 90.0 | 32 | NATIVE_FLOAT |
| Longitude | Geodetic Longitude (dim nTimes) | Decimal degrees | ± 180.0 | 32 | NATIVE_FLOAT |

| | | | | | |
|------------------------------|--|-------------------------|--------|----|---------------|
| SurfaceElevStandardDeviation | From DEM, standard deviation of average elevation over footprint (dim nTimes) | meters | | 32 | NATIVE_FLOAT |
| BoresightNadirAngle | TES boresight (LOS) nadir angle relative to the local nadir at SC (dim nTimes) | Decimal degrees | 0..90 | 64 | NATIVE_DOUBLE |
| BoresightNadirAngleUnc | Uncertainty in TES boresight nadir angle (dim nTimes) | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| BoresightAzimuth | TES boresight (LOS) azimuth angle relative to the local north at SC (dim nTimes) | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| SolarZenithAngle | Solar zenith relative to the local zenith at the spacecraft (dim nTimes) | degrees | 0--180 | 32 | NATIVE_FLOAT |
| LocalSolarTime | Local solar time at target geolocation. Computed from target longitude and UTC. (dim nTimes) | hours | | 32 | NATIVE_FLOAT |
| Tgt_SpacecraftZenith | TES boresight (LOS) zenith angle relative to the local zenith at the target geolocation. (dim nTimes) | degrees | ±90 | 32 | NATIVE_FLOAT |
| Tgt_SpacecraftAzimuth | TES boresight (LOS) azimuth angle relative to the local north at the target geolocation. (dim nTimes) | degrees (east of north) | ±90 | 32 | NATIVE_FLOAT |
| Latitude_Footprint_1 | Geo-location in geodetic coordinates of the four corners of the footprint. Nadir footprint determined by field of view of pixels. Limb footprint is ±60 km track, ±12 km crosstrack from surface expression of boresight tangent point. Latitude_Footprint_1=LowerLeft Latitude_Footprint_2=LowerRight Latitude_Footprint_3=UpperRight Latitude_Footprint_4=UpperLeft (dim nTimes) | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_2 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_3 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_4 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_1 | Geo-location in geodetic coordinates of the four corners of the footprint. Nadir footprint determined by field of view of pixels. Limb footprint is ±60 km track, ±12 km crosstrack from surface expression of boresight tangent point Longitude_Footprint_1=LowerLeft Longitude_Footprint_2=LowerRight Longitude_Footprint_3=UpperRight Longitude_Footprint_4=UpperLeft (dim nTimes) | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_2 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_3 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_4 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |

Table 4-16: Limb Geolocation Fields

| Geolocation Fields Name / Title | Data Description | Units | Data Range | Size | HDF-EOS 5 Type |
|---------------------------------|---|---------|------------|------|----------------|
| Time | Time (TAI93) of ZPD (Zero Path Difference) (dim nTimes) | sec | | 64 | NATIVE_DOUBLE |
| Latitude | Geodetic Latitude (dim nTimes) | degrees | ± 90.0 | 32 | NATIVE_FLOAT |

