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

## Level 3 Evapotranspiration (PT-JPL) Product Specification Document

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| | | |
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# TABLE OF CONTENTS

TABLE OF CONTENTS 6
1.1 Identification 7
1.2 Purpose and Scope 7
1.3 Mission Overview 7
1.4 Applicable and Reference Documents 8
1.4.1 Applicable Documents 8
1.4.2 Reference Documents 8
1.5 ECOSTRESS Data Products 8
DATA PRODUCT ORGANIZATION 11
1.6 Product File Format 11
1.7 HDF5 Notation 11
1.7.1 HDF5 File 11
1.7.2 HDF5 Group 11
1.7.3 HDF5 Dataset 11
1.7.4 HDF5 Datatype 11
1.7.5 HDF5 Dataspace 12
1.7.6 HDF5 Attribute 12
1.8 ECOSTRESS File Organization 13
1.8.1 Structure 13
1.8.2 Data 13
1.8.3 Element Types 13
1.8.4 File Level Metadata 14
1.8.5 Local Metadata 14
1.9 Data Definition Standards 14
1.9.1 Double Precision Time Variables 15
1.9.2 Array Representation 15
ECOSTRESS PRODUCT FILES 16
1.10 Standard Metadata 17
1.11 Product-Specific Metadata 18
1.12 Product Data 19
1.13 Product Metadata File 19
1.14 Quality Assessment Product 19
2.0 APPENDIX A: ABBREVIATIONS AND ACRONYMS 20

# INTRODUCTION

## 1.1 Identification

This is the Product Specification Document (PSD) for Level 3 (L3) data products of the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission. The ECOSTRESS L3(ET_PT-JPL) product provides evapotranspiration (ET) generated from data acquired by the ECOSTRESS radiometer instrument according to the PT-JPL algorithm described in the ECOSTRESS L3(ET_PT-JPL) Algorithm Theoretical Basis Document (ATBD) (JPL D-94645).

## 1.2 Purpose and Scope

This Product Specification Document (PSD) describes the standard Level 3 evapotranspiration (ET) product generated using the PT-JPL algorithm in the JPL facility. 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 use 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 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 29$^{th}$ 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 9$^{th}$ 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

ECOSTRESS Project Level 3 Science Data System Requirements (JPL D-94088).

ECOSTRESS Science Data Management Plan (JPL D-94607)

423-ICD-005 ICD Between ECOSTRESS SDS and LPDAAC

ECOSTRESS Level 1 Algorithm Theoretical Basis Documents (JPL D-94641, D-94642)

ECOSTRESS Level 1 Algorithm Specification Document

ECOSTRESS Level 2 Algorithm Theoretical Basis Documents (JPL D-94643, D-94644)

ECOSTRESS Level 2 Algorithm Specification Document

ECOSTRESS Level 3 (ET_PT-JPL) Algorithm Theoretical Basis Document (JPL D-94645)

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 Stations (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 black body 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 emissivities of 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 contain evapotranspiration data derived from

Level 2 data. Level 4 products contain 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 3 ET_PT-JPL product, and provide a brief description of the Level 3/4 QA product.

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_ALEXIU | 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_ALEXIU | 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 |

# DATA PRODUCT ORGANIZATION

## 1.6 Product File Format

All ECOSTRESS standard products are stored 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

## 1.7 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.

### 1.7.1 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.

### 1.7.2 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.

### 1.7.3 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.

### 1.7.4 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.

### 1.7.5 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.

### 1.7.6 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.

## 1.8 ECOSTRESS File Organization

### 1.8.1 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.

### 1.8.2 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.

### 1.8.3 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 |
| VarLenStr | H5T_STRING | H5T_NATIVE_CHAR | character string |

### 1.8.4 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.

### 1.8.5 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. | Yes for all numeric data types |
| long_name | A descriptive name that clearly describes the content of the associated Dataset. | Yes |
| scale_factor | Scale factor (always set to one) | No |
| add_offset | Additive offset (always set to zero) | No |

## 1.9 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. |

### 1.9.1 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.

### 1.9.2 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.

# 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 spacecrafts 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, and day of data start
hhmmss: Hour, minute, and second of data start
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.

## 1.10 Standard Metadata

This is the minimal set of metadata that must be included with each L3_ET_PT-JPL 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 (??) | | 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 | L3_ET_PT_JPL |
| PGEVersion | String | variable | |
| PlatformLongName | String | variable | ISS |
| PlatformShortName | String | variable | ISS |
| PlatformType | String | variable | Spacecraft |
| ProcessingLevelID | String | variable | 2 |
| ProcessingLevelDescription | String | variable | Level 3 Evapotranspiration PT-JPL |
| 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 | L3_ET_PT-JPL |
| SISName | String | variable | |
| SISVersion | String | variable | |
| SouthBoundingCoordinate | LongFloat | 8 | |
| StartOrbitNumber | String | variable | |
| StopOrbitNumber | String | variable | |
| WestBoundingCoordinate | LongFloat | 8 | |

## 1.11 Product-Specific Metadata

Any additional metadata necessary for describing the L3 ET product will be recorded in this group.

