Earth Observing System (EOS)

Tropospheric Emission Spectrometer (TES)

Science Data Processing

Standard and Special Observation

Data Products Specifications

Author: Scott Lewicki

Version 9.1 (Science Software Release 9.3)

D-22993

May 24, 2006

JPL

Jet Propulsion Laboratory
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9.1	CR 3866 - Modify Nadir_Primary_Data – AirDensity units Modify Limb_Primary_Data – AirDensity units	5/24/2006

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://romulus.gsfc.nasa.gov/PIMS/EMDS.html)
3. 420-TP-022-001	Release 7 Implementation Earth Science Data Model for the ECS Project, May 2004 (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 Document
7. JPL D-23176	Level-2 Functional Requirements Document

1.6 Reference Documents

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

1.7 Applicable Documents

9. 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
10. 194-207-SE1-001	System Design Specification for the ECS Project, Hughes Applied Information Systems, June 1994
11. 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. "R6.1.2".

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*>_**F**ff_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

ESDT Short Name	ECS File Type	Collection Summary	File Names
TL1BSOL	HDF 5	TES Aura L1B Special Observation Low Resolution	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
TL1BSOH	HDF 5	TES Aura Special Observation High Resolution	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

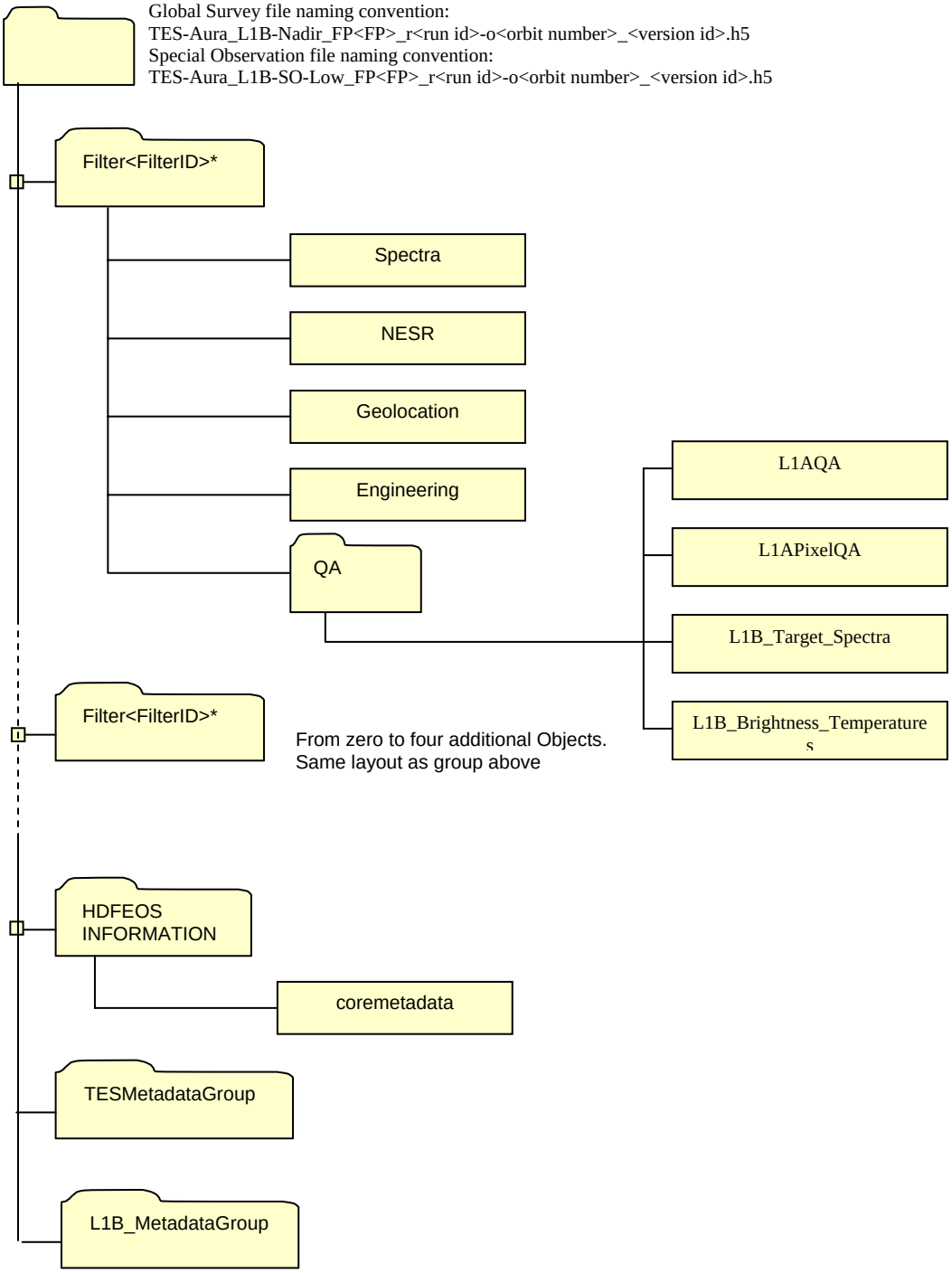
The Nadir standard product consists of four files, where each file is composed of the Global Survey Nadir observations from one of four focal planes for a single orbit. The number of observations within an orbit is fixed for a Global Survey, but that number may change if the configuration of the Global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