| | | | | | |
|------------------------------|--|-------------------------|---------|----|---------------|
| Longitude | Geodetic Longitude (dim nTimes) | degrees | ± 180.0 | 32 | NATIVE_FLOAT |
| SurfaceElevStandardDeviation | From DEM, standard deviation of average elevation over footprint (dim nTimes) | meters | | 32 | NATIVE_FLOAT |
| BoresightNadirAngle | TES boresight (LOS) nadir angle relative to local nadir at SC (dim nTimes) | Decimal degrees | 0..180 | 64 | NATIVE_DOUBLE |
| BoresightNadirAngleUnc | Uncertainty in TES boresight nadir angle (dim nTimes) | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| BoresightTangentHeight | Geodetic elevation of instrument boresight at the tangent point (around 16 km) (dim nTimes) | meters | | 32 | NATIVE_FLOAT |
| BoresightTangentHeightUnc | TES Boresight Tangent Height uncertainty (dim nTimes) | meters | | 32 | NATIVE_FLOAT |
| BoresightAzimuth | TES boresight (LOS) azimuth angle relative to local north at SC (dim nTimes) | Decimal degrees | 0..360 | 64 | NATIVE_DOUBLE |
| SolarZenithAngle | Solar zenith relative to the local zenith at the spacecraft (dim nTimes) | degrees | | 32 | NATIVE_FLOAT |
| LocalSolarTime | Local solar time at target geolocation. Computed from target longitude and UTC. (dim nTimes) | hours | | 32 | NATIVE_FLOAT |
| Tgt_SpacecraftZenith | TES boresight (LOS) zenith angle relative to the local zenith at the target geolocation. (dim nTimes) | degrees | ±90 | 32 | NATIVE_FLOAT |
| Tgt_SpacecraftAzimuth | TES boresight (LOS) azimuth angle relative to the local north at the target geolocation. (dim nTimes) | degrees (east of north) | ±90 | 32 | NATIVE_FLOAT |
| Latitude_Footprint_1 | Geo-location in geodetic coordinates of the four corners of the footprint. Nadir footprint determined by field of view of pixels. Limb footprint is ±60 km track, ±12 km crosstrack from surface expression of boresight tangent point. Latitude_Footprint_1=LowerLeft Latitude_Footprint_2=LowerRight Latitude_Footprint_3=UpperRight Latitude_Footprint_4=UpperLeft (dim nTimes) | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_2 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_3 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Latitude_Footprint_4 | | Decimal degrees | ±90 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_1 | Geo-location in geodetic coordinates of the four corners of the footprint. Nadir footprint determined by field of view of pixels. Limb footprint is ±60 km track, ±12 km crosstrack from surface expression of boresight tangent point Longitude_Footprint_1=LowerLeft Longitude_Footprint_2=LowerRight Longitude_Footprint_3=UpperRight Longitude_Footprint_4=UpperLeft (dim nTimes) | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_2 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_3 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |
| Longitude_Footprint_4 | | Decimal degrees | ±180 | 64 | NATIVE_DOUBLE |

4.9 L2 ECS and TES-specific Metadata

4.9.1 Introduction

As with all ESDTs, TES ESDTs contain metadata that describes specific attributes about the data or the quality of data contained in the ESDT. Some of the basic metadata items are required by EOSDIS. These data items commonly include basic identification information and other generic information about the particular ESDT. These data items are referred to as ECS Inventory Metadata. In addition to ECS Inventory Metadata, additional TES ESDTs contain additional metadata more specific to the TES program. The TES-specific metadata has been subdivided into four subcategories based on the uniqueness of its origin and identification:

- | | |
|--|---|
| 1. Production History | Production History Metadata |
| 2. TES-Common | Metadata common to all TES ESDTs |
| 3. TES-L2-Common | Metadata common to all Level 2 ESDTs |
| 4. TES-L2- <i>observation specific</i> | Metadata unique to a particular ESDT subtype. |

TES common metadata are fairly generic to the entire family of TES ESDTs or to TES L2 products. TES-L2-*observation specific*, as described by name, are unique to a particular family of L2 ESDTs.

4.9.2 ECS Inventory Metadata

The table below shows the ECS Inventory Metadata. The ECS Inventory Metadata is implemented in the HDF file as text block named coremetadata within a group named HDFEOS INFORMATION.

Table 4-17: ECS Inventory Metadata

| Data Layer Name | Data Description | TES Validates | Type ² | Source |
|-------------------------------|--|---|-------------------|--------|
| AssociatedInstrumentShortName | Instrument short name supplied by TES project. | TES | VA20 | MCF |
| AssociatedPlatformShortName | Platform short name supplied by EOS project. | Aura | VA20 | MCF |
| AssociatedSensorShortName | Sensor short name supplied by TES project. | FTS | VA20 | MCF |
| OperationMode | Mode of operation of the instrument. | Calibration Routine | VA20 | MCF |
| ShortName | This name will identify the ESDT short name associated with the collection or granule. | (set in MCF) | A8 | MCF |
| VersionID | Version identifier of the ESDT data collection. | (set in MCF) | SI | MCF |
| ProductionDateTime | The date and time a specific granule was produced a PGE. | YYYY-MM-DDT HH:MM:SS.SSSZ | DT | TK |
| SizeMBECSDDataGranule | The size attribute will indicate the volume of data contained in the granule. | | F10 | DSS |
| LocalGranuleID | Unique identifier for locally produced granule that ECS ingests and is required to capture. | e.g., TES-Aura_L2- H2O- Nadir_r0000000001 01 | VA80 | PGE |
| LocalVersionID | Local version identifier for PGE defined granule versions. Takes the form “executable name: Clearcase label” | | VA60 | PGE |

