ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)

ECOSTRESS Level-3 DisALEXI-JPL Evapotranspiration (ECO3ETALEXI) User Guide

Version 1
May 20, 2021

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This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Note:
The users' guide is designed to be a living document that describes the ECOSTRESS DisALEXI-JPL evapotranspiration (ET) product. The document describes the current state of the art, and is revised as progress is made in the development and assessment of the ET product. The primary purpose of the document is to present an overview of the ECOSTRESS L3 DisALEXI-JPL data product to the potential user. For more detailed information on the physical basis and algorithm details please see the Algorithm Theoretical Basis Document (ATBD).

Change History Log

Revision	Effective Date	Prepared by	Description of Changes
Draft	5/5/2021	Kerry Cawse-Nicholson	User Guide first draft

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1 Introduction

This is the user guide for the ECOSTRESS Level-3 DisALEXI-JPL (evapotranspiration (ET) product. The L3 product uses a physics-based surface energy balance (SEB) algorithm to retrieve estimates of daily ET using the ECOSTRESS L-2 land-surface temperature and emissivity (LST&E) products, along with ancillary meteorological data and remotely sensed vegetation cover information. The output ET is generated in an HDF5 format consistent with ECOSTRESS L-2 products. A future implementation will include data projected onto a 70 m grid. The algorithm is based on spatial disaggregation of regional-scale fluxes from the Atmosphere Land Exchange Inverse (ALEXI) SEB model, and this is an extension of the DisALEXI-USDA product that is available over selected sites at 30 m resolution. DisALEXI-JPL has been evaluated in comparison with micrometeorological flux tower observations over crop, forest, grassland, wetland and semiarid desert sites.

The algorithms and data content of the ET product are briefly described in this guide, with the purpose of providing a user with sufficient information about the content and structure of the data files to enable the user to access and use the data, in addition to understanding the uncertainties involved with the product and how to interpret the mask information. Overviews of the file formats and provided first followed by descriptions of the algorithm and product contents including all metadata. Publications and documents related to the ECOSTRESS ET products are listed in the final section.

A description of the major components of the ECOSTRESS algorithm implemented in version 1 of the DisALEXI-JPL ET code provided in the ATBD available at https://ecostress.jpl.nasa.gov/products.

1.1 File format for L3 products

The ECOSTRESS ET products are distributed in HDF5 format and can be read in by HDF5 software. Information on Hierarchical Data Format 5 (HDF5) may be found at https://www.hdfgroup.org/HDF5/. The HDF format was developed by NCSA, and has been widely used in the scientific domain. HDF5 can store two primary types of objects: datasets and groups. A dataset is essentially a multidimensional array of data elements, and a group is a structure for organizing objects in an HDF5 file. HDF5 was designed to address some of the limitations of the HDF4. Using these two basic objects, one can create and store almost any kind of scientific data structure, such as images, arrays of vectors, and structured and unstructured grids. They can be mixed and matched in HDF5 files according to user needs. HDF5 does not limit the size of files or the size or number of objects in a file. The scientific data results are delivered as SDSs with local attributes including summary statistics and other information about the data. More detailed information on HDF5 data types may be found in the L3 Product Specification Document (PSD) available at https://ecostress.jpl.nasa.gov/products.

The ECOSTRESS ET data product files contain one set of Attributes (metadata) describing information relevant to production, archiving, user services, input products, geolocation and analysis of data, as well as provenance and Digital Object Identifier (DOI) of the product attached to the root group (the file). The attributes listed in Table 4 are not described further in this user guide.

1.2 DisALEXI-JPL ET Product

The ECOSTRESS DisALEXI-JPL ET data product is produced for ECOSTRESS overpass dates in swath format, yielding estimates of daily integrated ET for pixels that were flagged as clear-sky in the input L2 LST&E product. The JPL product is generated CONUS-wide. Table 1 shows a summary of the L3 product characteristics.