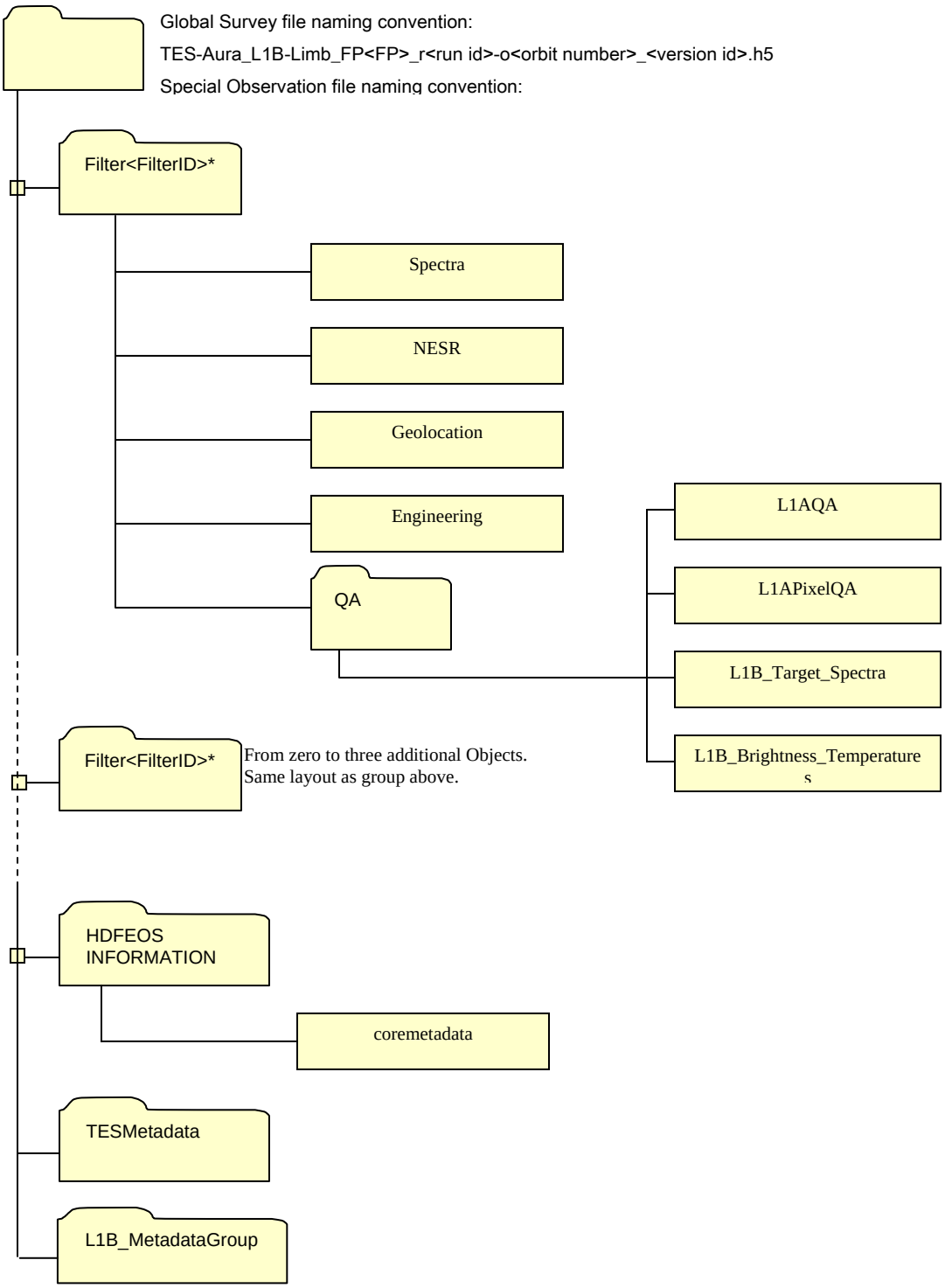
The Limb standard product consists of four files, where each file is composed of the Global Survey Nadir observations from one of four focal planes for a single orbit. The number of observations within an orbit is fixed for a Global Survey, but that number may change if the configuration of the Global 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 co-ordinates 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 co-ordinates 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)	Enumer-ated	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
M1_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 Postiioning Control Subsystem electonics board.	K	173 – 364 Fill = -999.0	32	NATIVE_FLOAT
M2_Mirror_Temp	M2 Mirror Temperature from the Postiioning Control Subsystem electonics 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 *suspicious* 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-*observation specific* — 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 Valids	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 Valids	Type[1]	Source
ShortName	This name will identify the ESDT short name associat 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
SizeMBECSDataGranule	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 granu	Granule	A40	PGE
ScienceQualityFlag	The granule level flag applying generally to the granul 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:SSSSSSZ	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:SSSSSSZ	T	PGE
PGEVersion	The Release of the PGE software: e.g. “R6.1.2”		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
InstrumentName	TES	----			NATIVE_CHAR
ProcessLevel	L1B,L2,L3,etc.	----			NATIVE_CHAR
TAI93At0zOfGranule		----			NATIVE_DOUBLE
GlobalSurveyNumber/ID	Run ID	----	0..	64	NATIVE_INT64
GranuleMonth	Month granule was produced (from ECS MD RangeBeginningDate)		1-12	8	NATIVE_INT
GranuleDay	Day granule was produced (from ECS MD RangeBeginningDate)		1-31	8	NATIVE_INT
GranuleYear	Year granule was produced (from ECS MD RangeBeginningDate)				NATIVE_INT
SurveyMode	Type of survey, e.g., Global or Special				NATIVE_CHAR
PGEVersion	Release of PGE software: e.g. “R6.1.2”				NATIVE_CHAR
Command_Seq_ID	Command Sequence (Run) ID	N/A		32	NATIVE_INT32

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

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: H_2O, O_3, CH_4, CO, HDO, AtmT (atmosphieric temperature). For limb observations, L2 standard products include more molecular species: H_2O, O_3, CH_4, CO, HDO, NO_2, HNO_3, and AtmT. See Table 4-1.

Table 4-1: View and Species Types

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

To minimize the duplication of information among all these standard products, an additional standard prouduct, 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
TL2HDON	HDF-EOS	TES/Aura L2 HDO Nadir	TES-Aura_L2-HDO-Nadir_rnnnnnnnnnn_ Fff_cc.he5
TL2HDOL	HDF-EOS	TES/Aura L2 HDO Limb	TES-Aura_L2-HDO-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 L2Atmospheric 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. For R9, nadir products have 66 atmospheric reporting levels and limbs products 87 atmospheric reporting levels. These levels range 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 67 nadir and 88 limb 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.

In the standard products, the data will be organized as shown in the diagram below. The diagram shows the organization for an example limb product at 88 pressure levels (87 + 1 surface pressure). For nadir there would be 67 pressure levels (66 + 1 surface pressure). The value retrieved at the surface pressure is placed at the level below the last valid atmospheric standard pressure level. (The user can identify the value retrieved at the surface pressure because the remaining “levels” below that will have a fill value.)

88 Levels	Obs. 1	Obs. 2	Obs. 3	Obs. 4	……..	Obs. 1149	Obs. 1150	Obs. 1151	Obs. 1152
88	Standard Pressure Level	Standard Pressure Level	Standard Pressure Level	Standard Pressure Level	……..	Standard Pressure Level	Standard Pressure Level	Standard Pressure Level	Standard Pressure Level
87	“	“	“	“	“	“	“	“	“
86	“	“	“	“	“	“	“	“	“
85	“	“	“	“	“	“	“	“	“
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
8	“	“	“	“	……..	Surface Pressure	Standard Pressure Level	“	“
7	“	“	Standard Pressure Level	“	……..	Fill	Surface Pressure	Standard Pressure Level	“
6	“	Standard Pressure Level	Surface Pressure	Standard Pressure Level	……..	Fill	Fill	Surface Pressure	“
5	Standard Pressure Level	Surface Pressure	Fill	Surface Pressure	……..	Fill	Fill	Fill	Standard Pressure Level
4	Surface Pressure	Fill	Fill	Fill	……..	Fill	Fill	Fill	Surface Pressure
3	Fill	Fill	Fill	Fill	……..	Fill	Fill	Fill	Fill
2	Fill	Fill	Fill	Fill	……..	Fill	Fill	Fill	Fill
1	Fill	Fill	Fill	Fill	……..	Fill	Fill	Fill	Fill

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 into separate products by observation type (limb and nadir).

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

Table 4-3: EOS Aura TES Special Observation Products (Level 2)

