Data Format Control Book

Level 1A product

V1.2

Updated: 24 June 2025

Contents

References

This document is one in our *Data Format Control Books* series. This series is meant to describe products created by *FarEarth* in a way that is readable by humans. The machine-readable schemas are published on our GitHub repository.

This document describes our Level 1A product. A sample of a complete Level 1A product with its individual files is available. The version of this document is intended to match the *FarEarth Executors* and software with the same version numbers. The links below are for the specific schema and sample versions that match this document.

Description	Link
A complete L1A product as created by the *FarEarth* system in a compressed format	LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1.zip
The GitHub repository containing schema and markdown files for the L1A product	Github: L1/V1.2/L1A/

1 Purpose and scope

This *Data Format Control Book* describes Level 1A products produced by *FarEarth*. For other Levels, see our series of *Data Format Control Books*.

Our public GitHub (https://github.com/pinkmatter) repositories contain schemas and examples that may be used to verify the files documented here.

1.1 Document conventions

The following terminology is used in this document. This document does not include information regarding the complete structure of the products but rather describes how to interpret and use the *FarEarth* product files. For a complete reference of the structure and format refer to the schema file and product sample files available on our GitHub repositories.

The following terminology is used in this document.

Term	Definition
Asset	An asset is a file that makes up part of a product
Tiepoint	A tiepoint is a collection of pixels representing a feature used to spatially correlate two or more images or bands
ISO-8601	ISO-8601 describes a format for date and time information. *FarEarth* uses UTC dates; an example of an ISO-8601-formatted string in *FarEarth* is: “2019-10-25T09:00:00Z”
NavAtt	Navigation and attitude data
Product	A product in *FarEarth* is a satellite images with its related metadata and consist of a collection of related files
RPC	Rational polynomial coefficient
ESUN	Exo-atmospheric solar irradiance

Table 1: Common terminology

1.2 About the *Data Format Control Book* series

The *FarEarth* processing system processes satellite raw data into orthorectified map-ready data. *FarEarth* can generate a variety of products. These products have different characteristics and levels of processing and correction. Low-level data is usually satellite specific. Higher levels are more useful for analysis and comparison between satellites.

The *FarEarth Data Format Control Books* series is a reference for the interpretation of the data and metadata of these different product levels. Here is a reminder of the different levels.

Raw

Raw data is the original data, as downlinked by the satellite. *FarEarth* supports various binary formats.

Level 0

A Level 0 product is raw data that has been reformatted but not processed. It is a format that *FarEarth* uses to represent raw data from different satellites in a standard and consistent way.

Level 1

Level 1 products are processed in stages with increasing radiometric calibration and geometric correction applied.

Sub-levels	Definition
L1A	Generated by using the L0 as input. This is a non-destructive operation. The main purpose is to mark bad pixels (dropped/under-saturated/over-saturated). The pixel digital number values are converted into radiance using radiometric calibration coefficients and the bands are systematically geolocated without resampling the pixels **See document:** FarEarth-L1A-Data-Format-Control-Book-V1_2.pdf (this document)
L1B	Generated by using the L1A as input. This is a destructive operation. The L1B product's pixel data is geometrically orthorectified and band-aligned, but the pixel data is not yet map-projected. The pixel data is converted to top-of-atmosphere (TOA) reflectance or kept in radiance. Orthorectification and band alignment may either be performed using a systematic or precision model. A systematic model is constructed using only geometric calibration and the satellite's NavAtt data, while a precision model is a refined model using tiepoints. For orthorectification, tiepoints to an absolute reference image are used. For band alignment, relative tiepoints between bands are used **See document:** FarEarth-L1B-Data-Format-Control-Book-V1_2.pdf
L1C	Generated by using the L1B as input. This is a destructive operation. The L1C product is map-projected. The pixel data is either in TOA reflectance or radiance. Some quality metrics are added to the product, such as geometric accuracy measurements (absolute and/or relative) **See document:** FarEarth-L1C-Data-Format-Control-Book-V1_2.pdf

Table 2: Level 1 sub-levels

Level 2

Level 2 data has radiometric corrections applied. Geometrically it is the same as Level 1 data.

Sub-level	Definition
L2A	The purpose of the L2A is to radiometrically correct the pixel data to account for atmospheric conditions. The reflective bands' pixel values are atmospherically corrected and converted to surface reflectance

Table 3: Level 2 sub-levels

2 Level 1A product file

A Level 1A product produced by *FarEarth* has radiometric calibration and basic geometric corrections applied. It is an intermediate product that may be useful for quick radiometric quality analysis when full orthorectification is not required.