Table 3-2: Product Specific Metadata

| Name | Type | Size | Example |
|---|---|---|---|
| **Group** | **L3_ET_PT-JPL Metadata** | | |
| AncillaryFiles | Int | 4 | 100 |
| AncillaryFileSurfacePressure | String | 255 | |
| AncillaryFileSurfacePressureFill | String | 255 | |
| AncillaryFileAirTemperatureNWP | String | 255 | |
| AncillaryFileAirTemperatureRS | String | 255 | |
| AncillaryFileDewpointTemperatureNWP | String | 255 | |
| AncillaryFileDewpointRS | String | 255 | |
| AncillaryFileVaporPressure | String | 255 | |
| AncillaryFileWaterMask | String | 255 | |
| AncillaryFileSnowMask | String | 255 | |
| AncillaryFileIceMask | String | 255 | |
| AncillaryFileNDVI | String | 255 | |
| AncillaryFileAerosolOpticalDepth | String | 255 | |
| AncillaryFileCOT | String | 255 | |
| AncillaryFileCloudFraction | String | 255 | |
| AncillaryFileCloudHeight | String | 255 | |
| AncillaryFileCloudMask | String | 255 | |
| AncillaryFileLandcover | String | 255 | MOD10A1.A2012129.h01v08.005.2012131060718.hdf |
| AncillaryFileBRDF_qc | String | 255 | |
| AncillaryFileWhiteSkyAlbedo | String | 255 | |
| AncillaryFileBlackSkyAlbedo | String | 255 | |
| AncillaryFileTemperatureProfile | String | 255 | |
| AncillaryFileAlbedo | String | 255 | |
| AncillaryFileEVI | String | 255 | |
| AncillaryFileFPAR | String | 255 | |
| AncillaryFileLAI | String | 255 | |
| AncillaryFileUWND | String | 255 | |
| AncillaryFileVWND | String | 255 | |
| AncillaryFileTmin | String | 255 | |

## 1.12 Product Data

The product data will be stored in this group.

Table 3-3: Product Data Definitions

| Field Name | Type | units | Field Data | valid min | valid max | fill |
|---|---|---|---|---|---|---|
| **GROUP** | **EVAPOTRANSPIRATION PT-JPL** | | | | | |
| ETinst | Float32 | $W/m^2$ | Instantaneous Evapotranspiration | 0 | 2000 | NaN |
| ETdaily | Float32 | $W/m^2$ | Daily Evapotranspiration | 0 | 2000 | NaN |
| ETcanopy | Float32 | % | Canopy ET | 0 | 100 | NaN |
| ETsoil | Float32 | % | Soil ET | 0 | 100 | NaN |
| ETinterception | Float32 | % | ET Interceptions | 0 | 100 | NaN |
| ETinstUncertainty | Float32 | $W/m^2$ | ET Instantaneous Uncertainty | 0 | 2000 | NaN |

units, valid_min, valid_max, and fill values are provided in HDF5 dataset attributes

## 1.13 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.

## 1.14 Quality Assessment Product

The QA product provides the quality flags as reported verbatim by all ancillary data products listed in Table 3-2, resampled onto the ECOSTRESS pixel coordinates (see Table 3-4). This is for the convenience of the end user, to aid in analyzing the ET science data product. Fields that contain temporal averages of ancillary data are excluded from this product. For the decoding of the quality flags we refer the user to the original documentation for the ancillary data products. The Standard Product Metadata for the L3_L4_QA product contains the same entries as Table 3-1.

Table 3-4: L3_L4_QA Quality Assessment Product Fields

| Output Dataset | Source Product | Source Dataset | No-Data | Bit-width |
|---|---|---|---|---|
| **GROUP** | **L3_L4_QA** | | | |
| ECOSTRESS_L2_QC | ECOSTRESS L2 | SDS/CloudMask | 255 | 8-bit |
| Landsat_8_QC | Landsat 8 | BQA | 1 | 16-bit |
| MCD12Q1_QC | MCD12Q1 | Land_Cover_Type_QC | 255 | 8-bit |

| | | | | |
|---|---|---|---|---|
| MCD43A3_QC | MCD43A3 | BRDF_Albedo_Band_Mandatory_Quality_shortwave | 255 | 8-bit |
| MOD04_QC | MOD04 | Quality_Assurance_Land | 255 | 8-bit |
| MOD06_5km_QC | MOD06 | Quality_Assurance_5km | 255 | 8-bit |
| MOD06_1km_QC | MOD06 | Quality_Assurance_1km | 255 | 8-bit |
| MOD07_QC | MOD07 | Quality_Assurance | 255 | 8-bit |
| MOD13Q1_QC | MOD13Q1 | 250m 16 days VI Quality | 65535 | 16-bit |
| MOD17A2H_QC | MOD17A2H | Psn_QC_500m | 255 | 8-bit |
| MOD44W_QC | MOD44W | water_mask_QA | 253 | 8-bit |

# 2.0 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 |
| ESI | Evaporative Stress Index |
| ET | Evapotranspiration |

| | |
|---|---|
| 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 |
| WUE | Water Use Efficiency |
| XML | Extensible Markup Language |