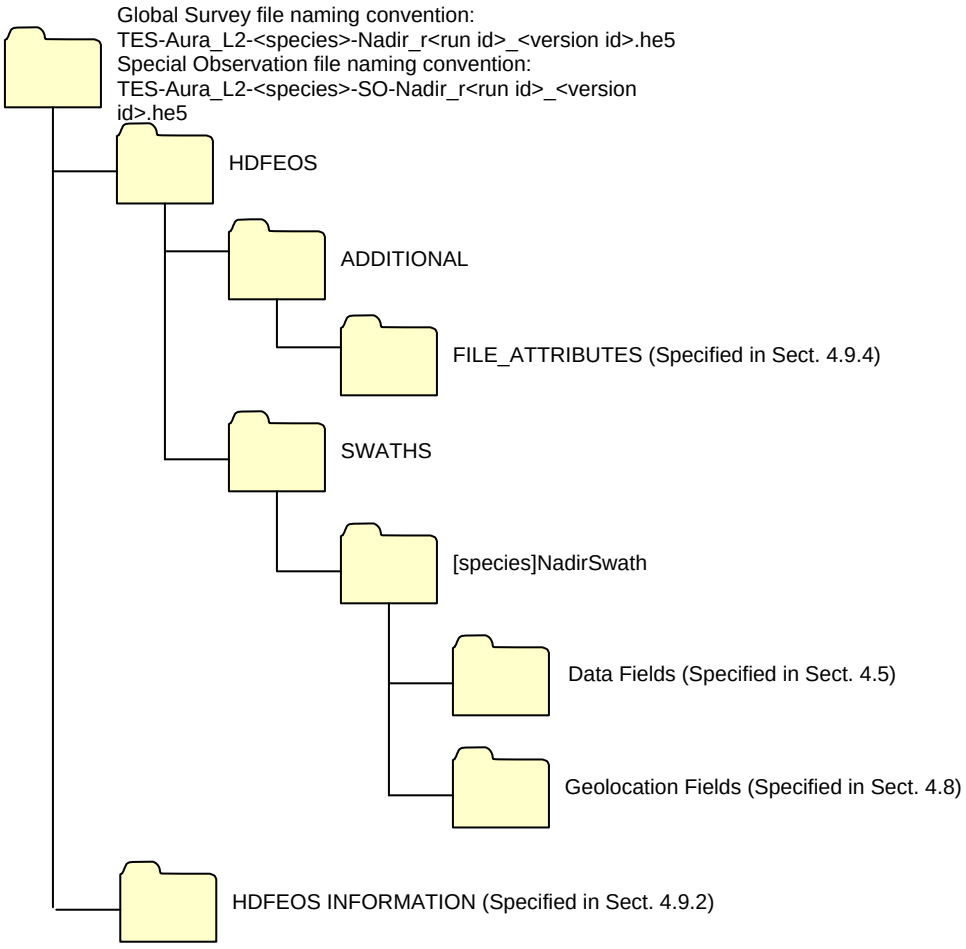
ESDT Short Name	ECS File Type	Collection Summary	Local Granule ID[a]
TL2H2ONS	HDF-EOS	TES/Aura L2 H2O Nadir Special Observation	TES-Aura_L2-H2O-SO-Nadir_rnnnnnnnnnn_ Fff_cc.he5
TL2H2OLS	HDF-EOS	TES/Aura L2 H2O Limb Special Observation	TES-Aura_L2-H2O-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2O3NS	HDF-EOS	TES/Aura L2 O3 Nadir Special Observation	TES-Aura_L2-O3-SO-Nadir_rnnnnnnnnnn_ Fff_cc.he5
TL2O3LS	HDF-EOS	TES/Aura L2 O3 Limb Special Observation	TES-Aura_L2-O3-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2CH4NS	HDF-EOS	TES/Aura L2 CH4 Nadir Special Observation	TES-Aura_L2-CH4-SO-Nadir_rnnnnnnnnnn_ Fff_cc.he5
TL2CH4LS	HDF-EOS	TES/Aura L2 CH4 Limb Special Observation	TES-Aura_L2-CH4-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2CONS	HDF-EOS	TES/Aura L2 CO Nadir Special Observation	TES-Aura_L2-CO-SO-Nadir_rnnnnnnnnnn_ Fff_cc.he5
TL2COLS	HDF-EOS	TES/Aura L2 CO Limb Special Observation	TES-Aura_L2-CO-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2HDONS	HDF-EOS	TES/Aura L2 HDO Nadir Special Observation	TES-Aura_L2-HDO-SO-Nadir_rnnnnnnnnnn_ Fff_cc.he5
TL2HDOLS	HDF-EOS	TES/Aura L2 HDO Limb Special Observation	TES-Aura_L2-HDO-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2NO2S	HDF-EOS	TES/Aura L2 NO2 Limb Special Observation	TES-Aura_L2-NO2-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2HNO3S	HDF-EOS	TES/Aura L2 HNO3 Limb Special Observation	TES-Aura_L2-HNO3-SO-Limb_rnnnnnnnnnn_ Fff_cc.he5
TL2TNS	HDF-EOS	TES/Aura L2Atmospheric Temperatures Nadir Special Observation	TES-Aura_L2-ATM-TEMP-SO-Nadir_rnnnnnnnnnn_ Fff_cc.he
TL2TLS	HDF-EOS	TES/Aura L2 Atmospheric Temperatures Limb Special Observation	TES-Aura_L2-ATM-TEMP-SO-Limb_rnnnnnnnnnn_ Fff_cc.he
TL2ANCS	HDF-EOS	TES/Aura L2 Ancillary Special Observation Data	TES-Aura_L2-ANCILLARY-SO_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 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.

