JPL D-94635

ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) Mission

Level 2 Product Specification Document

Version 2
June 13, 2019

Glynn Hulley
ECOSTRESS Algorithm Development Team
Jet Propulsion Laboratory
California Institute of Technology

JPL D-94635

Paper copies of this document may not be current and should not be relied on for official purposes. The current version is in the ECOSTRESS DocuShare Library (*) at https://bravo-lib.jpl.nasa.gov/docushare/dsweb/View/Library-509
(*) Access limited to user group

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109-8099
California Institute of Technology

ECOSTRESS Level 2 Product Specification Document

Prepared by:

_____ _____
Glynn Hulley Date
ECOSTRESS Algorithm Development Team

Approved by:

_____ _____
Dana Freeborn Date
ECOSTRESS Mission System Manager

_____ _____
Eugene Chu Date
ECOSTRESS SDS System Engineer

Concurred by:

_____ _____
Simon Hook Date
ECOSTRESS Principal Investigator

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109-8099
California Institute of Technology

*** Original signature page on file in project physical repository ***

Document Change Log

Revision	Date	Sections Changed	Author
Preliminary	02/23/2016	All	Glynn Hulley
	06/06/2016	T2-1, T2-2, T3-1	Eugene Chu
	07/19/2016	3.2.1, 3.2.2, 3.3.2	Glynn Hulley
	01/20/2018	Tables 3-4, 3-5, 3-6	Glynn Hulley
Version 1	03/05/2018	Updates to Tables 3-4, 3-5, 3-6	Glynn Hulley
Version 1	03/27/2018	Updates to PROD_TYPE and observation time definitions.	Glynn Hulley, Eugene Chu
Version 1	10/23/2018	Removed cloud bit field 4 (Table 3-6)	Glynn Hulley
	2019-02-28	Minor file name updates	Eugene Chu
	2019-05-15	Changes to adapt for the MSU failure anomaly	
	2019-06-13	Minor edits to reflect metadata changes	Robert Freepartner

Document TBD, TBR, TBS

Section/Page	Description	Date

Contacts

Readers seeking additional information about this document may contact the following ECOSTRESS Algorithm Development team members:

Glynn C. Hulley (Co-Investigator)
MS 183-501
Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena, CA 91109
Email: *glynn.hulley@jpl.nasa.gov*
Office: (818) 354-2979

Robert Freepartner
MS 233-200
Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena, CA 91109

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Identification

This is the Product Specification Document (PSD) for Level 2 (L2) data products of the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) project. The ECOSTRESS L2 products provide Land Surface Temperature and Emissivity (LST&E) and a Cloud Mask generated from data acquired by the ECOSTRESS radiometer instrument according to the algorithm described in the ECOSTRESS L2 LST&E Algorithm Theoretical Basis Document (ATBD) (JPL D-94643) and L2 Cloud ATBD (JPL-D-94644).

1.2 Purpose and Scope

This Product Specification Document (PSD) describes the standard Level 2 LSTE and Cloud Mask products generated in the ECOSTRESS SDS at JPL. These include the detailed descriptions of the format and contents of the product and ancillary files that will be delivered to the Land Process Distributed Active Archive Center (LP-DAAC).

1.3 Mission Overview

The ECOSTRESS instrument measures the temperature of plants and uses that information to better understand how much water plants need and how they respond to stress.

ECOSTRESS addresses three overarching science questions:

- How is the terrestrial biosphere responding to changes in water availability?
- How do changes in diurnal vegetation water stress impact the global carbon cycle?
- Can agricultural vulnerability be reduced through advanced monitoring of agricultural water consumptive use and improved drought estimation?

The ECOSTRESS mission answers these questions by accurately measuring the temperature of plants. Plants regulate their temperature by releasing water through tiny pores on their leaves called stomata. If they have sufficient water, they can maintain their temperature. However, if there is insufficient water, their temperatures rise. This temperature rise can be measured with a sensor in space. ECOSTRESS uses a multispectral thermal infrared (TIR) radiometer to measure the surface temperature, deployed on the International Space Station. The instrument will measure radiances at 5 spectral bands in the 8-12.5 μm range with approximately 38 meter by 57 meter of spatial resolution on the ground.

