ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)

ECOSTRESS Collection 2 Level-1-2-3-4 Gridded and Tiled Data Products User Guide

Version 2
April 4, 2023

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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 Collection 2 gridded and tiled products. The document describes the current state of the art, and is revised as progress is made in the development and assessment of the Collection 2 products. The primary purpose of the document is to present an overview of the ECOSTRESS Collection 2 gridded and tiled data products to the potential user. For more detailed information on the physical basis and algorithms used to produce these products details please see the Algorithm Theoretical Basis Document (ATBD).

Change History Log

Revision	Effective Date	Prepared by	Description of Changes
Draft	8/24/2022	Gregory Halverson, Kerry Cawse-Nicholson	User Guide first draft
Draft	12/15/2022	Margaret Johnson, Kerry Cawse-Nicholson	STARS Description
Draft	12/15/2022	Gregory Halverson	L1C Processing
Draft	01/12/2023	Gregory Halverson	Editing for URS submission
Version 1	4/13/2023	Kerry Cawse-Nicholson	Version approved for release

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Contents

1 Introduction

This is the user guide for the ECOSTRESS Collection 2 gridded and tiled products. ECOSTRESS acquires data within an orbit, and this orbit path is divided into scenes roughly 400 x 400 km in size. The ECOSTRESS collection 2 products are distributed in two formats: orbit/scene in Hierarchical Data Format 5 (HDF5) and orbit/scene/tile in Cloud-Optimized GeoTIFF (COG). The gridded and tiled products and their swath equivalents are listed in Table 1.

Product	Swath Orbit/Scene HDF5	Gridded Orbit/Scene HDF5	Tiled Orbit/Scene Tile GeoTIFF
Radiance	L1B RAD	L1CG RAD	L1CT RAD
Surface Temperature	L2 LSTE	L2G LSTE	L2T LSTE
Cloud	L2 CLOUD	L2G CLOUD	
STARS NDVI/Albedo			L2T STARS
Surface Energy Balance		L3G SEB	L3T SEB
Soil Moisture		L3G SM	L3T SM
Meteorology		L3G MET	L3T MET
Evapotranspiration Ensemble		L3G JET	L3T JET
DisALEXI-JPL Evapotranspiration		L3G ET ALEXI	L3T ET ALEXI
Evaporative Stress Index		L4G ESI	L4T ESI
DisALEXI-JPL Evaporative Stress Index		L4G ESI ALEXI	L4T ESI ALEXI
Water Use Efficiency		L4G WUE	L4T WUE

1 Listing of ECOSTRESS Collection 2 gridded and tiled products and their swath equivalents.

The L1CG RAD, L2G LSTE, and L2G CLOUD gridded products are gridded forms of the L1B RAD, L2 LSTE, and L2 CLOUD swath products. A cloud mask derived from L2G CLOUD is provided as a quality layer in each of the higher level products, and so the cloud mask is not necessary as a standalone tiled product. The L2T STARS ancillary NDVI and albedo product is generated at tiles only for each day that ECOSTRESS passes over a tile. The STARS product is not derived from ECOSTRESS and is not distributed as an ECOSTRESS scene.

1.1 HDF-EOS5 Orbit/Scene Gridded Products

The Hierarchical Data Format Earth Observing System 5 (HDF-EOS5) format is used to distribute ECOSTRESS granules at the orbit/scene level. These product files have a .h5 file extension and are internally organized using the HDF-EOS5 data standard. The L1C, L2, L3, and L4 gridded products using this format include the letter G in their level identifiers: L1CG, L2G, L3G and L4G. The HDF5 format is utilized here for long-term archiving, and is not recommended for end-user analysis. These HDF-EOS5 files are compatible with HDF-View, Panoply, and the h5py package in Python.

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.

All of the raster layers in all of the L1CG/L2G/L3G/L4G gridded products are projected to a globally snapped 0.0006° grid in WGS84 latitude and longitude to approximate 70 m resolution.

Each L1CG/L2G/L3G/L4G gridded product .h5 file contains spatial metadata defining the raster grid using a plaintext format defined by HDF-EOS5 under:

`HDFEOS INFORMATION/StructMetadata.0`

Each product contains a group containing the product layers following the HDF-EOS5 format:

`HDFEOS/GRIDS/grid_name/Data Fields`

where `grid_name` is a custom-named grid for each product, as listed in Table 2.