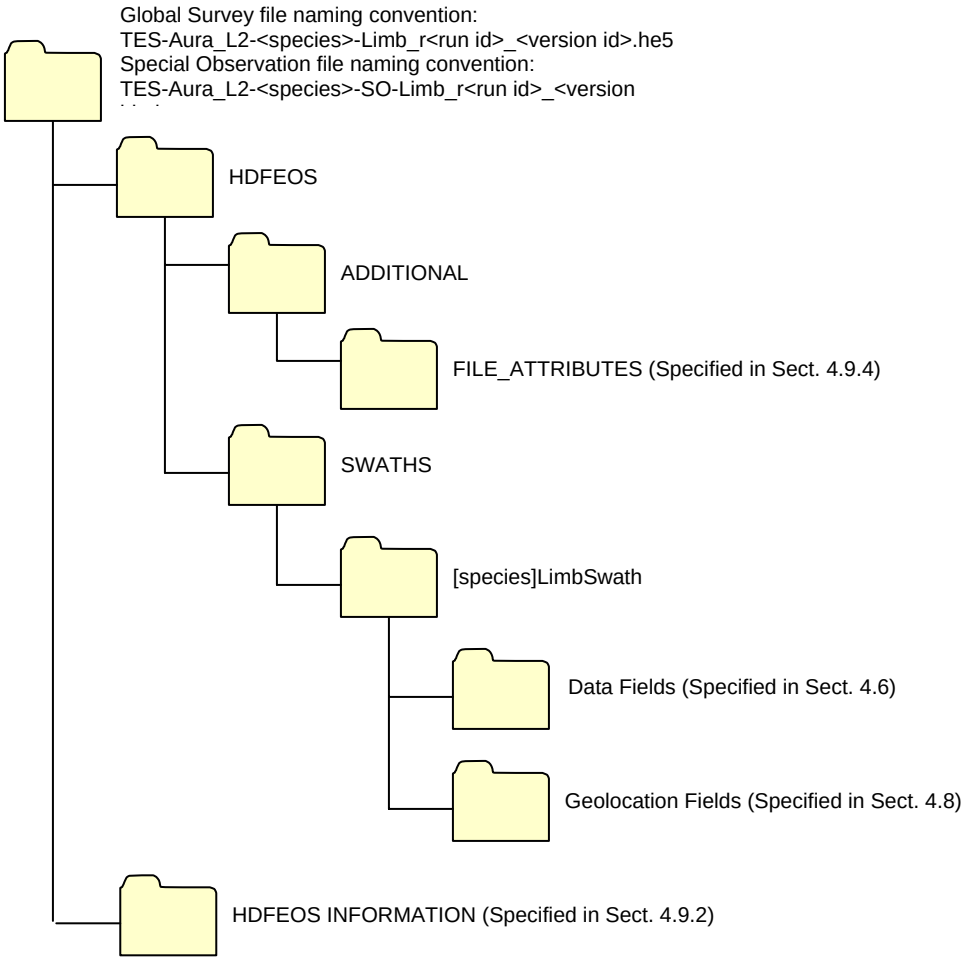
4.2 Nadir File Structure

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

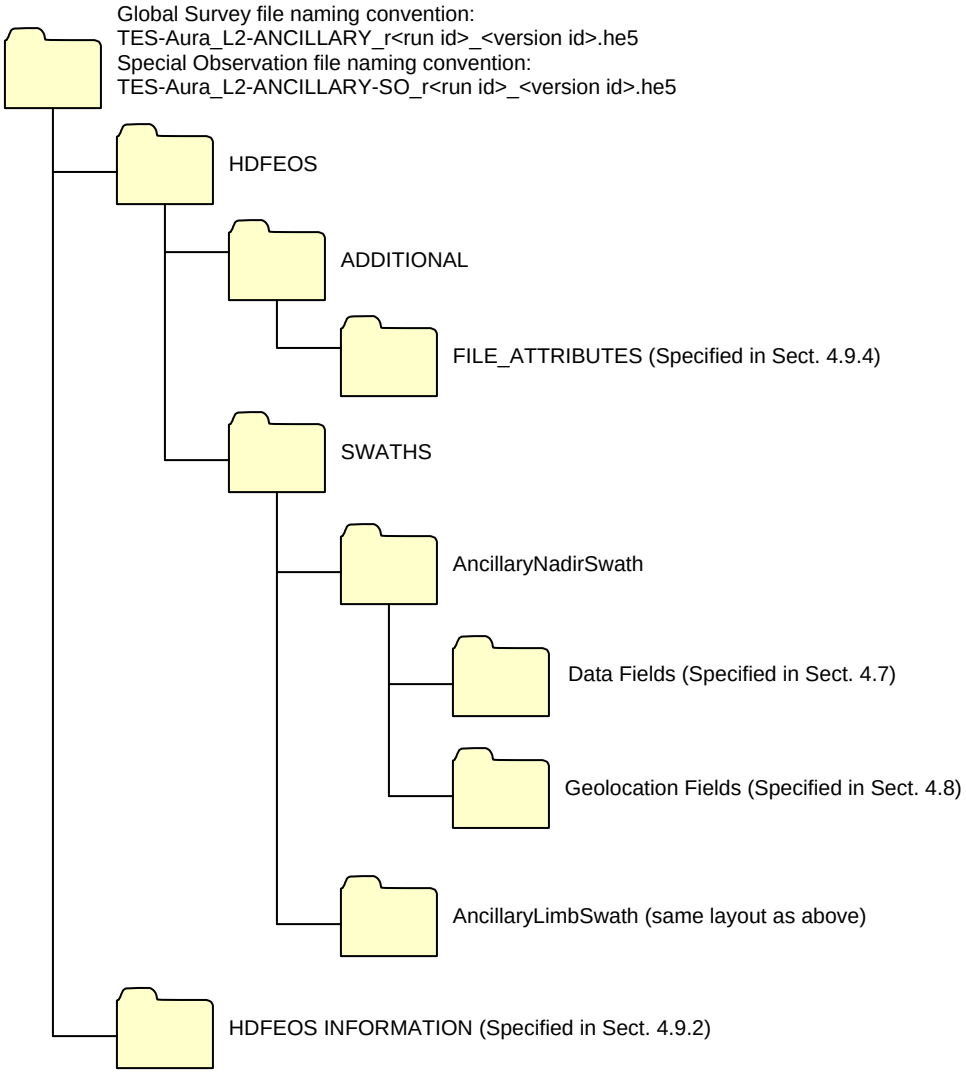
Similar in structure to the Nadir data product above , the Limb or High-Resolution product consists of both metadata and a swath data object (see figure below).



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. If for a given Global Survey or Special Observation run, no data are acquired for a particular viewing mode (Nadir or Limb) or all data for that mode are missing, the corresponding object (AncillaryNadirSwath or AncillayLimbSwath) is not written.

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_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 16 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 instrume 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 66 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	Number of reported 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 of the measurement error covariance. See comment for TotalError regarding use. (dim nLevels x nTimes)	ln(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). For T_{ATM}, these values are the error bars. For atmospheric species, the positive error bar is: error+ = exp(ln(VMR) + error) - VMR. The negative error bar is: error- = VMR - exp(ln(VMR) - error) (dim nLevels x nTimes)	ln(VMR) or K		32	NATIVE_FLOAT

Data Field Name / Title *	Data Descriptions	Units	Data Range	Size	HDF-EOS 5 Type
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)	ln(VMR) or K		32	NATIVE_FLOAT
AveragingKernel	Retrieval sensitivity. For temperature, this is the sensitivity of the retrieved temperature to the true temperature. For atmospheric species this is the sensitivity of retrieved ln(VMR) to the true ln(VMR). (dim nLevels x nLevels x nTimes)	N/A		32	NATIVE_FLOAT
TotalErrorCovariance	Sum of measurement, systematic, and smoothing error covariances. For T_{ATM}, this is the covariance of the error of temperature. For atmospheric species, this is the covariance of the error of ln(VMR). (dim nLevels x nLevels x nTimes)	ln(VMR)^2 or K^2		32	NATIVE_FLOAT
MeasurementErrorCovariance	Propagated measured radiance noise. See comment for TotalErrorCovariance. (dim nLevels x nLevels x nTimes)	ln(VMR)^2 or K^2		32	NATIVE_FLOAT
ObservationErrorCovariance	Measurement + systematic + cross-state errors. The utility of the observation error is for comparisons with other measurements and for assimilation. The smoothing error is accounted for when one applies the averaging kernel, so the observation error accounts for everything else. See comment for TotalErrorCovariance. (dim nLevels x nLevels x nTimes)	ln(VMR)^2 or K^2		32	NATIVE_FLOAT
Initial	Initial VMR data or temperature data (for retrieved temperature) used in the retrieval (dim nLevels x nTimes)	VMR or K		32	NATIVE_FLOAT
AveragingKernelDiagonal	Diagonal of the averaging kernel, which shows retrieval sensitivity. For temperature, this is the sensitivity of the retrieved temperature to the true temperature. For atmospheric species this is the sensitivity of retrieved ln(VMR) to the true ln(VMR). (dim nLevels x nTimes)	N/A		32	NATIVE_FLOAT
AirDensity	Air density for each pressure level (dim nLevels x nTimes)	Molec/m^3	0-1e+26	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, HDO, 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
nFreq	25 frequencies (values listed in TES-L2-Common metadata)

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 1 = no averaging	8	NATIVE_INT8
SpeciesRetrievalQuality	Species Retrieval Quality flag. True means retrieval passed quality check and reported errors are accurate. (dim nTimes)	n/a	0 = poor quality 1 = passed quality chec	8	NATIVE_INT8
CloudTopPressure	Pressure of inferred cloud top (species independent) (dim nTimes)	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudTopPressureError	Error on Cloud Top Pressure (dim nTimes)	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepth	Vertical optical depth for the retrieved non-scattering cloud calculated at 25 frequencies listed in TES-L2-Common-Metadata (dim nTimes x nFreq)	n/a	0.0--500.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepthError	Error for Cloud Effective Optical Depth calculated at 25 frequencies listed in TES-L2-Common-Metadata (dim nTimes x nFreq)	n/a	0.0--500.0	32	NATIVE_FLOAT
SurfaceTemperature	Retrieved surface temperature from the atmospheric termperature retrieval step (dim nTimes)	K	150.0 - 350	32	NATIVE_FLOAT
SurfaceTempError	Error in retrieved surface temperature (dim nTimes)	K	0.0 – 20.0	32	NATIVE_FLOAT
SurfaceTempInitial	Initial surface temperature used for the retrieval (dim nTimes)	K	150.0 - 350	32	NATIVE_FLOAT

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
SurfaceTempDegreesOfFreedom	Degrees of freedom for surface temperature (dim nTimes)	N/A	0.0 – 2.0	32	NATIVE_FLOAT
SurfaceTempObservationError	Measurement + systematic + cross-state errors. The utility of the observation error is for comparisons with other measurements and for assimilation. The smoothing error is accounted for when one applies the averaging kernel, so the observation error accounts for everything else. (dim nTimes)	K	0-50	32	NATIVE_FLOAT
SurfaceTempConstraint	Surface temperature value used to constrain the retrieval (species independent) (dim nTimes)	K	150.0 - 350	32	NATIVE_FLOAT
SurfaceTempPrecision	Square-root of diagonal element of the measurement error covariance (dim nTimes)	K	150.0 - 350	32	NATIVE_FLOAT
TotalColumnDensity	Total column amount computed from the retrieved profile. For the Atmospheric Temperature Product this will be a fill value. (dim nTimes)	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
TotalColumnDensityError	Error in total column amount computed from total error covariance For the Atmospheric Temperature Product this will be a fill value. (dim nTimes)	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
TotalColumnDensityInitial	Total column amount computed from the initial profile. For the Atmospheric Temperature Product this will be a fill value. (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	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