² Data types and Sources given are specified in document [3] on page 1-1.

| Data Layer Name | Data Description | TES Valid | Type ² | Source |
|-------------------------------|---|---|-------------------|--------|
| InputPointer | Description of location of Production History information. | “Production History block at: /HDFEOS/ADDITIONAL/FILE_ATTRIBUTES/PRODUCTION HISTORY” | VA255 | PGE |
| ParameterName | Scope of quality flags. For TES, refers to entire granule. | Granule | A40 | PGE |
| ScienceQualityFlag | The granule level flag applying generally to the granule and specifically to parameters at the granule level. | Passed Failed Being Investigated Not Investigated Inferred Passed Inferred Failed Suspect | VA25 | DP |
| ScienceQualityFlagExplanation | A text explanation of the criteria used to set the ScienceQualityFlag including thresholds or other criteria. | (Free text) | VA255 | DP |
| RangeBeginningDate | The year, month, and day when the temporal coverage period being described began. | YYYY-MM-DD | DT | PGE |
| RangeBeginningTime | The first hour, minute, and second of the temporal coverage period being described. | HH:MM:SS | T | PGE |
| RangeEndingDate | The last year, month, and day when the temporal coverage period being described. | YYYY-MM-DD | DT | PGE |
| RangeEndingTime | The last hour, minute, and second of the temporal coverage period being described. | HH:MM:SS | T | PGE |
| PGEVersion | The Release of the PGE software: e.g. “R6.1” | | A10 | PGE |

4.9.3 Production History Metadata

The Production History Metadata is implemented as a single text block and written to the HDF file as a file level attribute. The Production History text block contains information about the L2 PGE and the running execution of the PGE to produce ESDT standard products. Static information in the text block describes the elements that make up the PGE like build configuration, support files and database table population. Dynamic information describes all the running parameters involved in a PGE execution for a specific RUN ID. This information is captured for both pre and post execution of the L2 Product PGE.

Table 4-18: L2 Production History

| History Data | Data Description | Size (K) | State |
|-----------------------------|--|----------|---------|
| ECS | Toolkit file for input/output file specification | 23 | Dynamic |
| Environment Variable | SIPS environment variables | 5 | Dynamic |
| Fetch | SIPS fetch list from archived | 5 | Dynamic |
| SIPS PCF | SIPS-specific PCF file for PGE processing | 3 | Dynamic |
| Workspace List (PRE) | File listing in SIPS PGE workspace prior to PGE execution | 5 | Dynamic |
| Workspace List (POST) | File listing in SIPS PGE workspace following PGE execution | 5 | Dynamic |
| Runtime | CPU and Wallclock PGE run time | 0.1 | Dynamic |
| Control Definition | Framework Parameter Definition File for output files | 1 | Static |
| Control Parameter | Framework Parameter Specification File for output files | 0.02 | Static |
| Control Parameter (Runtime) | Framework Parameter specified in the command line of the PGE | 0.02 | Dynamic |
| TimeStamp | RUN ID begin date and end date timestamp | 0.05 | Dynamic |
| README | README file that describes production history context | 1 | Static |
| PGE Version | PGE version information | 0.2 | Static |
| PGE specific configurations | TBD | TBD | TBD |

4.9.4 TES-Common Metadata

Metadata shown below is common to all TES files. For Level 2, these are implemented as File Level Attributes (HDF-EOS Global File Attributes). This is information that helps to describe this particular data set. It can be useful in labeling plots, calculating dates, etc.. These will be set via calls to `he5_ehwrglatt(HE5_EHwriteglbattr` for C users).

Table 4-19: TES-Common-Metadata

| Data Layer Name | Data Description | Valids | Size | HDF-EOS 5 Type | Source |
|-----------------------|---|--------|------|----------------|--------|
| InstrumentName | TES | | | NATIVE_CHAR | MCF |
| ProcessLevel | L1B,L2,L3,etc. | | | NATIVE_CHAR | MCF |
| TAI93AtOzOfGranule | | | | NATIVE_DOUBLE | PGE |
| GlobalSurveyNumber/ID | Run ID | | | NATIVE_INT | PGE |
| GranuleMonth | Month granule was produced (from ECS MD RangeBeginningDate) | 1-12 | 8 | NATIVE_INT | PGE |
| GranuleDay | Day granule was produced (from ECS MD RangeBeginningDate) | 1-31 | 8 | NATIVE_INT | PGE |
| GranuleYear | Year granule was produced (from ECS MD RangeBeginningDate) | | | NATIVE_INT | PGE |
| SurveyMode | Type of survey, e.g., Global or Special | | | NATIVE_CHAR | MCF |
| PGEVersion | Release of PGE Software: e.g. "R6.1" | | | NATIVE_CHAR | MCF |