On September 29th 2018, ECOSTRESS experienced an anomaly with its primary mass storage unit (MSU). ECOSTRESS has a primary and secondary MSU (A and B). On December 5th, the instrument was switched to the secondary MSU and operations resumed with initial acquisitions over Australia and wider coverage resumed on January 9th 2019. The initial anomaly was attributed to exposure to high radiation regions, primarily over the Southern Atlantic Anomaly, and the acquisition strategy was revised to exclude these regions from future acquisitions. On March 14th 2019, the secondary MSU experienced an anomaly, and acquisitions are temporarily on hold. Work is underway to implement a direct streaming option, which will bypass the need for mass storage units. The streaming acquisition mode will change the format of the data being

collected. Specifically, the new collection mode will eliminate the 1.6 μm (SWIR), 8.2 μm (TIR), and 9.0 μm (TIR) bands. To simplify product formats, the L1 and L2 products will continue to contain the datasets for these bands, but the datasets will contain fill values. This will be seen in products generated after May 15th 2019, when the instrument resumes operations. These changes will be described in the detailed product specifications.

1.4 Applicable and Reference Documents

"Applicable" documents levy requirements on the areas addressed in this document. "Reference" documents are identified in the text of this document only to provide additional information to readers. Unless stated otherwise, the document revision level is Initial Release. Document dates are not listed, as they are redundant with the revision level.

1.4.1 Applicable Documents

1. ECOSTRESS Project Level 3 Science Data System Requirements (JPL D-94088).
2. ECOSTRESS Science Data Management Plan (JPL D-94607)
3. 423-ICD-005 ICD Between ECOSTRESS SDS and LPDAAC
4. ECOSTRESS Level 1 Algorithm Theoretical Basis Document (JPL D-94641, D-94642)
5. ECOSTRESS Level 1 Algorithm Specification Document
6. ECOSTRESS Level 2 Algorithm Theoretical Basis Documents (JPL D-94643, D-94644)
7. ECOSTRESS Level 2 Algorithm Specification Document
8. ECOSTRESS Level 3 (ET_PT-JPL) Algorithm Theoretical Basis Document (JPL D-94645)
9. ECOSTRESS Level 3 (ET_PT-JPL) Algorithm Specification Document

1.4.2 Reference Documents

1.5 ECOSTRESS Data Products

The ECOSTRESS mission will generate 13 different distributable data products. The products represent four levels of data processing, with data granules defined as an image scene. Each image scene consists of 44 scans of the instrument mirror, each scan taking approximately 1.181 seconds, and each image scene taking approximately 52 seconds. Each image scene starts at the beginning of the first target area encountered during each orbit. Each orbit is defined as the equatorial crossing of an ascending International Space Station (ISS) orbit.

ECOSTRESS Level 0 data include spacecraft packets that have been pre-processed by the Ground Data System (GDS). Level 1 products include spacecraft engineering data, the time-tagged raw sensor pixels appended with their radiometric calibration coefficients, the blackbody pixels used to generate the calibration coefficients, geolocated and radiometrically calibrated at-sensor radiances of each image pixel, the geolocation tags of each pixel, and the corrected spacecraft attitude data. Level 2 products include the land surface temperature and emissivity for each spectral band retrieved from the at-sensor radiance data, and a cloud mask. Level 2 products also appear in image scene granules. Level 3 products include evapotranspiration data derived from Level 2 products. Level 4 products include evaporative stress index and water use efficiency derived from Level 3 data.

The ECOSTRESS products are listed in Table 1-1. This document will discuss only the Level 2 products.

Table 1-1: ECOSTRESS Distributable Standard Products

Product type	Description
L0A_FLEX	Level 0 “raw” spacecraft packets
L0A_HK	Level 0 housekeeping packets
L1A_ENG	Spacecraft and instrument engineering data, including blackbody gradient coefficients
L1A_BB	Instrument Black Body calibration pixels
L1A_PIX	Raw pixel data with appended calibration coefficients
L1B_GEO	Geolocation tags, sun angles, and look angles, and calibrated, resampled at-sensor radiances
L1B_RAD	Radiometrically corrected, band-aligned, squared at-sensor radiance pixels
L1B_MAP_RAD	L1B_RAD data map projected to fixed 70 meter pixels
L1B_ATT	Corrected spacecraft ephemeris and attitude data
L2_LSTE	Land Surface temperature and emissivity
L2_CLOUD	Cloud mask
L3_ET_PT-JPL	Evapotranspiration retrieved from L2_LSTE using the PT-JPL Algorithm
L3_ET_ALEXI-USDA	Evapotranspiration generated at USDA with the ALEXI/DisALEXI Algorithm over specific calibration sites
L4_ESI_PT-JPL	Evaporative Stress Index generated with PT-JPL
L4_ESI_ALEXI-USDA	Evaporative Stress Index generated at USDA with the ALEXI/DisALEXI over specific calibration sites
L4_WUE	Water Use efficiency
L3_L4_QA	Quality Assessment fields for all ancillary data used in L3 and L4 products

