European ECOSTRESS Hub 2 Product Specification Document

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1	0	2025-10-16	Hu, Lin, Didry	Initial version
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List of abbreviation

Abbreviation	Full name
ATBD	Algorithm Theoretical Basis Document
EEH2	European ECOSTRESS Hub Phase 2
ECOSTRESS	ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station
ET_i	Instantaneous evapotranspiration
ET_d	Daily evapotranspiration
GPP_i	Instantaneous Gross Primary Productivity
GPP_d	Daily Gross Primary Productivity
LUT	Look-Up Table
PSD	Product Specification Document
RTTOV	Radiative Transfer for TIROS Operational Vertical Sounder
TES	Temperature and Emissivity Separation
TOA	Top of Atmosphere
WUE	Water Use Efficiency

Contents

1. Introduction

1.1. Identification

This is the Product Specification Document (PSD) for Levels 2-4 products of ECOSTRESS over Europe and Africa generated in the European ECOSTRESS Hub 2 (EEH2) project. The EEH2 Levels 2-4 products provide land surface temperature (LST), instantaneous evapotranspiration (ET_i), daily evapotranspiration (ET_d), gross primary productivity (GPP), and water use efficiency (WUE). The algorithms for generating these products can be found in the corresponding Algorithm Theoretical Basis Documents (ATBDs).

1.2. Purpose and scope

The PSD describes the Levels 2-4 products generated in EEH2. These include the detailed descriptions of the format and contents of the products stored on the WASDI platform (https://www.wasdi.cloud/). The scope is to provide readers with sufficient information for better utilisation of the EEH2 products.

1.3. Applicable and reference documents

The applicable and reference documents are presented in this document to provide additional information to readers for a better understanding of the products. The applicable documents include the EEH1 ATBD for LST (EEH-LST_ATBD), the EEH1 ATBD for ET_i (EEH-ET_ATBD), the EEH2 ATBD for ET_d (D1.1-ATBD-ET) and the EEH2 ATBD for GPP and WUE (D1.2-ATBD-GPP-WUE). The reference documents can be found in respective parts in Section 2.

2. EEH2 products

In EEH2, the ECOSTRESS Collection 2 L1B top-of-atmosphere (TOA) radiance (L1B_RAD) and geolocation (L1B_GEO) data, along with the L2 cloud mask data (L2_CLOUD), are downloaded from the NASA Earthdata Search platform (https://search.earthdata.nasa.gov/). The L2-L4 products generated in EEH2 are listed in Table 1.

Table 1 EEH2 products and related descriptions

Product type	Description
L2_LSTE	Land surface temperature and emissivity
L3_ET	Instantaneous and daily evapotranspiration
L3_GPP	Gross primary productivity
L4_WUE	Water use efficiency

2.1. LST

The LST product is generated using the temperature and emissivity separation (TES) algorithm adapted to ECOSTRESS. The ERA5 atmospheric profiles are input into the atmospheric radiative transfer model Radiative Transfer for TIROS Operational Vertical Sounder (RTTOV). The calculated atmospheric parameters, along with the ECOSTRESS TOA radiances, are used to estimate LST and emissivity simultaneously. More details about the TES algorithm used for generating the EEH LST can be found in the EEH1 LST ATBD (EEH-LST_ATBD) and the LST evaluation paper published by Hu et al. (2022).

The LST product is stored in the Hierarchical Data Format version 5 (HDF5). The HDF5 format is widely used to storing scientific data. It organizes data in a hierarchical structure and stores groups and datasets. More information about the HDF5 structure and application software can be found at https://www.hdfgroup.org/solutions/hdf5/.

The filename of the EEH2 LST product has the following form:

EEH2TES_L2_LSTE_<OOOOO>_<SSS>_<YYYYMMDD>T<HHMMSS>_0000_00.h5

Where:

EEH2TES_L2_LSTE indicates the product is the EEH2 Level 2 land surface temperature and emissivity product generated using the TES algorithm,

<OOOOO> is the orbit number, starting at the start of mission, ascending equatorial crossing,

<SSS> is the Scene ID, starting at the first scene of each orbit,

<YYYYMMDD> is the year, month and day of the scene,

<HHMMSS> is the hour, minute and second (UTC time) of the scene.

The structure of the EEH2 LST product file is organized as in Table 2.