Other data product levels briefly described: Level 1B (L1B) is a swath (scene) of measured radiance data geolocated to latitude and longitude centers of 70m resolution pixels. A Level 2 (L2) product is a geophysical product retrieved from the L1B data that remains in latitude and longitude orientation; it has not been temporally or spatially manipulated. The Level 3 and 4 (L3, L4) ECOSTRESS products consist of higher level geophysical variables output from models (evapotranspiration, evaporative stress index, water use efficiency) derived from the L2 and other ancillary data.

Table 1: Summary of the ECOSTRESS DisALEXI-JPL ET product.

Earth Science Data Type (ESDT)	Product Level	Data Dimension	Spatial Resolution	Grid/swath	Map Projection
ECOSTRESS_L3_ET (USDA)	L3	Approximately 3000 lines by 3000 samples	30 m	gridded	UTM
ECOSTRESS_L3_ET (JPL)	L3	5400 x 5632	~70 m	swath	Geographic

1.3 Product Availability

The ECOSTRESS L3 product will be made available at the NASA Land Processes Distribution Active Archive Center (LPDAAC), https://earthdata.nasa.gov/ and can be accessed via the Earthdata search engine (initially only available to early adopters; for access see https://ecostress.jpl.nasa.gov/applications).

2 ECOSTRESS_L3_ET Product

2.1 Algorithm Description

The basic processing steps involved in L3 ET product generation are outlined schematically in Fig. 2 - for a full detailed description of the DisALEXI-JPL processing scheme please see the ATBD at https://ecostress.jpl.nasa.gov/products. The energy balance model employed here is a multi-scale system designed to generated self-consistent flux assessments from field to regional/continental scales (Anderson, 2003). The regional Atmosphere-Land Exchange Inverse (ALEXI) model relates time-differential LST observations from geostationary satellites to the time-integrated energy balance within the surface-atmospheric boundary layer system (Anderson et al., 1997, 2007). ALEXI has minimal reliance on absolute (instantaneous) air or surface temperature input data, and therefore provides a relatively robust flux determination at the coarse geostationary pixel scale. For finer scale ET applications, ALEXI flux fields can be spatially disaggregated using higher resolution LST information from ECOSTRESS, polar orbiting systems (e.g., Landsat or MODIS), or from aircraft using an algorithm referred to as DisALEXI-JPL (Norman et al., 2003; Anderson et al., 2004; Cammalleri et al., 2013, 2014; Anderson et al., 2018). Both ALEXI and DisALEXI-JPL use the two-source energy balance (TSEB; Norman, 1995; Kustas, 1999) land-surface representation to partition surface fluxes between the canopy and the soil.