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
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
CloudVariability_QA	Quality value calculated from cloud variability. This will be fill for the species HDO and H2O. (dim nTimes)	N/A	0- 100	32	NATIVE_FLOAT
KDotDL_QA	Quality value calculating the signal left in the residual. This is the maximum of the dot product of the Jacobian (K) and the Radiance (L) divided by sqrt(K dot K) * sqrt(L dot L) (dim nTimes)	N/A	-100 - 100	32	NATIVE_FLOAT
LDotDL_QA	Quality value calculating the signal left in the residual. This is the dot product of the radiance (L) with the residual (dL) divided by sqrt(L dot L) * sqrt(dL dot dL) (dim nTimes)	N/A	-100 - 100	32	NATIVE_FLOAT
Calibration_QA	Quality value of calculated from the calibration factors. This will be fill for the species HDO and H2O. (dim nTimes)	N/A	-2 - 2	32	NATIVE_FLOAT
AverageCloudEffOpticalDepth	Quality value: the cloud mean optic depth from 975 – 1200 cm-1. This will be fill for the species HDO and H2O. (dim nTimes)	N/A	0 - 10000	32	NATIVE_FLOAT
SurfaceEmissMean_QA	Quality value comparing the retrieve emissivity to the initial emissivity. Fill for ocean and limb scenes. This will be fill for the species HDO and H2O. (dim nTimes)	N/A	-2 - 2	32	NATIVE_FLOAT
SurfaceTempVsApriori_QA	Quality value comparing the surface temperature to a priori value (dim nTimes)	K	-100 - 100	32	NATIVE_FLOAT
SurfaceTempVsAtmTemp_QA	Quality value comparing the surface temperature to the lowest atmospher pressure. This will be fill for the species CO, CH4, HDO, and H2O. (dim nTimes)	K	-100 - 100	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 16 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 instrumer 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	Number of reported 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. See comment for TotalError regarding use. (dim nLevels x nTimes)	ln(VMR) or K		32	NATIVE_FLOAT

Data Field Name / Title *	Data Descriptions	Units	Data Range	Size	HDF-EOS 5 Type
TotalError	Square-roots of diagonal elements o the output total error covariance (includes smoothing error, systemati error, and measurement error). For T_{ATM}, these values are the error bars For atmospheric species, the positiv error bar is: error+ = exp(ln(VMR) error) - VMR. The negative error b is: error- = VMR - exp(ln(VMR) - error) (dim nLevels x nTimes)	ln(VMR) or K		32	NATIVE_FLOAT
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)	ln(VMR) or K		32	NATIVE_FLOAT
AveragingKernel	Retrieval sensitivity. For temperature, this is the sensitivity of the retrieved temperature to the true temperature. For atmospheric species this is the sensitivity of retrieved ln(VMR) to the true ln(VMR). (dim nLevels x nLevels x nTimes)	N/A		32	NATIVE_FLOAT
TotalErrorCovariance	Sum of measurement, systematic, and smoothing error covariances. For T_{ATM}, this is the covariance of the error of temperature. For atmospheric species, this is the covariance of the error of ln(VMR). (dim nLevels x nLevels x nTimes)	ln(VMR)^2 or K^2		32	NATIVE_FLOAT
MeasurementErrorCovariance	Propagated measured radiance noise. See comment for TotalErrorCovariance. (dim nLevels x nLevels x nTimes)	ln(VMR)^2 or K^2		32	NATIVE_FLOAT
ObservationErrorCovariance	Measurement + systematic + cross-state errors. The utility of the observation error is for comparisons with other measurements and for assimilation. The smoothing error is accounted for when one applies the averaging kernel, so the observation error accounts for everything else. See comment for TotalErrorCovariance. (dim nLevels x nLevels x nTimes)	ln(VMR)^2 or K^2		32	NATIVE_FLOAT
Initial	Initial VMR data or temperature data (for retrieved temperature) used in the retrieval (dim nLevels x nTimes)	VMR or K		32	NATIVE_FLOAT
AveragingKernelDiagonal	Diagonal of the averaging kernel, which shows retrieval sensitivity. For temperature, this is the sensitivity of the retrieved temperature to the true temperature. For atmospheric species this is the sensitivity of retrieved ln(VMR) to the true ln(VMR). (dim nLevels x nTimes)	N/A		32	NATIVE_FLOAT
AirDensity	Air density for each pressure level (dim nLevels x nTimes)	Molec/m^3	0-1e+26	32	NATIVE_FLOAT

Data Field Name / Title *	Data Descriptions	Units	Data Range	Size	HDF-EOS 5 Type
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, HDO, 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
nFreq	25 frequencies (values listed in TES-L2-Common metadata

Table 4-10: Limb Associated Data Fields

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
SpeciesRetrievalQuality	Species Retrieval Quality flag. True means retrieval passed quality check and reported errors are accurate. (dim nTimes)	n/a	0 = poor quality 1 = passed quality chec	8	NATIVE_INT8
CloudTopPressure	Pressure of inferred cloud top (specie independent) (dim nTimes) **THIS DATAFIELD WILL BE FIL FOR R9 PRODUCTS.**	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudTopPressureError	Error on Cloud Top Pressure (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepth	Vertical optical depth for the retrieved non-scattering cloud calculated at 25 frequencies listed in TES-L2-Common-Metadata (dim nTimes x nFreq) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	n/a	0.0--500.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepthErr or	Error for Cloud Effective Optical Depth calculated at 25 frequencies listed in TES-L2-Common-Metadata (dim nTimes x nFreq) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	n/a	0.0--500.0	32	NATIVE_FLOAT

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
TotalColumnDensity	Total column amount computed from the retrieved profile. For the Atmospheric Temperature Product this will be a fill value. (dim nTimes)	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
TotalColumnDensityError	Error in total column amount computed from total error covariance For the Atmospheric Temperature Product this will be a fill value. (dim nTimes)	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
TotalColumnDensityInitial	Total column amount computed from the initial profile. For the Atmospheric Temperature Product this will be a fill value. (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	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)		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 betwee model and data (dim nTimes)		-10000.0 – 10000.0	32	NATIVE_FLOAT
NumberIterPerformed	Actual number of iterations performe (dim nTimes)	Integer	Small numb typically < 8 and could be	8	NATIVE_INT8
MaxNumIterations	Maximum number of iterations allow 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
CloudVariability_QA	Quality value calculated from cloud variability (dim nTimes) **THIS DATAFIELD WILL BE FIL FOR R9 PRODUCTS.**	N/A	0- 100	32	NATIVE_FLOAT
KDotDL_QA	Quality value calculating the signal left in the residual. This is the maximum of the dot product of the Jacobian (K) and the Radiance (L) divided by sqrt(K dot K) * sqrt(L dot L) (dim nTimes)	N/A	-100 - 100	32	NATIVE_FLOAT

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
LDotDL_QA	Quality value calculating the signal left in the residual. This is the dot product of the radiance (L) with the residual (dL) divided by sqrt(L dot L) * sqrt(dL dot dL) (dim nTimes)	N/A	-100 - 100	32	NATIVE_FLOAT
Calibration_QA	Quality value of calculated from the calibration factors. This will be fill fo the species HDO and H2O. (dim nTimes)	N/A	-2 - 2	32	NATIVE_FLOAT
AverageCloudEffOpticalDepth	Quality value: the cloud mean optica depth from 975 – 1200 cm-1 (dim nTimes) **THIS DATAFIELD WILL BE FIL FOR R9 PRODUCTS.**	N/A	0 - 10000	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. If for a given Global Survey or Special Observation run, no data are acquired for a particular viewing mode (Nadir or Limb) or all data for that mode are missing, the corresponding object (AncillaryNadirSwath or AncillayLimbSwath) is not written.