Product	HDF-EOS5 Grid Name
L1CG RAD	ECO_L1CG_RAD_70m
L2G LSTE	ECO_L2G_LSTE_70m
L2G CLOUD	ECO_L2G_CLOUD_70m
L3G SEB	ECO_L3G_SEB_70m
L3G SM	ECO_L2G_SM_70m
L3G MET	ECO_L3G_MET_70m
L3G JET	ECO_L3G_JET_70m
L3G ET ALEXI	ECO_L3G_ET_ALEXI_70m
L4G ESI	ECO_L4G_ESI_70m
L4G ESI ALEXI	ECO_L4G_ESI_ALEXI_70m
L4G WUE	ECO_L4G_WUE_70m

2. HDF-EOS5 grid names used in the L1CG/L2G/L3G/L4G product files.

All data layers in the L1CG/L2G/L3G/L4G products are written as 32-bit floating point representations of real units with missing values indicated by the standard IEEE 754 not-a-number (`NaN`) value. Each HDF5 dataset containing a raster layer includes a common set of attributes, with `_Fillvalue` always set to `NaN`, `add_offset` always set to zero, and `scale_factor` always set to one. The `long_name` attribute is always set to the dataset name, and the `units` attribute represents the units of the dataset as text.

Each L1CG/L2G/L3G/L4G product .h5 file contains two sets of product metadata:

`HDFEOS/ADDITIONAL/FILE_ATTRIBUTES/ProductMetadata`

and

`HDFEOS/ADDITIONAL/FILE_ATTRIBUTES/StandardMetadata`

Each product contains a custom set of `ProductMetadata` attributes.

The `StandardMetadata` attributes are consistent across products at each orbit/scene, as listed in Table 3.

Name	Type
AncillaryInputPointer	string
AutomaticQualityFlag	string
BuildID	string
CRS	string
CampaignShortName	string
CollectionLabel	string
DataFormatType	string
DayNightFlag	string
EastBoundingCoordinate	float64
FieldOfViewObstruction	string
HDFVersionID	string
ImageLineSpacing	float64
ImageLines	int32
ImagePixelSpacing	float64
ImagePixels	int32
InputPointer	string
InstrumentShortName	string
LocalGranuleID	string
LongName	string
NorthBoundingCoordinate	float64
PGEName	string
PGEVersion	string
PlatformLongName	string
PlatformShortName	string
PlatformType	string
ProcessingEnvironment	string
ProcessingLevelDescription	string
ProcessingLevelID	string
ProducerAgency	string
ProducerInstitution	string
ProductionDateTime	string
ProductionLocation	string
RangeBeginningDate	string
RangeBeginningTime	string
RangeEndingDate	string

RangeEndingTime	string
RegionID	string
SISName	string
SISVersion	string
SceneBoundaryLatLonWKT	string
SceneID	string
ShortName	string
SouthBoundingCoordinate	float64
StartOrbitNumber	string
StopOrbitNumber	string
WestBoundingCoordinate	float64

3. Name and type of metadata fields contained in the common StandardMetadata group in each L1CG/L2G/L3G/L4G product .h5 file.

1.2 Cloud-Optimized GeoTIFF Orbit/Scene/Tile Products

To provide an analysis-ready format, the ECOSTRESS Collection 2 products are distributed in a tiled form and using the COG format. The tiled products include the letter T in their level identifiers: L1CT, L2T, L3T, and L4T. The tiling system used for ECOSTRESS Collection 2 is borrowed from the modified Military Grid Reference System (MGRS) tiling scheme used by Sentinel 2. These tiles divide the Universal Transverse Mercator (UTM) zones into square tiles 109760 m across. ECOSTRESS uses a 70 m cell size with 1568 rows by 1568 columns in each tile. This allows the end user to assume that each 70 m ECOSTRESS pixel will remain in the same location at each timestep observed in analysis. The COG format also facilitates end-user analysis as a universally recognized and supported format, compatible with open-source software, including QGIS, ArcGIS, GDAL, the Raster package in R, rioxarray in Python, and Rasters.jl in Julia.