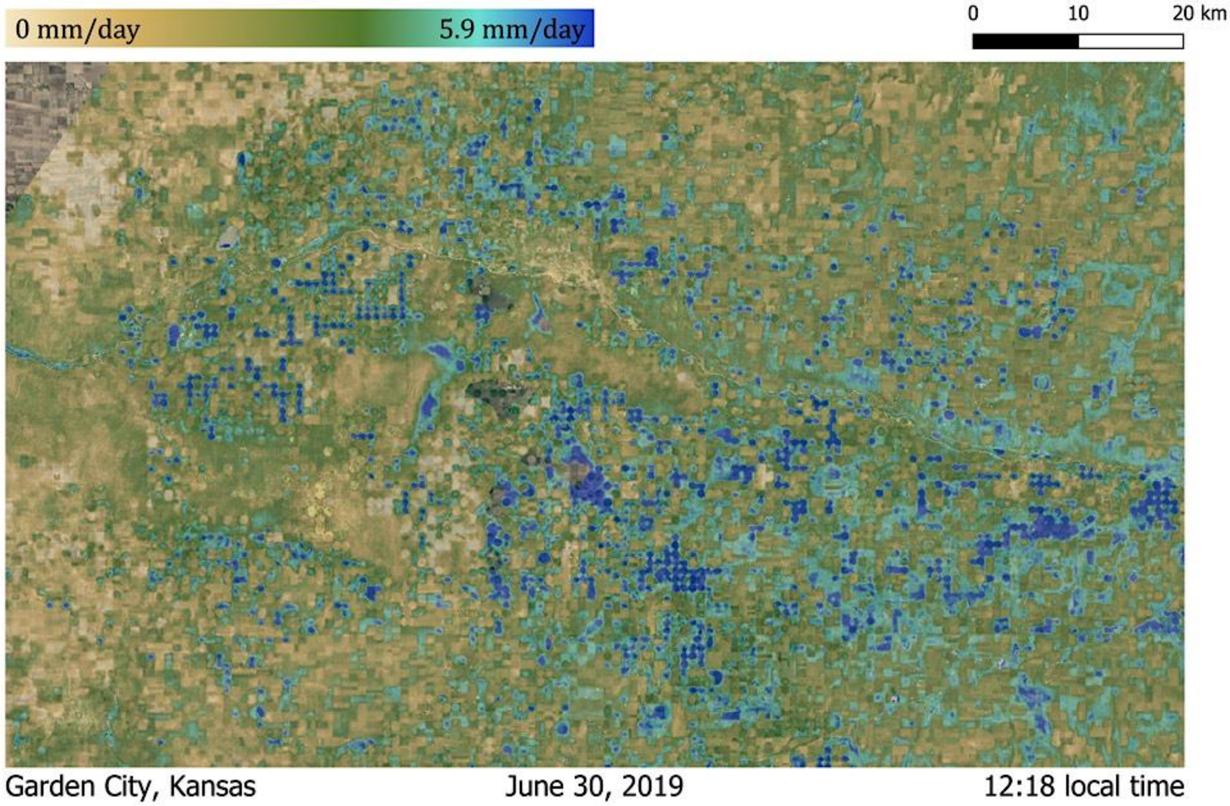

Figure 1. Example ECOSTRESS L3 Evapotranspiration (ET) scene produced by DisALEXI-JPL over Garden City Kansas, acquired on June 30, 2019.

Data inputs to the ECOSTRESS L2 algorithm are listed in Table 2. Baseline ALEXI daily ET fluxes are produced at 4km resolution over CONUS using hourly morning LST retrievals from the East and West Geostationary Operational Environmental Satellites covering CONUS. Primary high resolution remote sensing inputs to DisALEXI-JPL are LST, leaf area index (LAI; used in the soil/canopy partitioning) and surface albedo (used to compute net radiation). For the L3 ET product, LST is obtained from the L2 LST&E product, while albedo and LAI are computed from Landsat spectral reflectance (SR) data. Gridded meteorological inputs (solar radiation, wind speed, vapor pressure, atmospheric pressure and air temperature) are obtained from the Climate Forecast System Reanalysis (CFRS) dataset at native resolution of 0.25 degrees (Saha, 2010).