Table 2 EEH2 LST product definition

Field name	Type	Unit	Field data	Valid minimum	Valid maximum	Fill value	Scale factor	Offset
BBE	Int8	N/A	Broadband emissivity	1	255	0	0.002	0.49
Emis2	Int8	N/A	Band 2 emissivity	1	255	0	0.002	0.49
Emis4	Int8	N/A	Band 4 emissivity	1	255	0	0.002	0.49
Emis5	Int8	N/A	Band 5 emissivity	1	255	0	0.002	0.49
LST	Int16	K	Land surface temperature	7500	65535	0	0.02	0
qa[*]	Int8	N/A	Quality assurance flag	-5	5	-9999	1	0

[*]The qa information can be found in the LST ATBD (EEH-LST_ATBD).

The LST product is generated using the ECOSTRESS swath data and is therefore not georeferenced. The geolocation information is needed from the L1B_GEO data. Meanwhile, all the pixels from L1B_RAD are processed, including both clear-sky and cloudy conditions. The L2_CLOUD product is needed to filter out the cloudy pixels and keep only the clear-sky pixels.

2.2. ET_i and ET_d

The ET_i product is generated using the Surface Temperature Initialized Closure (STIC) model adapted to ECOSTRESS. The EEH2 LST is used in the model to characterize the surface wetness condition that is integrated into the calculation of surface conductance, aerodynamic conductance, and aerodynamic temperature. More details about the STIC model adapted for

Project: EUROPEAN ECOSTRESS HUB 2   PSD (D1.3) V2.0 Status: **Updated**
Contract-No.:4000129873/20/I-NS   Date: 10.11.2025
p. 8 / 14

the ECOSTRESS ET retrieval can be found in the EEH1 ET ATBD (EEH-ET_ATBD) and the ET evaluation paper published by Hu et al. (2023).

The ET_d product is produced based on the ET_i data, which integrates the instantaneous retrieval to the daily scale. A look-up table (LUT) method is used in EEH2 based on the extraterrestrial solar radiation and constrained by different stress factors across various ecosystems. More details of the newly developed LUT method for generating ET_d can be found in the EEH2 Daily ET ATBD (D1.1-ATBD-ET).

The ET_i and ET_d data are stored in the same HDF5, through which users can obtain both information from the same product. Meanwhile, the intermediate variables are also provided in the same file to facilitate further analysis of the surface energy balance process.

The filename of the EEH2 ET product has the following form:

EEH2STIC_L3_ET_<OOOOO>_<SSS>_<YYYYMMDD>T<HHMMSS>_0000_00.h5

Where:

EEH2STIC_L3_ET indicates the product is the EEH2 Level 3 evapotranspiration product generated using the STIC model,

<OOOOO> is the orbit number, starting at the start of mission, ascending equatorial crossing,

<SSS> is the Scene ID, starting at the first scene of each orbit,

<YYYYMMDD> is the year, month and day of the scene,

<HHMMSS> is the hour, minute and second (UTC time) of the scene.

The structure of the EEH2 ET product file is organized as in Table 3.

Table 3 EEH2 ET product definition

Field name	Type	Unit	Field data	Valid minimum	Valid maximum	Fill value	Scale factor	Offset
ETD	Float32	mm. day^{-1}	Daily ET	0	2000	-9999	1	0
G	Float32	W.m^{-2}	Soil heat flux	0	2000	-9999	1	0
H	Float32	W.m^{-2}	Sensible heat flux	0	2000	-9999	1	0
LE	Float32	W.m^{-2}	Latent heat flux	0	2000	-9999	1	0

Mrz	Float32	N/A	Water stress root zone	0	2000	-9999	1	0
Ms	Float32	N/A	Surface water stress	0	2000	-9999	1	0
Rn	Float32	$W.m^{-2}$	Net radiation	0	2000	-9999	1	0
gah	Float32	$m.s^{-1}$	Aerodynamic conductance	0	2000	-9999	1	0
gsc	Float32	$m.s^{-1}$	Surface conductance	0	2000	-9999	1	0

The ET product is generated based on the EEH2 LST swath data and is therefore not georeferenced. The geolocation information is needed from the L1B_GEO data. During the data generation, the L2_CLOUD product is used to filter out the cloudy pixels and keep only the clear-sky pixels.

2.3. GPP_d and WUE

The GPP_i product is generated based on STIC-LUE model adapted to ECOSTRESS, and then is scaled to GPP_d based on ratio of instantaneous PAR to daily PAR. The WUE product is generated based on GPP_d and ET_d product stored in the Hierarchical Data Format version 5 (HDF5). More details about the STIC model adapted for the ECOSTRESS GPP_d and WUE retrieval can be found in the EEH2 GPP ATBD (D1.2-ATBD-GPP-WUE).