2 DATA PRODUCT ORGANIZATION

2.1 Product File Format

All ECOSTRESS standard products are in the Hierarchical Data Format version 5 (HDF5). HDF5 is a general purpose file format and programming library for storing scientific data. The National Center for Supercomputing Applications (NCSA) at the University of Illinois developed HDF to help scientists share data regardless of the source. The following sections provide some key elements of HDF5 that will be employed in ECOSTRESS data products. Complete documentation of the HDF5 structure and application software can be found at http://www.hdfgroup.org/HDF5

2.2 HDF5 Notation

The key concepts of the HDF5 Abstract Data Model are Files, Groups, Datasets, Datatypes, Attributes and Property Lists. The following sections provide a brief description of each of these key HDF5 concepts.

2.2.1 HDF5 File

A File is the abstract representation of a physical data file. Files are containers for HDF5 Objects. These Objects include Groups, Datasets, and Datatypes.

2.2.2 HDF5 Group

Groups are containers for other Objects, including Datasets, named Datatypes and other Groups. In that sense, groups are analogous to directories that are used to categorize and classify files in standard operating systems.

The notation for files is identical to the notation used for Unix directories. The root Group is "/". Like Unix directories, Objects appear in Groups through "links". Thus, the same Object can simultaneously be in multiple Groups.

2.2.3 HDF5 Dataset

The Dataset is the HDF5 component that stores user data. Each Dataset associates with a Dataspace that describes the data dimensions, as well as a Datatype that describes the basic unit of storage element. A Dataset can also have Attributes.

2.2.4 HDF5 Datatype

A Datatype describes a unit of data storage for Datasets and Attributes. Datatypes are subdivided into Atomic and Composite Types.

Atomic Datatypes are analogous to simple basic types in most programming languages. HDF5 Atomic Datatypes include Time, Bitfield, String, Reference, Opaque, Integer, and Float. Each atomic type has a specific set of properties. Examples of the properties associated with Atomic Datatypes are:

- Integers are assigned size, precision, offset, pad byte order, and are designated as signed or unsigned.
- Strings can be fixed or variable length, and may or may not be null-terminated.

- References are constructs within HDF5 Files that point to other HDF5 Objects in the same file.

HDF5 provides a large set of predefined Atomic Datatypes. Table 2-1 lists the Atomic Datatypes that are used in ECOSTRESS data products.

Table 2-1: HDF5 Atomic Datatypes

HDF5 Atomic Datatypes	Description
H5T_STD_U8LE	unsigned, 8-bit, little-endian integer
H5T_STD_U16LE	unsigned, 16-bit, little-endian integer
H5T_STD_U32LE	unsigned, 32-bit, little-endian integer
H5T_STD_U64LE	unsigned, 64-bit, little-endian integer
H5T_STD_I8LE	signed, 8-bit, little-endian integer
H5T_STD_I16LE	signed, 16-bit, little-endian integer
H5T_STD_I32LE	signed, 32-bit, little-endian integer
H5T_STD_I64LE	Signed, 64-bit, little-endian integer
H5T_IEEE_F32LE	32-bit, little-endian, IEEE floating point
H5T_IEEE_F64LE	64-bit, little-endian, IEEE floating point
H5T_STRING	character string made up of one or more bytes

Composite Datatypes incorporate sets of Atomic datatypes. Composite Datatypes include Array, Enumeration, Variable Length and Compound.

- The Array Datatype defines a multi-dimensional array that can be accessed atomically.
- Variable Length presents a 1-D array element of variable length. Variable Length Datatypes are useful as building blocks of ragged arrays.

Named Datatypes are explicitly stored as Objects within an HDF5 File. Named Datatypes provide a means to share Datatypes among Objects. Datatypes that are not explicitly stored as Named Datatypes are stored implicitly. They are stored separately for each Dataset or Attribute they describe.

None of the ECOSTRESS data products employ Enumeration or Compound data types.

2.2.5 HDF5 Dataspace

A Dataspace describes the rank and dimension of a Dataset or Attribute. For example, a “Scalar” Dataspace has a rank of 1 and a dimension of 1. Thus, all subsequent references to “Scalar” Dataspace in this document imply a single dimensional array with a single element.