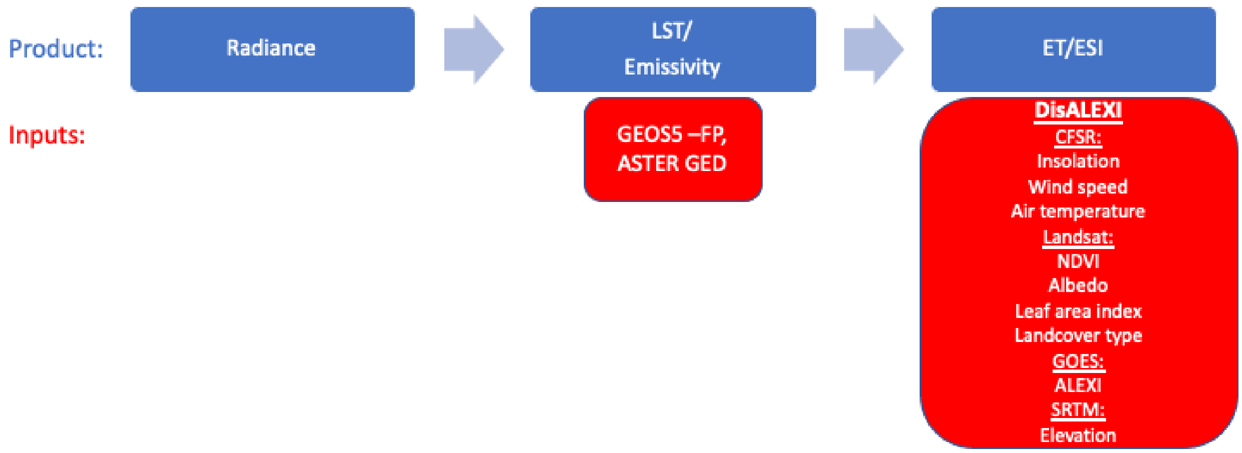

Figure 2. Conceptual diagram describing computation of L3 (ECO3ETALEXI) evapotranspiration, along with required inputs.

Table 2: ECOSTRESS input products and ancillary data required to produce the L3 DisALEXI-JPL ET product.

Ancillary Data Set	**Long Name**	**Data Used**
ECOSTRESS_L2	ECOSTRESS Level-2 land-surface temperature and emissivity	Land-surface temperature
ECOSTRESS_L1B_GEO	Geolocation	Land/ocean mask Elevation Sensor and solar zenith angles Latitude, Longitude
Landsat Surface Reflectance product	Landsat Surface Reflectances, Collection 1 (EROS)	Multi-band surface reflectance
MCD15A3H	MODIS/Terra+Aqua Leaf Area Index/FPAR 4-Day L4 Global 500 m SIN Grid V006	Leaf Area Index
CFSR	Climate Forecast System Reanalysis	Air temperature, wind speed, mixing ratio, atmospheric pressure
NLCD	National Land Cover Dataset	Landcover classification

2.2 Scientific Data Sets (SDS)

The ECOSTRESS Level-3 DisALEXI-JPL ET product contains 3 scientific data sets (SDSs): ETdaily, ETdailyUncertainty, and QualityFlag. All SDS data are output ECOSTRESS native swath resolution. The ETdailyUncertainty data reflect the uncertainty ET associated with the error reported for the L2 ECOSTRESS LST inputs (LST_Err). Details of each SDS including data type and units are shown in Table 3.

Table 3. The Scientific Data Sets (SDS) in the ECOSTRESS L3 ET product.

Field Name	Type	Unit	Field Data
GROUP	**EVAPOTRANSPIRATION ALEXI**		
ETdaily	Float	mm/day	
ETdailyUncertainty	Float	mm/day	
QualityFlag	UInt16		

2.3 Attributes

Archived with the SDS are attributes (metadata) describing characteristics of the data. Contents of these attributes were determined and written during generation of the product at JPL by the Process Control System (PCS) and are used in archiving and populating the database at the LPDAAC to support user services. They are stored as very long character strings in parameter value language (PVL) format. Descriptions of the attributes are given here to assist the user in understanding them. ECOSTRESS products consist of a set of standard metadata (Table 4) and product-specific metadata (Table 5). The product specific metadata in Table 5 give details on ancillary data sets and average ET uncertainty values for the entire scene.

Table 4. Standard product metadata included in all ECOSTRESS products.

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	
CampaignShortName	String	variable	Primary
CollectionLabel	String	variable	
DataFormatType	String	variable	NCSAHDF5
DayNightFlag	String	variable	
EastBoundingCoordinate	LongFloat	8	
HDFVersionID	String	variable	1.8.16
ImageLines	Int32	4	5400
ImageLineSpacing	Float32	4	70
ImagePixels	Int32	4	5632
ImagePixelSpacing	Float32	4	70
InputPointer	String	variable	
InstrumentShortName	String	variable	ECOSTRESS