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	Type	HDF-EOS 5 Type
MissingValue	Contains the value for missing data. 32 float : -999.0 64 double: -999.0 32 int : -999 16 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 instrume names (in alphabetical order)		char	NATIVE_CHAR

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Each Ancillary ESDT will consist of two Ancillary Data swaths, Nadir and Limb. 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	121 frequencies (listed in TES-L2-Common metadata)
nLevels	Number of reported pressure levels
nPixels	64 total number of pixels

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)	Decimal degrees	± 90.0	32	NATIVE_FLOAT
SpacecraftLongitude	Longitude referenced to WGS84 ellipsoid (dim nTimes)	Decimal 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)	Decimal degrees		32	NATIVE_FLOAT
PixelsUsedFlag	True=1, False=0 (dim nTimes x nPixels)		64 chars, one for each pixel	520 total	NATIVE_CHAR
OzoneTroposphericColumn	Column amount from the surface to TropopausePressue computed from the retrieved profile. (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
OzoneTroposphericColumnError	Error in the column amount from the surface to TropopausePressue computed from the total error covariance. (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
OzoneTroposphericColumnInitial	Initial column amount from the surface to TropopausePressue computed from the initial profile. (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	Molec/cm^2	0 – 10^28	32	NATIVE_FLOAT
TropopausePressure	Pressure between the troposphere and stratosphere used to calculate the tropospheric column	hPa	10 - 1300	32	NATIVE_FLOAT
SurfaceEmissivity	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
SurfaceEmissErrors	Errors in retrieved surface emissivity for land nadir targets. Fill values for scenes where emissivity not retrieved. (dim nFreq x nTimes)			32	NATIVE_FLOAT

Ancillary Data Fields / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
SurfaceEmissConstraint	A priori 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
SurfaceEmissInitial	Initial surface emissivity land nadir targets. (dim nFreq x nTimes)		0.0 - 2.0	32	NATIVE_FLOAT
T_H2OCovariance	Error covariance terms for joint temperature and water retrieval (dim nLevels x nLevels x nTimes)	K*ln(VMR)	-10.0 – 10.0	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
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)	Decimal degrees	± 90.0	32	NATIVE_FLOAT
SpacecraftLongitude	Longitude referenced to WGS84 ellipsoid (dim nTimes)	Decimal 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)	Decimal degrees		32	NATIVE_FLOAT
PixelsUsedFlag	True=1, False=0 (dim nTimes x nPixels)		64 chars, one for each pixel	520 total	NATIVE_CHAR
TropopausePressure	Pressure between the troposphere and stratosphere used to calculate the troposphe column	hPa	10 - 1300	32	NATIVE_FLOAT
RetrievedPointingAngle	Retrieved value of the boresight nadir angles using TES limb spectral radiances. (Limb only) (dim nTimes)	Decimal degrees		32	NATIVE_FLOAT
RetrievedPointingAngleError	Error of retrieved value of the boresight nad angles using TES limb spectral radiances. (Limb only) (dim nTimes)	Decimal degrees		32	NATIVE_FLOAT

Ancillary Data Fields / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
T_H2OCovariance	Error covariance terms for joint temperature and water retrieval (dim nLevels x nLevels x nTimes)	K*ln(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
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 16 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 instrumer 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
nLength	27 character length of UTCTime

Table 4-15: Nadir Geolocation Fields

Geolocation Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
Sequence	Sequence number within a run (dim nTimes)	n/a		16	NATIVE_INT16
Scan	Scan number within a sequence, or if averaging was performed, first scan of an averaged set. (dim nTimes)	n/a		16	NATIVE_INT16
Time	Time (TAI93) of ZPD (Zero Path Difference) (dim nTimes)	sec		64	NATIVE_DOUBLE
UTCTime	UTC time of ZPD (Zero Path Difference) 27 character string. (dim nTimes x nLength)	sec		216 total	NATIVE_CHAR
DayNightFlag	Flag for day or night (dim nTimes)	N/A	0 = night 1 = day	8	NATIVE_INT8
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

SurfaceTypeFootprint	From DEM, 1=Fresh Water, 2=Salt Water, 3=Land, 4=Mixed (not 100% of FW, SW, or Land). If averaging was performed, refers to first scan of an averaged set. (dim nTimes)	Enumer-ated	1..4	8	NATIVE_INT8
DominantSurfaceType	From the USGS Global Land Cover Characteristics Data Base described at: http://edcsns17.cr.usgs.gov/glcc/globdoc2_0.html If averaging was performed, refers to first scan of an averaged set. 1 = Urban and Built-Up Land 2 = Dryland Cropland and Pasture 3 = Irrigated Cropland and Pasture 4 = Mixed Dryland/Irrigated Cropland and Pasture 5 = Cropland/Grassland Mosaic 6 = Cropland/Woodland Mosaic 7 = Grassland 8 = Shrubland 9 = Mixed Shrubland/Grassland 10 = Savanna 11 = Deciduous Broadleaf Forest 12 = Deciduous Needleleaf Forest 13 = Evergreen Broadleaf Forest 14 = Evergreen Needleleaf Forest 15 = Mixed Forest 16 = Water Bodies 17 = Herbaceous Wetland 18 = Wooded Wetland 19 = Barren or Sparsely Vegetated 20 = Herbaceous Tundra 21 = Wooded Tundra 22 = Mixed Tundra 23 = Bare Ground Tundra 24 = Snow or Ice 99 = Interrupted Areas (Goodes Homolosine Projection) 100 = Alluvial Sand (dim nTimes) **THIS DATAFIELD WILL BE FILL FOR R9 PRODUCTS.**	Enumera ted	1-24, 99, 100	8	NATIVE_INT8
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)	Decimal 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)	Decimal degrees	±90	32	NATIVE_FLOAT

Tgt_SpacecraftAzimuth	TES boresight (LOS) azimuth angle relative to the local north at the target geolocation. (dim nTimes)	Decimal degrees (east of north)	±90	32	NATIVE_FLOAT
Latitude_Footprint_1	Geo-location in geodetic co-ordinates 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 co-ordinates 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
Sequence	Sequence number within a run (dim nTimes)	n/a		16	NATIVE_INT16
Scan	Scan number within a sequence, or if averaging was performed, first scan of an averaged set. (dim nTimes)	n/a		16	NATIVE_INT16
Time	Time (TAI93) of ZPD (Zero Path Difference) (dim nTimes)	sec		64	NATIVE_DOUBLE
UTCTime	UTC time of ZPD (Zero Path Difference) 27 character string. (dim nTimes x nLength)	sec		216 total	NATIVE_CHAR
DayNightFlag	Flag for day or night (dim nTimes)	N/A	0 = night 1 = day	8	NATIVE_INT8
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

SurfaceTypeFootprint	From DEM, 1=Fresh Water, 2=Salt Water, 3=Land, 4=Mixed (not 100% of FW, SW, or Land). If averaging was performed, refers to first scan of an averaged set. (dim nTimes)	Enumer-ated	1..4	8	NATIVE_INT8
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)	Decimal 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)	Decimal degrees	±90	32	NATIVE_FLOAT
Tgt_SpacecraftAzimuth	TES boresight (LOS) azimuth angle relative to the local north at the target geolocation. (dim nTimes)	Decimal degrees (east of north)	±90	32	NATIVE_FLOAT
Latitude_Footprint_1	Geo-location in geodetic co-ordinates 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 co-ordinates 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-*observation specific* — 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 Valids	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	YYYY-MM-DDT HH:MM:SS.SSSZ	DT	TK
SizeMBECSDataGranule	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_F01_01.he5	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 Valids	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:SSSSSSZ	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:SSSSSSZ	T	PGE
PGEVersion	The Release of the PGE software: e.g. "R6.1.2"		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
InstrumentName	TES			NATIVE_CHAR
ProcessLevel	L1B,L2,L3,etc.			NATIVE_CHAR
TAI93At0zOfGranule				NATIVE_DOUBLE
GlobalSurveyNumber/ID	Run ID			NATIVE_INT
GranuleMonth	Month granule was produced (from ECS MD RangeBeginningDate)	1-12	8	NATIVE_INT
GranuleDay	Day granule was produced (from ECS MD RangeBeginningDate)	1-31	8	NATIVE_INT
GranuleYear	Year granule was produced (from ECS MD RangeBeginningDate)			NATIVE_INT
SurveyMode	Type of survey, e.g., Global or Special			NATIVE_CHAR
PGEVersion	Release of PGE Software: e.g. “R6.1.2”			NATIVE_CHAR
Command_Seq_ID	Command Sequence (Run) ID	N/A	32	NATIVE_INT32

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	Units	Size	HDF-EOS 5 Type
VerticalCoordinate	"Pressure","Altitude", "Potential Temperature"				NATIVE_CHAR
CloudFrequency	Wave number array corresponding to retrieved Cloud Effective Optical Depth points. 25 values.	600.0--2250.0	cm^{-1}	32	NATIVE_FLOAT

Data Layer Name	Data Description	Data Range	Units	Size	HDF-EOS 5 Type
EmissivityWavenumber	Wavenumber array corresponding to retrieval emissivity points. 121 values.	600.0 – 3500.0	cm^{-1}	32	NATIVE_FLOAT

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	Data Definition	Data Range	Units	Size	HDF-EOS 5 Type
Scan_Resolution	Designates Low or High Resolution for this view	'High', 'Low			NATIVE_CHAR
Pressure	Dimensioned over superset of UARS Levels only. 66 values.		hPa	32	NATIVE_FLOAT

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_swwrattr (HE5_SWwriteattr for C users).