4.9.5 TES-L2-Common

Metadata shown below is common to all TES L2 files. These are implemented as Swath Level Attributes (HDF-EOS Group Attributes). This is information which helps describe the swath to which it is attached. These will be set via calls to `he5_swwrattr(HE5_SWwriteattr` for C users).

Table 4-20: TES-L2-Common-Metadata

| Data Layer Name | Data Description | Data Range | Size | HDF-EOS 5 Type |
|--------------------|--|------------|------|----------------|
| Pressure | Dimensioned over nUARSLevels only | | 32 | NATIVE_FLOAT |
| VerticalCoordinate | "Pressure","Altitude", "Potential Temperature" | | | NATIVE_CHAR |

4.9.6 TES-L2-Nadir Metadata

Metadata shown below are common to all TES L2 Nadir files. These are implemented as Swath Level Attributes (HDF-EOS Group Attributes) attached to the NadirSwath groups. This is information which helps describe the swath to which it is attached. These will be set via calls to `he5_swwrattr(HE5_SWwriteattr` for C users).

Table 4-21: TES-L2-Nadir-Metadata

| Data Layer Name | Definition | Data Range | Size | HDF-EOS 5 Type |
|-----------------|---|--------------|------|----------------|
| Scan_Resolution | Designates Low or High Resolution for this view | 'High', 'Low | | NATIVE_CHAR |

4.9.7 TES-L2-Limb Metadata

Metadata shown below are common to all TES L2 Limb files. These are implemented as Swath Level Attributes (HDF-EOS Group Attributes) attached to the Limb1Swath group. This is information which helps describe the swath to which it is attached. These will be set via calls to `he5_swvratr` (`HE5_SWwriteattr` for C users).

Table 4-22: TES-L2-Limb1-Metadata

| Data Layer Name | Definition | Data Range | Size | HDF-EOS 5 Type |
|-----------------|---|---------------|------|----------------|
| Scan_Resolution | Designates Low or High Resolution for this view | 'High', 'Low' | | NATIVE_CHAR |

4.9.8 TES-L2-Ancillary Metadata

TBD.

APPENDIX A -- ACRONYMS

| | |
|--------|--|
| API | Application Program Interface |
| BB | Black Body |
| DEM | Digital Elevation Model |
| DPS | Data Products Specification |
| ECI | Earth-Centered Inertial |
| ECS | EOSDIS Core System |
| EOS | Earth Observation System |
| EOSDIS | EOS Data and Information System |
| ESDIS | Earth Science Data and Information System |
| ESDT | Earth Science Data Type |
| FP | Focal Plane |
| FWHM | Full Width at Half Maximum |
| GDS | Ground Data System |
| HAIS | Hughes Applied Information Systems |
| HDF | Hierarchical Data Format |
| ICD | Interface Control Document |
| ICS | Interferometer Control System |
| ID | Identification |
| JPL | Jet Propulsion Laboratory |
| LOS | Line of Sight |
| MCF | Metadata Control File |
| MD | Metadata |
| NCAR | National Center for Atmospheric Research |
| NESR | Noise-Equivalent Spectral Radiance |
| OSE | Operational Support Equipment |
| OSP | Operational Support Product |
| PCS | Position Control System |
| PGE | Product Generation Executive |
| PRT | Platinum Resistance Thermistor |
| RMS | Root-Mean-Square |
| SC | Spacecraft |
| SIPS | Science Investigator-led Processing System |
| TAI | International Atomic Time |
| TBD | To Be Determined |
| TES | Tropospheric Emission Spectrometer |
| UARS | Upper Atmosphere Research Satellite |
| VMR | Volume Mixing Ratio |
| ZPD | Zero Path Difference |

APPENDIX B -- WORK-OFF PLAN TABLE

| Section or Table Number | What's Missing | Targeted Release |
|-------------------------|----------------|------------------|
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