LocalGranuleID	String	variable	
LongName	String	variable	ECOSTRESS
NorthBoundingCoordinate	LongFloat	8	
PGEName	String	variable	L3_ET_ALEXI
PGEVersion	String	variable	
PlatformLongName	String	variable	ISS
PlatformShortName	String	variable	ISS
PlatformType	String	variable	Spacecraft
ProcessingLevelID	String	variable	3
ProcessingLevelDescription	String	variable	Level 3 Evapotranspiration ALEXI
ProducerAgency	String	variable	
ProducerInstitution	String	variable	JPL
ProductionDateTime	String	variable	
ProductionLocation	String	variable	
RangeBeginningDate	String	variable	
RangeBeginningTime	String	variable	
RangeEndingDate	String	variable	
RangeEndingTime	String	variable	
SceneID	String	variable	
ShortName	String	variable	L3_ALEXI
SISName	String	variable	
SISVersion	String	variable	Final
SouthBoundingCoordinate	LongFloat	8	
StartOrbitNumber	String	variable	
StopOrbitNumber	String	variable	
WestBoundingCoordinate	LongFloat	8	

Table 5.Product specific metadata for the ECOSTRESS L3 ET product.

Name	**Type**	**Size**	**Example**
Group	**L3_ET_ALEXI Metadata**		
QualityBitFlag	String	255	01011011011
AvgETUncertainty	LongFloat	8	
AncillaryFiles	Int	4	100
AncillaryFileAirTemperature	String	255	CFSR_FILENAME_DATE
AncillaryFileALEXIETd	String	255	EDAY_V7NC_CFSRINSOL_2018200.dat
AncillaryFileBadMask	String	255	
AncillaryFileInsolation	String	255	CFSR_FILENAME_DATE
AncillaryFileLandcover	String	255	NLCD_FILENAME
AncillaryFileLST	String	255	LSTE_FILENAME
AncillaryFileMixingRatio	String	255	CFSR_FILENAME_DATE
AncillaryFilePressure	String	255	CFSR_FILENAME_DATE
AncillaryFileSurfaceReflectance	String	255	LANDSAT_TARFILE_NAME
AncillaryFileSurfReflectanceFill	String	255	
AncillaryFileWindSpeed	String	255	CFSR_FILENAME_DATE
BandSpecification	Float32	6	
Projection	String	255	ECOSTRESS

Geotransform	String	255	
OGC Well Known Text	String	variable	Blank if Projection=ECOSTRESS If Projection=UTM, EG: {PROJCS["UTM_Zone_11N",GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["WGS_1984",6378137.0,298.257223563]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-117.0],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0.0],UNIT["Meter",1.0]]}

2.4 Quality Flag

Indicators of data quality are described in the quality flag SDS generated during production. The QualityFlag SDS provides information on regarding cause of missing data in the L3 DisALEXI-JPL ET product. A successful ET retrieval for a given pixel requires 1) good quality clear-sky L2 LST data are available, 2) good quality surface reflectance data are available from bracketing Landsat overpass date, 3) an ALEXI retrieval is available for the 4-km ALEXI grid cell encompassing the 70-m target pixel; and 4) the pixel is designated as land in the NLCD (retrievals for open water bodies are not conducted). These conditions are tracked in the QualityFlag SDS at the pixel level. The QualityFlag SDS unsigned 8-bit data are stored as bit flags in the SDS. This QC information can be extracted by reading the bits in the 8-bit unsigned integer.

Table 6. Bit flags defined in the QC SDS in the L3 ALEXI ET product. (Note: Bit 0 is the least significant bit).

Bit Field	Long Name	Result
0	Pixel computed	0 = yes 1 = no
1	Good quality LSTE available	0 = yes 1 = no
2	Good quality Surface Reflectance data available	0 = yes 1 = no
3	ALEXI data available	0 = yes 1 = no
4	Other (land pixel, etc.)	0 = yes

		1 = no

Acknowledgements

We thank Martha Anderson, Munish Sikka, Erin Wong, Gregory Halverson, Chris Hain, Feng Gao, Bill Kustas, John Norman, Carmelo Cammalleri, Peijuan Wang, Kate Semmens, Yun Yang, Wayne Dulaney, Liang Sun, and Yang Yang for contributions to the algorithm development described in this User Guide.

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