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

Data Layer Name	Definition	Data Range	Units	Size	HDF-EOS 5 Type
Scan_Resolution	Designates Low or High Resolution for this view	'High', 'Low			NATIVE_CHAR
Pressure	Dimensioned over superset of UAR Levels only. 87 values.		hPa	32	NATIVE_FLOAT

5. LEVEL 2 SUMMARY PRODUCT

5.1 Overview

The Level 2 Summary Product is essentially a subset of all of the L2 Standard or Special Observation Products generated for a run combined into one product. Subsets of data for each species and of ancillary data are combined into one file. Besides having fewer data fields per species, in addition, the number of pressure levels the data are reported on is less: only the standard 15 UARS pressure levels plus the surface or cloud top.

For nadir observations, TES L2 standard products are produced for the following molecular species: H_2O, O_3, CH_4, CO, HDO, AtmT (atmosphieric temperature). For limb observations, L2 standard products include more molecular species: H_2O, O_3, CH_4, CO, HDO, NO_2, HNO_3, and AtmT. When combined into one Summary Product, each view and species combination then becomes a Swath object within the file (though not all view/species combinations may be present.)

Table 5-1: View and Species Types

Species	H2O	O3	CH4	CO	HDO	NO2	HNO3	AtmT
Nadir Swath Objects	X	X	X	X	X			X
Limb Swath Objects	X	X	X	X	X	X	X	X

In addition, a subset of datafields from the TES L2 Ancillary Data product is placed into Swath objects in the file.

To facilitate sharing data products between all Aura platform science teams, the organization of the L2 Summary Product also 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. The L2 Summary Product though only contains a subset of all of the data and geolocation fields identified as TES parameters.

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 data product produced by Level 2. The L2 Summary product file is also 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 Summary product is constructed using the following template:

TES-Aura_L2-SUMMARY_r<run id>_<version id>.he5

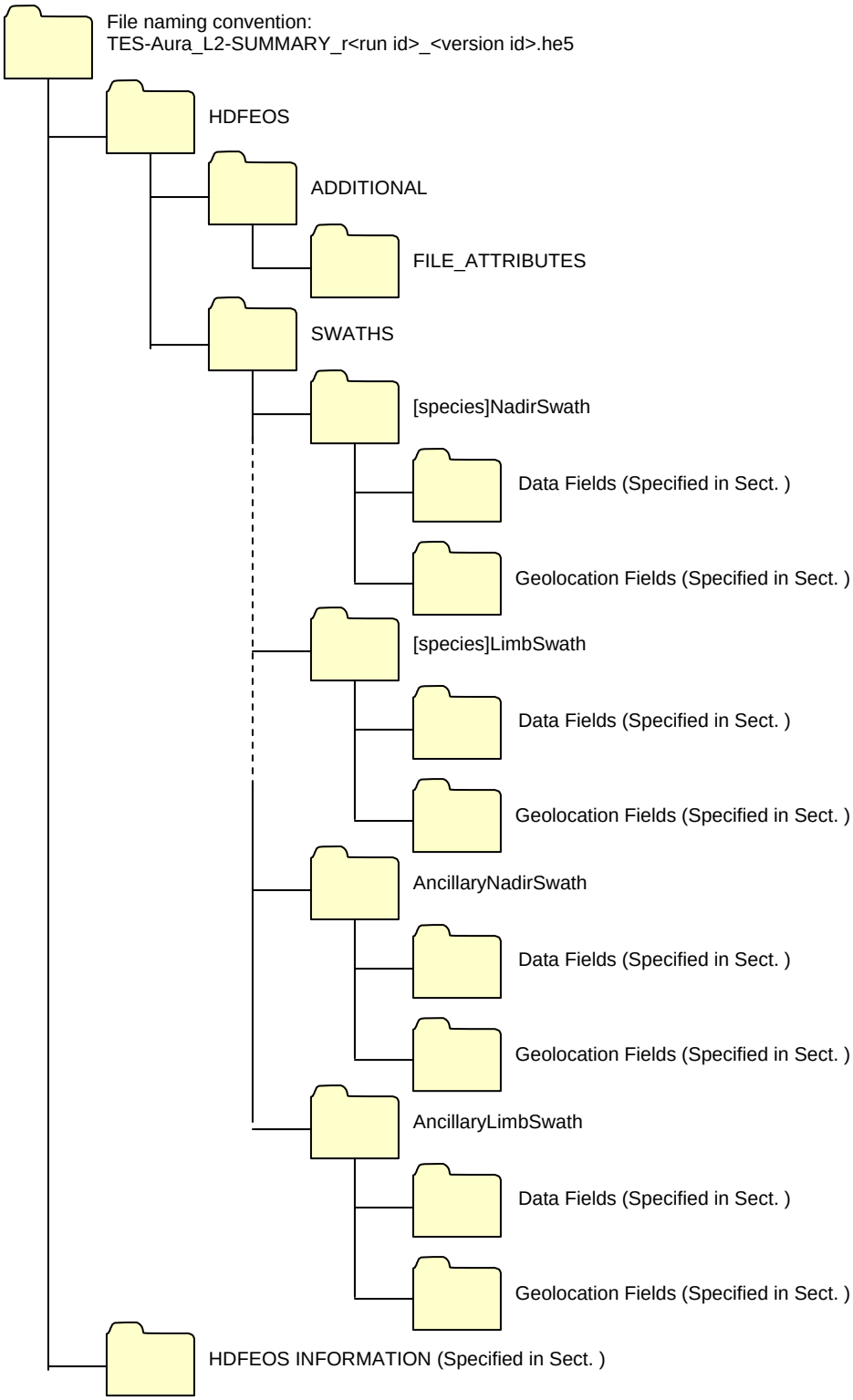
The table below lists each of the TES L2 Summary product ESDT.

Table 5-2: TES L1B Standard Products

ESDT Short Name	ECS File Type	Collection Summary	File Name
TL2SUM	HDF-EOS 5	TES Aura L2 Summary Product	TES-Aura_L2-SUMMARY_rnnnnnnnnn_Fff_cc.he5

5.2 Summary Product File Structure

The file structure of the Summary Product is depicted in the figure below. In addition to the swath objects, each 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 the L2 Summary product.



There can be multiple [species]NadirSwath and [species]LimbSwath in the file, where [species] can be H2O, O3, CH4, CO, HDO, NO2, HNO3, or AtmT.

5.3 Nadir Objects 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_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 16 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 instrumer names (in alphabetical order)		NATIVE_CHAR

5.3.1 Nadir Primary Data Fields

The table below shows the swath data dimensions. The pressure levels as shown in this table are the 15 pressure levels plus one surface level as described in the Overview.

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.