Dataspaces provide considerable flexibility to HDF5 products. They incorporate the means to subset associated Datasets along any or all of their dimensions. When associated with specific properties, Dataspaces also provide the means for Datasets to expand as the application requires.

2.2.6 HDF5 Attribute

An Attribute is a small aggregate of data that describes Groups or Datasets. Like Datasets, Attributes are also associated with a particular Dataspace and Datatype. Attributes cannot be subsetted or extended. Attributes themselves cannot have Attributes.

2.3 ECOSTRESS File Organization

2.3.1 Structure

ECOSTRESS data products follow a common convention for all HDF5 Files. Use of this convention provides uniformity of data access and interpretation.

The ECOSTRESS Project uses HDF5 Groups to provide an additional level of data organization. All metadata that pertain to the complete data granule are members of the "/Metadata" Group. All other data are organized within Groups that are designed specifically to handle the structure and content of each particular data product.

2.3.2 Data

All data in HDF5 files are stored in individual Datasets. All related Datasets in an ECOSTRESS product are assigned to an HDF5 Group. A standard field name is associated with each Dataset. The field name is a unique string identifier. The field name corresponds to the name of the data element the Dataset stores. This document lists these names with the description of each data element that they identify.

Each Dataset is associated with an HDF5 Dataspace and an HDF5 Datatype. They provide a minimally sufficient set of parameters for reading the data using standard HDF5 tools.

2.3.3 Element Types

ECOSTRESS HDF5 employs the Data Attribute "Type" to classify every data field as a specific data type. The "Type" is an embellishment upon the standard HDF5 Datatypes that is designed specifically to configure ECOSTRESS data products.

Table 2-2 lists all of the "Type" strings that appear in the ECOSTRESS data products. The table maps each ECOSTRESS "Type" to a specific HDF5 Datatype in both the HDF5 file and in the data buffer. The table also specifies the common conceptual data type that corresponds to the "Type" in ECOSTRESS executable code.

Table 2-2: Element Type Definitions

Type	HDF5 Datatype (File)	HDF5 Datatype (Buffer)	Conceptual Type
Unsigned8	H5T_STD_U8LE	H5T_NATIVE_UCHAR	unsigned integer
Unsigned16	H5T_STD_U16LE	H5T_NATIVE_USHORT	unsigned integer
Unsigned32	H5T_STD_U32LE	H5T_NATIVE_UINT	unsigned integer
Unsigned64	H5T_STD_U64LE	H5T_NATIVE_ULLONG	unsigned integer
Signed8	H5T_STD_I8LE	H5T_NATIVE_SCHAR	signed integer
Signed16	H5T_STD_I16LE	H5T_NATIVE_SHORT	signed integer
Signed32	H5T_STD_I32LE	H5T_NATIVE_INT	signed integer
Signed64	H5T_STD_I64LE	H5T_NATIVE_LLONG	signed integer
Float32	H5T_IEEE_F32LE	H5T_NATIVE_FLOAT	floating point
Float64	H5T_IEEE_F64LE	H5T_NATIVE_DOUBLE	floating point

Type	HDF5 Datatype (File)	HDF5 Datatype (Buffer)	Conceptual Type
VarLenStr	H5T_STRING	H5T_NATIVE_CHAR	character string

2.3.4 File Level Metadata

All metadata that describe the full content of each granule of the ECOSTRESS data product are stored within the explicitly named "/Metadata" Group. Metadata are handled using exactly the same procedures as those that are used to handle data. The contents of each Attribute that stores metadata conform to one of the ECOSTRESS Types. Most metadata elements are stored as scalars. A few metadata elements are stored as arrays. The metadata appear in a set of HDF5 Groups under the "/Metadata" Group. These HDF5 Groups contain a set of HDF5 Attributes.

2.3.5 Local Metadata

ECOSTRESS standards incorporate additional metadata that describe each HDF5 Dataset within the HDF5 file. Each of these metadata elements appear in an HDF5 Attribute that is directly associated with the HDF5 Dataset. Wherever possible, these HDF5 Attributes employ names that conform to the Climate and Forecast (CF) conventions. Table 2-3 lists the CF names for the HDF5 Attributes that ECOSTRESS products typically employ.