Each .tif COG data layer in each L1CG/L2T/L3T/L4T product additionally contains a rendered browse image in GeoJPEG format with a .jpeg extension. This image format is universally recognized and supported, and these files are compatible with Google Earth. Each L1CT/L2T/L3T/L4T tile granule includes .json file containing the Product Metadata and Standard Metadata in JSON format.

1.3 Quality Flags

Two high-level quality flags are provided in all gridded and tiled products as thematic/binary masks encoded to zero and one in unsigned 8-bit integer layers. The cloud layer represents the final cloud test from L2 CLOUD. The water layer represents the surface water body in the Shuttle Radar Topography Mission (SRTM) Digital Elevation Model. For both layers, zero means absence, and one means presence. Pixels with the value 1 in the cloud layer represent detection of cloud in that pixel. Pixels with the value 1 in the water layer represent open water surface in that pixel. All tiled product data layers written in float32 contain a standard not-a-number (NaN) value at each pixel that could not be retrieved. The cloud and water layers are provided to explain these missing values.

1.4 Product Availability

The ECOSTRESS Collection 2 products are 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 Level 1 Radiance Product

2.1 Algorithm Description

The L1CG RAD gridded product is processed by ingesting the L1B RAD and L2 CLOUD swath products, geolocating them using the L1B GEO product, and resampling them by nearest neighbor to a globally snapped 0.0006° grid. The L1B RAD product is resampled and repackaged as the L1CG RAD product, and it contains the cloud mask from L2 CLOUD as a quality layer. The L1CT RAD tiled products are subset from the L1CG RAD product and resampled to the 70 m UTM grid in each tile.

2.2 L1CG RAD and L1CT RAD Radiance Products

The L1CG RAD gridded radiance and L1CT RAD tiled radiance products distribute ECOSTRESS top-of-atmosphere radiance in units of watts per square meter per steradian per micron in the `radiance_1` through `radiance_5` layers. The QC flags from the L1B RAD swath product are resampled here as `data_quality_1` through `data_quality_5`. Please refer to the L1B user guide for interpretation of these low-level quality flags. The dataset name, data type, and units of each data layer in the L1CG RAD and L1CT RAD radiance products are listed in Table **Error! Reference source not found.**.

Name	Type	Units
radiance_1	float32	W m^{-2} sr^{-1} m^{-1}
radiance_2		
radiance_3		
radiance_4		
radiance_5		
data_quality_1	uint16	quality flag
data_quality_2		
data_quality_3		
data_quality_4		
data_quality_5		
cloud	uint8	mask
water		

4. Listing of the raster data layers in the L1CG RAD and L1CT RAD data products.

Some ECOSTRESS acquisitions recorded five bands of radiance, but most include only three bands. In the case of 3-band granules, the `radiance_1` and `radiance_3` layers are filled entirely with `NaN`.
The browse images for the L1CG RAD and L2T RAD products are generated as false-color composites of radiance bands 2, 4, and 5, with band 5 assigned to red, band 3 assigned to green, and band 2 assigned to blue.

3 Level 2 Temperature and Cloud Products

3.1 Algorithm Description

The L2G LSTE and L2G CLOUD gridded products are processed with a similar procedure to L1CG RAD by ingesting the L2 LSTE and L2 CLOUD swath products, geolocating them using the L1B GEO product, and resampling them by nearest neighbor to a globally snapped 0.0006° grid. The L2 LSTE product is resampled and repackaged as the L2G LSTE product. The L2 CLOUD product is resampled and repackaged as the L2G CLOUD product. The L2T LSTE tiled products are subset from the L2G LSTE product and resampled to the 70 m UTM grid in each tile.