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 5-2: Primary Data Dimensions Definitions

Dimension Name	Valid Value (Description)
nLevels	16 pressure levels
nTimes	Number of reported observations

Table 5-3: 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
Pressure	List of the 16 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, HDO, or Temperature

5.3.2 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 5-4: Associated Data Field Dimensions Definitions

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

Table 5-5: 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 1 = no averaging	8	NATIVE_INT8
SpeciesRetrievalQuality	Species Retrieval Quality flag. True means retrieval passed quality check and reported errors are accurate. (dim nTimes)	n/a	0 = poor quality 1 = passed quality chec	8	NATIVE_INT8
CloudTopPressure	Pressure of inferred cloud top (specie independent) (dim nTimes)	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudTopPressureError	Error on Cloud Top Pressure (dim nTimes)	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepthAveraged	Vertical optical depth for the retrieved non-scattering cloud calculated using a weighted average of frequencies between 975 & 1200 (dim nTimes)	n/a	0.0--500.0	32	NATIVE_FLOAT

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
CloudEffectiveOpticalDepthErrorAveraged	Error for Cloud Effective Optical Depth calculated using a weighted average of frequencies between 975 & 1200 (dim nTimes)	n/a	0.0--500.0	32	NATIVE_FLOAT
SurfaceTemperature	Retrieved surface temperature (specie independent) (dim nTimes)	K	150.0 - 350	32	NATIVE_FLOAT
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
DeviationVsRetrievalCovarianc	Deviation vs. Retrieval Covariance (dim nTimes)		0.0 – 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 betwee model and data (dim nTimes)		-10000.0 – 10000.0	32	NATIVE_FLOAT
NumberIterPerformed	Actual number of iterations performe (dim nTimes)	Integer	Small number, typically < 8 and could be 0	8	NATIVE_INT8
MaxNumIterations	Maximum number of iterations allow 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

5.4 Limb Objects 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 16 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 instrumer names (in alphabetical order)		NATIVE_CHAR

5.4.1 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 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 5-6: Primary Data Fields Dimensions Definitions

Dimension Name	Valid Value (Description)
nLevels	16 pressure levels
nTimes	Number of reported observations

Table 5-7: 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

Data Field Name / Title *	Data Descriptions	Units	Data Range	Size	HDF-EOS 5 Type
TotalError	Square-roots of diagonal elements o the output total error covariance (includes smoothing error, systemat error, and measurement error) (dim nLevels x nTimes)	VMR or K		32	NATIVE_FLOAT
Pressure	List of the 16 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, HDO, NO2, HNO3, or Temperature

5.4.2 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 5-8: Associated Data Field Dimensions Definitions

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

Table 5-9: Limb Associated Data Fields

Data Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
SpeciesRetrievalQuality	Species Retrieval Quality flag. True means retrieval passed quality check a reported errors are accurate. (dim nTimes)	n/a	0 = poor quality 1 = passed quality chec	8	NATIVE_INT8
CloudTopPressure	Pressure of inferred cloud top (species independent) (dim nTimes)	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudTopPressureError	Error on Cloud Top Pressure (dim nTimes)	hPa	0.001 -- 1300.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepth	Vertical optical depth for the retrieved non-scattering cloud calculated using a weighted average of frequencies between 975 & 1200 (dim nTimes)	n/a	0.0--500.0	32	NATIVE_FLOAT
CloudEffectiveOpticalDepthError	Error for Cloud Effective Optical Depth calculated using a weighted average of frequencies between 975 & 1200 (dim nTimes)	n/a	0.0--500.0	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

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)		0.0 – 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 numb 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

5.5 Ancillary Objects Data Fields

The Ancillary Objects contains the Associated Data Fields common to all species.

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 16 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 instrumer names (in alphabetical order)		NATIVE_CHAR

Table 5-10: Ancillary Data Dimensions Definitions

Dimension Name	Valid Value (Description)
nTimes	Number of reported observations
nFreq	119 frequencies (listed in TES-L2-Common metadata)
nLevels	16 pressure levels

Table 5-11: 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
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
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 5-12: 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

Ancillary Data Fields / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
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 nad angles using TES limb spectral radiances. (Limb only) (dim nTimes)	degrees		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

5.6 Geolocation Fields

The Geolocation Data is used to provide generic geolocation and spacecraft pointing information. This information is included with each species and ancillary Swath.

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 16 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 instrume names (in alphabetical order)		NATIVE_CHAR

The values used for these attributes are also in the data fields tables below.

Table 5-13: Geolocation Dimensions

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

Table 5-14: Nadir Geolocation Fields

Geolocation Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
Sequence	Sequence number within a run (dim nTimes)	n/a		16	NATIVE_INT16
Scan	Scan number within a sequence, or if averaging was performed, first scan of an averaged set. (dim nTimes)	n/a		16	NATIVE_INT16
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
SurfaceTypeFootprint	From DEM, 1=Fresh Water, 2=Salt Water, 3=Land, 4=Mixed (not 100% of FW, SW, or Land)	Enumer-ated	1..4	8	NATIVE_INT8
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 (ea of north)	±90	32	NATIVE_FLOAT

Table 5-15: Limb Geolocation Fields

Geolocation Fields Name / Title	Data Description	Units	Data Range	Size	HDF-EOS 5 Type
Sequence	Sequence number within a run (dim nTimes)	n/a		16	NATIVE_INT16
Scan	Scan number within a sequence, or if averaging was performed, first scan of an averaged set. (dim nTimes)	n/a		16	NATIVE_INT16
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
SurfaceTypeFootprint	From DEM, 1=Fresh Water, 2=Salt Water, 3=Land, 4=Mixed (not 100% of FW, SW, or Land)	Enumer-ated	1..4	8	NATIVE_INT8
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 (ea of north)	±90	32	NATIVE_FLOAT

5.7 L2 ECS and TES-specific Metadata

5.7.1 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 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

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.

5.7.2 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 5-16: ECS Inventory Metadata

Data Layer Name	Data Description	TES Valids	Type[3]	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
SizeMBECSDataGranule	The size attribute will indicate the volume of data contained in the granule.		F10	DSS

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

Data Layer Name	Data Description	TES Valids	Type[3]	Source
LocalGranuleID	Unique identifier for locally produced granule that ECS ingests and is required to capture.	e.g., TES-Aura_L2-SUMMARY_r0000000001_F01_01.he5	VA80	PGE
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: /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.SSSZ	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.SSSZ	T	PGE
PGEVersion	The Release of the PGE software: e.g. "R6.1.2"		A10	PGE

5.7.3 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 5-17: 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

5.7.4 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 5-18: TES-Common-Metadata

Data Layer Name	Data Description	Valids	Size	Type	HDF-EOS 5 Type
InstrumentName	TES			char	NATIVE_CHAR
ProcessLevel	L1B,L2,L3,etc.			char	NATIVE_CHAR
TAI93At0zOfGranule				double	NATIVE_DOUBLE
GlobalSurveyNumber/ID	Run ID			int	NATIVE_INT
GranuleMonth	Month granule was produced (from ECS MD RangeBeginningDate)	1-12	8	int	NATIVE_INT
GranuleDay	Day granule was produced (from ECS MD RangeBeginningDate)	1-31	8	int	NATIVE_INT
GranuleYear	Year granule was produced (from ECS MD RangeBeginningDate)			int	NATIVE_INT
SurveyMode	Type of survey, e.g., Global or Special			char	NATIVE_CHAR
PGEVersion	Release of PGE Software: e.g. “R6.1.2”			char	NATIVE_CHAR
Command_Seq_ID	Command Sequence (Run) ID	N/A	32	int	NATIVE_INT32

5.7.5 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 5-19: TES-L2-Common-Metadata

Data Layer Name	Data Description	Data Range	Size	Type	HDF-EOS 5 Type
Pressure	Dimensioned over superset of nUARSLevels only. 87 values.			32	NATIVE_FLOAT
VerticalCoordinate	"Pressure","Altitude", "Potential Temperature"				NATIVE_CHAR
CloudFrequency	Wave number array corresponding to retrieved Cloud Effective Optical Depth points. 25 values.	600.0--2250.0	cm^{-1}	32	NATIVE_FLOAT
EmissivityWavenumber	Wavenumber array corresponding to retrieval emissivity points. 119 values.	600.0 – 3500.0	cm^{-1}	32	NATIVE_FLOAT

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