Table 2-3: ECOSTRESS Specific Local Attributes

CF Compliant Attribute Name	Description	Required?
Units	Units of measure. Appendix A lists applicable units for various data elements in this product.	Yes
valid_max	The largest valid value for any element in the Dataset. The data type in valid_max matches the type of the associated Dataset. Thus, if the associated Dataset stores float32 values, the corresponding valid_max will also be float32.	No
valid_min	The smallest valid value for any element in the Dataset. The data type in valid_min matches the type of the associated Dataset. Thus, if the associated Dataset stores float32 values, the corresponding valid_min will also be float32.	No
_FillValue	Specification of the value that will appear in the Dataset when an element is missing or undefined. The data type of _FillValue matches the type of the associated Dataset. Thus, if the associated Dataset stores float32 values, the corresponding _FillValue will also be float32. Datasets that do not have a fill value will omit this attribute.	No
long_name	A descriptive name that clearly describes the content of the associated Dataset.	Yes

2.4 Data Definition Standards

The following sections of this document specify the characteristics and definitions of every data element stored in the ECOSTRESS data products. Table 2-4 defines each of the specific characteristics that are listed in those sections. Some of these characteristics correspond with the ECOSTRESS HDF5 Attributes that are associated with each Dataset. Data element characteristics that correspond to ECOSTRESS HDF5 Attributes bear the same name. The remaining characteristics are descriptive data that help users better understand the data product content.

In some situations, a standard characteristic may not apply to a data element. In those cases, the field contains the character string 'n/a'. Hexadecimal representation sometimes indicates data content more clearly. Numbers represented in hexadecimal begin with the character string '0x'.

Table 2-4: Data Element Characteristic Definitions

Characteristic	Definition
Type	The data representation of the element within the storage medium. The storage class specification must conform to a valid ECOSTRESS type.
Units	Units of measure. Typical values include "deg", "degC", "Kelvin", "meters/second", "meters", "m**2", "seconds" and "counts". Appendix A includes references to important data measurement unit symbols.

2.4.1 Double Precision Time Variables

ECOSTRESS double precision time variables contain measurements relative to the J2000 epoch. Thus, these variables represent a real number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

2.4.2 Array Representation

This document employs array notation to demonstrate and clarify the correspondence among data elements in different product data elements. The array notation adopted in this document is similar to the standards of the Fortran programming language. Indices are one based. Thus, the first index in each dimension is one. This convention is unlike C or C++, where the initial index in each dimension is zero. In multidimensional arrays, the leftmost subscript index changes most rapidly. Thus, in this document, array elements ARRAY(15,1,5) and ARRAY(16,1,5) are stored contiguously.

HDF5 is designed to read data seamlessly regardless of the computer language used to write an application. Thus, elements that are contiguous using the dimension notation in this document will appear in contiguous locations in arrays for reading applications in any language with an HDF5 interface.

This document differentiates among array indices based on relative contiguity of storage of elements referenced with consecutive numbers in that index position. A faster or fastest moving index implies that the elements with consecutive numbers in that index position are stored in relative proximity in memory. A slower or slowest moving index implies that the elements referenced with consecutive indices are stored more remotely in memory. For instance, given array element ARRAY(15,1,5) in Fortran, the first index is the fastest moving index and the third

index is the slowest moving index. On the other hand, given array element array[4][0][14] in C, the first index is the slowest moving index and the third index is the fastest moving index.

3 ECOSTRESS PRODUCT FILES

The ECOSTRESS product file will contain at least 3 groups of data: A standard metadata group that specifies the same type of contents for all products, a product specific metadata group that specifies those metadata elements that are useful for defining attributes of the product data, and the group(s) containing the product data. (Note: A product metadata is not to be confused with a HDF5 object metadata.)

All product file names will have the form:

```
ECOSTRESS_<PROD_TYPE>_<OOOOO>_<SSS>_<YYYYMMDD>T<hhmmss>_<BBBB>_<VV>.<TYPE>
```

Where:

PROD_TYPE: Product type =
- L0A_FLEX, Raw instrument data packets (non-distributed)
- L0A_HK, Raw instrument engineering and housekeeping packets (non-distributed)
- L1A_PIX, Time-tagged, image frames formed from L0A_FLEX packets
- L1A_BB, Calibration black body pixels recorded from instrument with each image frame
- L1A_ENG, Orbital engineering data
- L1B_RAD, Calibrated at-sensor radiance image frames
- L1B_MAP_RAD, L1B_RAD product mapped projected to fixed 70 meter pixels
- L1B_GEO, Geolocation parameters of image frames
- L1B_ATT, Refined spacecraft orbital attitude and ephemeris parameters
- L2_LSTE, Land surface Temperature and Emissivity data
- L2_CLOUD, Level 2 Cloud mask data
- L3_ET_PT-JPL, Evapotranspiration generated by JPL with PT-JPL
- L3_ET_ALEXI, Evapotranspiration generated by JPL with ALEXI/DisALEXI
- L3_ET_ALEXI-USDA, Evapotranspiration generated by USDA with ALEXI/DisALEXI
- L4_ESI_PT-JPL, Evaporative Stress Index generated by JPL with PT-JPL
- L4_ESI_ALEXI, Evaporative Stress Index generated by JPL with ALEXI/DisALEXI
- L4_ESI_ALEXI-USDA, Evaporative Stress Index generated by USDA with ALEXI/DisALEXI
- L4_WUE, Water Use Efficiency generated by JPL
- L3_L4_QA, Quality Assessment fields for all ancillary data used in L3 and L4 products generated by JPL

OOOOO: Orbit number; starting at start of mission, ascending equatorial crossing
SSS: Scene ID; starting at first scene of first orbit
YYYYMMDD: Year, month, day of scene start time
hhmmss: Hour, minute, seconds of scene start time
BBBB: Build ID of software that generated product, Major+Minor (2+2 digits)
VV: Product version number (2 digits)
TYPE: File type extension=
- h5 for the data file
- h5.met for the metadata file.

A SITE name is added to the ALEXI-USDA file name:

```
ECOSTRESS_<PROD_TYPE>_<OOOOO>_<SSS>_<YYYYMMDD>T<hhmmss>_<BBbb>_<VV>.
<SITE>.<TYPE>
```

3.1 Standard Metadata

This is the minimal set of metadata that must be included with each product file. The standard metadata consists of the following:

Table 3-1: Standard Product Metadata

Name	Type	Size	Example
Group	**StandardMetadata**		
AncillaryInputPointer	String	variable	Group name of ancillary file list
AutomaticQualityFlag	String	variable	PASS/FAIL (of product data)
BuildId	String	variable	
CollectionLabel	String	variable	
DataFormatType	String	variable	NCSAHDF5
DayNightFlag	String	variable	
EastBoundingCoordinate	LongFloat	8	
HDFVersionId	String	variable	1.8.16
ImageLines	Int32	4	5632
ImageLineSpacing	Float32	4	68.754
ImagePixels	Int32	4	5400
ImagePixelSpacing	Float32	4	65.536
InputPointer	String	variable	
InstrumentShortName	String	variable	ECOSTRESS
LocalGranuleID	String	variable	
LongName	String	variable	ECOSTRESS
NorthBoundingCoordinate	LongFloat	8	
PGEName	String	variable	L2_LSTE (L2_CLOUD)
PGEVersion	String	variable	
PlatformLongName	String	variable	ISS
PlatformShortName	String	variable	ISS
PlatformType	String	variable	Spacecraft
ProcessingLevelID	String	variable	1
ProcessingLevelDescription	String	variable	Level 2 Land Surface Temperatures and Emissivity (Level 2 Cloud mask)
ProducerAgency	String	variable	JPL
ProducerInstitution	String	variable	Caltech
ProductionDateTime	String	variable	
ProductionLocation	String	variable	
CampaignShortName	String	variable	Primary
RangeBeginningDate	String	variable	
RangeBeginningTime	String	variable	
RangeEndingDate	String	variable	
RangeEndingTime	String	variable	
SceneID	String	variable	
ShortName	String	variable	L2_LSTE (L2_CLOUD)
SISName	String	variable	

SISVersion	String	variable	
SouthBoundingCoordinate	LongFloat	8	
StartOrbitNumber	String	variable	
StopOrbitNumber	String	variable	
WestBoundingCoordinate	LongFloat	8	

3.2 Product-Specific Metadata

Any additional metadata necessary for describing the product will be recorded in this group.