3.2 L2G LSTE and L2T LSTE Surface Temperature Products

The L2G LSTE and L2T LSTE surface temperature (ST) products distribute ECOSTRESS bottom-of-atmosphere ST in Kelvin as the land-surface temperature (LST) layer, though valid estimates of both land and water surface temperatures are provided. Please refer to the L2 LSTE user guide/ATBD for further details on the Temperature and Emissivity Separation (TES) algorithm deployed to produce this ST estimate from multiple radiance bands. The uncertainty of the ST estimate is provided as `LST_err`, and the broadband emissivity associated with this temperature is given as `EmisWB`. The low-level QC flag from the L2 LSTE product is resampled here. Please refer to the L2 LSTE user guide for interpretation of this quality flag. The view zenith angle of the observation is given in degrees as `view_zenith`. And the elevation in meters of the surface observed is included as `height`, taken from the SRTM. The names, types, and units of the L2G LSTE and L2T LSTE data layers are listed in Table 5.

Name	Type	Units

LST	float32	Kelvin
LST_err		Kelvin
EmisWB		unitless: 0 to 1
height		meters
view_zenith		degrees
QC	uint16	quality flag
cloud	uint8	mask
water		mask

5. Listing of L2G LSTE and L2T LSTE data layers, data types, and units.

4 L2T STARS NDVI and Albedo Product

NDVI and albedo are estimated at 70 m ECOSTRESS standard resolution for each daytime ECOSTRESS overpass by fusing temporally sparse but fine spatial resolution images from the Harmonized Landsat Sentinel (HLS) 2.0 product with daily, moderate spatial resolution images from the Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) VNP09GA product. The data fusion is performed using a variant of the Spatial Timeseries for Automated high-Resolution multi-Sensor data fusion (STARS) algorithm developed by Dr. Margaret Johnson and Gregory Halverson at the Jet Propulsion Laboratory. STARS is a Bayesian timeseries methodology that provides streaming data fusion and uncertainty quantification through efficient Kalman filtering.

Operationally, each L2T STARS tile run loads the means and covariances of the STARS model saved from the most recent tile run, then iteratively advances the means and covariances forward each day updating with fine imagery from HLS and/or moderate resolution imagery from VIIRS up to the day of the target ECOSTRESS overpass. A pixelwise, lagged 16-day implementation of the VNP43 algorithm (Schaaf, 2017) is used for a near-real-time BRDF correction on the VNP09GA products to produce VIIRS NDVI and albedo.

The layers of the L2T STARS product are listed in Table 6. All layers of this product are represented by 32-bit floating point arrays. The NDVI estimates and 1σ uncertainties (-UQ) are unitless from -1 to 1. The albedo estimates and 1σ uncertainties (-UQ) are proportions from 0 to 1.

The layers of the L2T STARS product are listed in Table 6.

Name	Type	Units
NDVI	float32	index: -1 to 1
NDVI-UQ		
albedo	float32	proportion: 0 to 1
albedo-UQ		

6. Listing of the L2T STARS layer names, types, and units.

5 L3/L4 JPL Evapotranspiration Ensemble

The JPL Evapotranspiration Ensemble (JET) product combines the ST and emissivity observed by ECOSTRESS with the NDVI and albedo estimated by STARS, estimates near-surface meteorology by downscaling GEOS-5 FP to these three high resolution images, and runs these variables through a set of surface energy balance models.

5.1 L3G MET and L3T MET Meteorology Products

Coarse resolution near-surface air temperature (Ta) and relative humidity (RH) are taken from the GEOS-5 FP `tavg1_2d_slv_Nx` product. Ta and RH are down-scaled using a linear regression between up-sampled ST, NDVI, and albedo as predictor variables to Ta or RH from GEOS-5 FP as a response variable, within each Sentinel tile. These regression coefficients are then applied to the 70 m ST, NDVI, and albedo, and this first-pass estimate is then bias-corrected to the coarse image from GEOS-5 FP. These downscaled meteorology estimates are recorded in the L3T MET product and mosaicked into the L3G MET product, listed in Table 7. Areas of cloud are filled in with bi-cubically resampled GEOS-5 FP.

Name	Type	Units
Ta	float32	Celsius
RH		proportion: 0 to 1
cloud	uint8	mask
water		

7. Listing of the L3G MET and L3T MET data layer names, types, and units.

5.2 L3G SM and L3T SM Soil Moisture Products

This same down-scaling procedure is applied to soil moisture (SM) from the GEOS-5 FP `tavg1_2d_lnd_Nx` product, which is recorded in the L3T SM product and mosaicked into the L3G SM product, listed in Table 8.