The GPP_d and WUE data are stored in the same HDF5. Meanwhile, the intermediate variables and the land cover map for generating GPP_i, also provided in the same file to facilitate further analysis.

The filename of the EEH2 GPP_d and WUE product has the following form:

EEH2STIC_L3_GPP_<OOOOO>_<SSS>_<YYYYMMDD>T<HHMMSS>_0000_00.h5

Where:

EEH2STIC_L3_GPP indicates the product is the EEH2 Level 3 GPP product generated using the STIC model,

<OOOOO> is the orbit number, starting at the start of mission, ascending equatorial crossing

<SSS> is the Scene ID, starting at the first scene of each orbit,

<YYYYMMDD> is the year, month and day of the scene,

<HHMMSS> is the hour, minute and second (UTC time) of the scene.

The structure of the EEH2 GPP_d and WUE product file is organized as in Table 4.

<p align="center">Table 4 EEH2 GPP product definition</p>

Field name	Type	Unit	Field data	Valid minimum	Valid maximum	Fill value	Scale factor	Offset
GPP_d	Float32	$gC.m^{-2}.day^{-1}$	Daily GPP	0	50	-9999	1	0
WUE	Float32	$gC\ m^{-2}/mm\ H_2O$	Water use efficiency	0	100	-9999	1	0
GPP_i	Float32	$gC.m^{-2}.s^{-1}$	Instantaneous GPP	0	0.001	-9999	1	0
GPP_LUE	Float32	$gC.m^{-2}.s^{-1}$	LUE-based GPP	0	0.001	-9999	1	0
GPP_gs	Float32	$gC.m^{-2}.s^{-1}$	STIC-gs based GPP	0	0.001	-9999	1	0
LUCC	Int16	None	Land cover map	0	18	-9999	1	0

The GPP_d and WUE product is generated based on the EEH2 LST swath data and is therefore not georeferenced. The geolocation information is needed from the L1B_GEO data. During the data generation, the L2_CLOUD product is used to filter out the cloudy pixels and keep only the clear-sky pixels. We did not generate data if the cloud coverage of the scene is more than 75%, because such cloud contamination will cause significant errors for the GPP estimation. Images observed at nighttime (solar zenith angle>90 degree) and pixels where vegetation coverage less than 25% (FCOVER<0.25) are also excluded in this dataset when generating GPP_i.

3. Summary

The EEH2 product generation builds on the EEH1. Based on the LST and ET evaluation results in EEH1, the TES and STIC models are selected to generate the ECOSTRESS LST and ET in EEH2, respectively. Based on the generated instantaneous ET products, the daily ET is subsequently generated. The surface and aerodynamic conductances, which are the byproducts of ET, are used to generate GPP. Finally, the ECOSTRESS WUE product is generated based on the daily ET and daily GPP. The relationship between these products is described in the flowchart below.
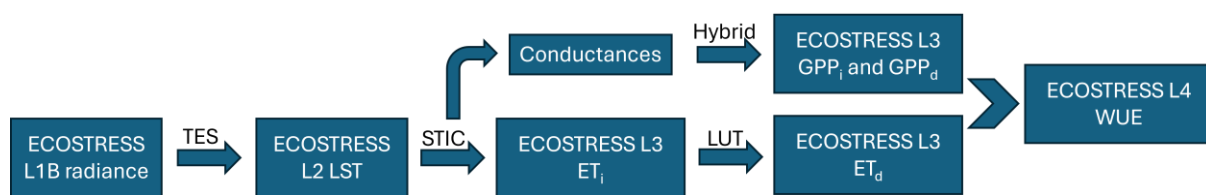

Figure 1 Interconnection between the ECOSTRESS L2-L4 products.

All the ECOSTRESS products generated in EEH2 have the same temporal (1-5 days revisit) and spatial resolutions (~70 m) as the ECOSTRESS L1B radiance data. The spatial extend covers Europe and Africa. Since the swath data are used in the generation, the ECOSTRESS L1B geolocation data are also needed to provide the geo-reference.

Acknowledgement

Reference

Tian Hu, Kaniska Mallick et al. (2022). Continental-scale evaluation of three ECOSTRESS land surface temperature products over Europe and Africa: Temperature-based validation and cross-satellite comparison, Remote Sensing of Environment, 282, 113296

Tian Hu, Kaniska Mallick et al. (2023). Evaluating European ECOSTRESS Hub evapotranspiration products across a range of soil-atmospheric aridity and biomes over Europe, Water Resources Research, 59(8), e2022WR034132