3.2.1 L2 LSTE Metadata

Table 3-2: L2 LSTE Metadata Definitions

Name	Type	Size	Example
Group	**L2 LSTE Metadata**		
QAPercentCloudCover	Int	4	80
CloudMeanTemperature	Long Float	8	231
CloudMaxTemperature	Long Float	8	275
CloudMinTemperature	Long Float	8	221
CloudSDevTemperature	Long Float	8	0.45
QAFractionGoodQuality	Int	4	0.7
LSTGoodAvg	Long Float	8	285.4
Emis1GoodAvg	Long Float	8	0.95
Emis2GoodAvg	Long Float	8	0.95
Emis3GoodAvg	Long Float	8	0.95
Emis4GoodAvg	Long Float	8	0.95
Emis5GoodAvg	Long Float	8	0.95
AncillaryGEOS5	Str	255	GEOS.fp.asm.inst3_3d_asm_Np.20140702_0000.V01
BandSpecification	Float 32	μm	Wavelength of pixel data in corresponding datasets for bands 1 through 6: 1.6, 8.2, 8.7,9.0, 10.5, 12.0; 0=fill data

3.2.2 L2 CLOUD Metadata

Table 3-3: L2 CLOUD Metadata Definitions

Name	Type	Size	Example

Group	**L2 CLOUD Metadata**		
QAPercentCloudCover	Int	4	80
CloudMeanTemperature	LongFloat	8	231
CloudMaxTemperature	LongFloat	8	275
CloudMinTemperature	LongFloat	8	221
CloudSDevTemperature	LongFloat	8	0.45

3.3 Product Data

The product data will be stored in this group.

3.3.1 L2 LSTE data

Table 3-4: Product Data Definitions for the L2 LSTE Product

SDS	Long Name	Data type	Units	Valid Range	Fill Value	Scale Factor	Offset
Group	**SDS (per pixel, 5400 * 5632)**						
LST	Land Surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC	Quality control for LST and emissivity	uint16	n/a	0-65535	n/a	n/a	n/a
Emis1	Band 1 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis2	Band 2 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis3	Band 3 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis4	Band 4 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis5	Band 5 emissivity	uint8	n/a	1-255	0	0.002	0.49
LST_Err	Land Surface Temperature error	uint8	K	1-255	0	0.04	0.0
Emis1_Err	Band 1 emissivity error	uint16	n/a	0-65535	0	0.0001	0.0
Emis2_Err	Band 2 emissivity error	uint16	n/a	0-65535	0	0.0001	0.0
Emis3_Err	Band 3 emissivity error	uint16	n/a	0-65535	0	0.0001	0.0
Emis4_Err	Band 4 emissivity error	uint16	n/a	0-65535	0	0.0001	0.0
Emis5_Err	Band 5 emissivity error	uint16	n/a	0-65535	0	0.0001	0.0
EmisWB	Wideband emissivity	uint8	n/a	1-255	0	0.002	0.49
PWV	Precipitable Water Vapor	uint16	cm	0-65535	n/a	0.001	0.0

Table 3-5: Bit flags defined in the QC SCS

Bits	Long Name	Description
1&0	Mandatory QA flags	00 = Pixel produced, best quality 01 = Pixel produced, nominal quality. Either one or

		more of the following conditions are met: 1. emissivity in both bands 4 and 5 < 0.95, i.e. possible cloud contamination 2. low transmissivity due to high water vapor loading (<0.4), check PWV values and error estimates 3. Pixel falls on missing scan line in bands 1&5, and filled using spatial neural net. Check error estimates. Recommend more detailed analysis of other QC information 10 = Pixel produced, but cloud detected 11 = Pixel not produced due to missing/bad data, user should check Data quality flag bits
3 & 2	Data quality flag	00 = Good quality L1B data 01 = Missing stripe pixel in bands 1 and 5 10 = not set 11 = Missing/bad L1B data
5 & 4	Cloud/Ocean Flag	Not set. Please check ECOSTRESS GEO and CLOUD products for this information.
7 & 6	Iterations	00 = Slow convergence 01 = Nominal 10 = Nominal 11 = Fast
9 & 8	Atmospheric Opacity	00 = >=3 (Warm, humid air; or cold land) 01 = 0.2 - 0.3 (Nominal value) 10 = 0.1 - 0.2 (Nominal value) 11 = <0.1 (Dry, or high altitude pixel)
11 & 10	MMD	00 = > 0.15 (Most silicate rocks) 01 = 0.1 - 0.15 (Rocks, sand, some soils) 10 = 0.03 - 0.1 (Mostly soils, mixed pixel) 11 = <0.03 (Vegetation, snow, water, ice)

13 & 12	Emissivity accuracy	00 = >0.02 (Poor performance) 01 = 0.015 - 0.02 (Marginal performance) 10 = 0.01 - 0.015 (Good performance) 11 = <0.01 (Excellent performance)
15 & 14	LST accuracy	00 = >2 K (Poor performance) 01 = 1.5 - 2 K (Marginal performance) 10 = 1 - 1.5 K (Good performance) 11 = <1 K (Excellent performance)