Name	Type	Units
SM	float32	proportion: 0 to 1
cloud	uint8	mask
water		

8. Listing of the L3G SM and L3T SM layer names, types, and units.

5.3 L3G SEB and L3T SEB Surface Energy Balance Products

The JET surface energy balance workflow begins with an artificial neural network (ANN) implementation of the Forest Light Environmental Simulator (FLiES) radiative transfer algorithm, following the workflow established by Dr. Hideki Kobayashi and Dr. Youngryel Ryu. GEOS-5 FP provides sub-daily Cloud Optical Thickness (COT) in the `tavg1_2d_rad_Nx` product and Aerosol Optical Thickness (AOT) from `tavg3_2d_aer_Nx`. Together with STARS albedo, these variables are run through the ANN implementation of FLiES to estimate incoming shortwave radiation (Rg), bias-corrected to Rg from the GEOS-5 FP `tavg1_2d_rad_Nx` product.

The Breathing Earth System Simulator (BESS) algorithm, contributed by Dr. Youngryel Ryu, iteratively calculates net radiation (Rn), ET, and Gross Primary Production (GPP) estimates. The BESS Rn is used as the Rn input to the remaining ET models and is recorded in the L3T SEB product and mosaicked into the L3G SEB product, listed in Table 9.

<table>
<tr><td>Name</td><td>Type</td><td>Units</td></tr>
<tr><td>Rg</td><td rowspan="2">float32</td><td rowspan="2">W m^2</td></tr>
<tr><td>Rn</td></tr>
<tr><td>cloud</td><td rowspan="2">uint8</td><td rowspan="2">mask</td></tr>
<tr><td>water</td></tr>
</table>

9. Listing of the L3G SEB and L3T SEB layer names, types, and units.

5.4 L3G JET and L3T JET JPL Evapotranspiration Ensemble Products

The PT-JPL-SM model, developed by Dr. Adam Purdy and Dr. Joshua Fisher was designed as a SM-sensitive evapotranspiration product for the Soil Moisture Active-Passive (SMAP) mission, and then reimplemented as an ET model in the ECOSTRESS ensemble, using the downscaled soil moisture from the L3T SM product. Similar to the PT-JPL model used in ECOSTRESS Collection 1, The PT-JPL-SM model estimates instantaneous canopy transpiration, leaf surface evaporation, and soil moisture evaporation using the Priestley-Taylor formula with a set of constraints. The total instantaneous ET estimate combining these three partitions is recorded in the L3T JET product as `PTJPLSMinst`. The proportion of instantaneous canopy transpiration is recorded as `PTJPLSMcanopy`, leaf surface evaporation as `PTJPLSMinterception`, and soil moisture as `PTJPLSMsoil`.

The Surface Temperature Initiated Closure (STIC) model, contributed by Dr. Kaniska Mallick, was designed as an ST-sensitive ET model, adopted by ECOSTRESS for improved diurnal estimates of ET. The STIC instantaneous ET is recorded in the L3T JET product as `STICinst`.

The MOD16 algorithm was designed as the ET product for the Moderate Resolution Imaging Spectroradiometer (MODIS). MOD16 uses a similar approach to PT-JPL and PT-JPL-SM to independently estimate vegetation and soil components of instantaneous ET, but using the Penman-Monteith formula instead of Priestley-Taylor. It is provided here as an additional estimate in the L3T JET product, `MOD16inst`.

The ET estimate from BESS is recorded in the L3T JET product as `BESSinst`. The median of `PTJPLSMinst`, `STICinst`, `MOD16inst`, and `BESSinst` is upscaled to a daily ET estimate in millimeters per day and recorded in the L3T JET product as `ETdaily`. The standard deviation between these multiple estimates of ET is considered the uncertainty for the ECOSTRESS evapotranspiration product, as `ETinstUncertainty`. The L3T JET tiles product is mosaicked into the L3G JET gridded product. The layers for the L3G JET and L3T JET products are listed in Table 10. Note that the ETdaily product represents the integrated ET between sunrise and sunset.