3.3.2 L2 CLOUD data

Table 3-6: Product Data Definitions for the 8-bit L2 Cloud Product

Bit Field	Long Name	Result
0	Cloud Mask Flag	0 = not determined 1 = determined
1	Cloud, either one of bits 2, 3, or 4 set.	0 = no 1 = yes
2	Thermal Brightness Test	0 = no 1 = yes
3	Band 4-5 Thermal Difference test	0 = no 1 = yes
4	land/water mask	0 = land 1 = water

3.4 Product Metadata File

The product metadata for each product file will be generated by the PCS from the metadata contents of each product file. The metadata will be converted into extensible markup language (XML). These will be used by the DAAC for cataloging. Exact contents and layout to be defined by PCS.

4 APPENDIX A: ABBREVIATIONS AND ACRONYMS

ALEXI	Atmospheric-Land Exchange Inversion
ARS	Agricultural Research Service
ASD	Algorithm Specifications Document
ATBD	Algorithm Theoretical Basis Document
CCB	Change Control Board
CDR	Critical Design Review
CF	Climate and Forecast (metadata convention)
CM	Configuration Management
CONUS	Continental United States
COTS	Commercial Off The Shelf
DAAC	Distributed Active Archive Center
dB	DeciBel
DCN	Document Change Notice
deg	Degrees
deg/sec	Degrees per Second
DEM	Digital Elevation Model
DisALEXI	ALEXI Disaggregation algorithm
DN	Data Number
EASE	Equal Area Scalable Earth
ECI	Earth Centered Inertial coordinate system
ECR	Earth Centered Rotating coordinate system
ECS	EOSDIS Core System
ECOSTRESS	ECOsystem Spaceborne Thermal Radiometer on Space Station
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESDIS	Earth Science Data and Information System
ESDT	Earth Science Data Type
FOV	Field of View
FSW	Flight Software
GB	gigabytes, 10^9 bytes
GDS	Ground Data System
GHA	Greenwich Hour Angle
GHz	Gigahertz, 10^9 hertz
GMAO	Global Modeling and Assimilation Office
GMT	Greenwich Mean Time
GPP	Gross Primary Production
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HK	Housekeeping (telemetry)
HRSL	Hydrology and Remote Sensing Laboratory
Hz	Hertz
HSD	Health and Status Data

I&T	Integration and Test
ICD	Interface Control Document
I/O	Input/Output
IOC	In-Orbit Checkout
IPA	Inter-Project Agreement
ITAR	International Traffic in Arms Regulation
JPL	Jet Propulsion Laboratory
K	Kelvin
KHz	Kilohertz
Km	kilometer, 1000 meters
L0 – L4	Level 0 through Level 4
LAN	Local Area Network
LEO	Low Earth Orbit
LOE	Level of Effort
LOM	Life of Mission
LP	Land Processes
LSTE	Land Surface Temperature and Emissivity
m	meter
MB	megabytes, 10^6 bytes
Mbps	Mega bits per second
MHz	Megahertz
MMR	Monthly Management Review
MOA	Memorandum of Agreement
MODIS	Moderate Resolution Imaging Spectroradiometer
MOS	Mission Operations System
m/s	meters per second
ms	milliseconds
MS	Mission System
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Protection
NCSA	National Center for Supercomputing Applications
netCDF	Network Common Data Format
NISN	NASA Integrated Services Network
NOAA	National Oceanic and Atmospheric Administration
OA	Operations Agreement
ODL	Object Description Language
OODT	Object Oriented Data Technology
ORR	Operational Readiness Review
ORT	Operational Readiness Test
PDR	Preliminary Design Review
percent	%, per hundred
PR	Problem Report
PSD	Product Specifications Document
PT-JPL	Priestly-Taylor-JPL
QA	Quality Assurance
rad	radians
RDD	Release Description Document
RFA	Request For Action

S/C	Spacecraft
SCP	Secure Copy
SDP	Software Development Plan
SDS	Science Data System
sec, s	seconds
SITP	System Integration and Test Plan
SMP	Software Management Plan
SOM	Software Operators Manual
TAI	International Atomic Clock
T_b	Brightness Temperature
TBD	To Be Determined
TBS	To Be Specified
TOA	Time of Arrival
TPS	Third Party Software
USDA	United State Department of Agriculture
USGS	United States Geological Society
UTC	Coordinated Universal Time
V&V	Verification and Validation
XML	Extensible Markup Language