Name	Type	Units
ETdaily	float32	W m^{-2}
ETinstUncertainty		
PTJPLSMinst		
STICinst		
MOD16inst		
BESSinst		
PTJPLSMcanopy	uint8	percent: 0 to 100
PTJPLSMinterception		
PTJPLSMsoil		
cloud	uint8	mask
water		

10. Listing of the L3G and L3T JET layer names, types, and units.

5.5 L4G and L4T ESI and WUE Products

The PT-JPL-SM model generates estimates of both actual and potential instantaneous ET. The potential evapotranspiration (PET) estimate represents the maximum expected ET if there were no water stress to plants on the ground. The ratio of the actual ET estimate to the PET estimate forms an index representing the water stress of plants, with zero being fully stressed with no observable ET and one being non-stressed with ET reaching PET. These ESI and PET estimates are distributed in the L4T ESI product and mosaicked into the L4G ESI product, as listed in Table 11.

Name	Type	Units
ESI	float32	ratio: 0 to 1
PET	float32	W m^{-2}
cloud	uint8	mask
water	uint8	mask

Table 11. Listing of the L4G and L4T ESI layer names, types, and units.

The BESS GPP estimate represents the amount of carbon that plants are taking in. The transpiration component of PT-JPL-SM represents the amount of water that plants are releasing. The BESS GPP is divided by the PT-JPL-SM transpiration to estimate water use efficiency (WUE), the ratio of grams of carbon that plants take in to kilograms of water that plants release. These WUE and GPP estimates are distributed in the L4T ESI product and mosaicked into the L4G ESI product, as listed in Table 12.

Name	Type	Units
WUE	float32	g C kg^{-1} H_2O
GPP	float32	μmol m^{-2} s^{-1}
cloud	uint8	mask
water	uint8	mask

Table 12. Listing of the L4G and L4T WUE layer names, types, and units.

6 L3/L4 DisALEXI-JPL Products

In addition to the ensemble product containing PT-JPL-SM, STIC, MOD16, and BESS estimates of ET, there is a separate ET product for DisALEXI-JPL. This product is run independently because it limited to processing within the United States and is prone to unavailable input data. Contributed by Martha Anderson of the United States Department of Agriculture (USDA), DisALEXI-JPL takes an iterative approach to mapping of fine spatial resolution ET based on surface temperature. DisALEXI-JPL ingests the coarse resolution ET images produces by the Atmospheric Land Exchange Interface (ALEXI) model and downscales them using ECOSTRESS ST by running the Two-Source Energy Balance (TSEB) ET model using the ST image from ECOSTRESS, NDVI and albedo from STARS, and meteorology from Climate Forecast System Reanalysis (CSFR). The fine spatial resolution ET output from each TSEB run is compared to the coarse resolution image from ALEXI, and an adjustment is applied to the air temperature input before running TSEB again. This spatial disaggregation approach to ET estimation produces daily ET images that are sensitive to ECOSTRESS ST, but this product does not contain an instantaneous estimate of ET for diurnal analysis. Daily ET in millimeters per day with uncertainty is written to the L3T ET ALEXI product, as listed in Table 13, and ESI with uncertainty is written to the L4T ESI ALEXI product, as listed in Table 14. These tiled products are mosaicked into the L3G ET ALEXI and L4G ESI ALEXI products.

Name	Type	Units
ETdaily	float32	mm/day
ETdailyUncertainty	float32	mm/day

13. Listing of the L3G and L3T ET ALEXI layer names, types, and units.

Name	Type	Units
ESIdaily	float32	ratio: 0 to 1
ESIdailyUncertainty	float32	ratio: 0 to 1

Table 14. Listing of the L4G and L4T ET ALEXI layer names, types, and units.

Acknowledgements

We would like to thank Joshua Fisher as the initial science lead of the ECOSTRESS mission and PI of the ROSES project to re-design the ECOSTRESS products.

We would like to thank Adam Purdy for contributing the PT-JPL-SM model.

We would like to thank Kaniska Mallick for contributing the STIC model.

We would like to thank Martha Anderson for contributing the DisALEXI-JPL algorithm.

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Schaaf, C. (2017). *VIIRS BRDF, Albedo, and NBAR Product Algorithm Theoretical Basis Document (ATBD).* NASA Goddard Space Flight Center.