Every *FarEarth* product consists of a *product* file and a set of asset files. The *product* file describes the product at a high-level and lists the asset files. Each asset file has a type and at least one role associated with it. The role describes the information and intended use of the file. The type describes the file format.

Product files may also contain high-level metadata used to index the *product*.

Asset types are described in Table 4.

Role	Asset description	Described in document section
data	Data asset files contain data that was captured by the satellite sensor	3 Level 1A data files
metadata	Metadata asset files provide context and information about the data assets	4 Level 1A metadata files
quality	Quality assessment assets provide information about the quality of the data assets	5 Level 1A quality assessment files
thumbnail	Thumbnail assets provide small overview images typically used in catalogues and web browsers	6 Level 1A thumbnail files
rpc	RPC files contain coefficients used to transform pixel and scanline coordinates into latitude, longitude and height	7 Level 1A RPC files

Table 4: Asset roles

Note: Because Level 1A is an intermediate product, your workflow may not be configured to archive this product.

3 Level 1A data files

A Level 1A product has one *data* file per band. Geolocated pixel data for each band is contained in a separate cloud optimised GeoTiff file. A systematic geometric model is applied. The pixel data is not precision aligned against reference data. LZW compression and a block size of 512 are used.

Property	Description
digital numbers	Pixel values in digital numbers as acquired by the sensor. Values have not been scaled to any units
radiance	Pixel values in radiance. Images in radiance has absolute radiometric calibration applied to the digital numbers. The value of each pixel is in units of watts per square meter per steradian $[\frac{W}{m^2\ sr}]$

Table 5: Pixel units

4 Level 1A metadata files

One or more files containing metadata are created with each *FarEarth* product. These files describe the product and conditions under which the data was acquired. Different files containing metadata of the Level 1A product are listed in Table 6.

File	Description	Section
Metadata	The main metadata file for the product. Typically has the extension *.geojson* and is readable by third-party applications	4.1 Metadata file
NavAtt	A file that contains all the navigation and attitude information for the product	4.2 NavAtt file
Scantime	A file that contains all the scan times for each row for the product	4.3 Scantimes file

Table 6: Metadata files

The samples below are JSON or GeoJSON files but additional formats are available in *FarEarth*. The property descriptions below are valid for all of these formats.

4.1 Metadata file

The *metadata* file is the GeoJSON file that describes the product. The file is made up of a feature collection with a single feature representing the product properties which includes sensor properties. The geometry describes the product geolocation footprint. Only selected properties distinct to *FarEarth* are documented in this section.

See schema: METADATA_V1_2.json

See sample: LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1.geojson

Product properties

This section documents general properties of the product.

Property	Description
descriptor	The descriptor element contains general product properties
descriptor:productId	An identifier for this product. Identifiers do not necessarily need to be unique within the *FarEarth Catalogue*, but it is recommended that the naming scheme be designed in such a way that it is unique
descriptor:productType	For L1A products this is always L1A
descriptor:spacecraft	The name of the satellite that captured this product
descriptor:sensors	A list of identifiers used to uniquely identify the sensor modules on the satellite
descriptor:temporalRange	A pair of ISO-8601 dates and times indicating the start and end of the period when the sensor was capturing pixels
descriptor:generationDate	An ISO-8601 date and time indicating when this product was generated
descriptor:sceneRow	If an interval is subdivided into multiple scenes, this property will reflect the row number of the scene. Row numbers start at 1, along the track of the satellite
descriptor:sceneCol	If an interval is subdivided into multiple scenes, this property will reflect the column number of the scene. Column numbers start at 1 from the left
thumbnails	An array of thumbnails
thumbnails:name	The human readable name of the thumbnail
thumbnails:image	The reference to the thumbnail image file
elevation	Elevation metadata of the product
elevation:averageMsl	The average meters above sea level of the area covered in the product
elevation:averageHae	The average Height Above Ellipsoid of the area covered in the product
pixelCount	The number of pixels in the L1A product. This is the sum of all the pixels in all the bands
navAtt	Reference to the *NavAtt* file. See Section 4.2 NavAtt file for details
scanTimes	Reference to the *scantime* file. See Section 4.3 Scantimes file for details
software	Information regarding the software used to generate the product

Table 7: Product properties

Sensors

The *sensors* section contains details of each sensor module on the satellite. Each sensor module listed in the *descriptor:sensors* property of the product section has a corresponding entry here.

Each sensor has a *descriptor* section and a *bands* section.

This table documents the *descriptor* section of the sensor.

Property	Description
name	Human readable name for the sensor. This is not guaranteed to be unique within the product
id	Identifier that the processing system uses internally to uniquely identify each band on the sensor
ancillaries	A list of the ancillary files or products that were used to process this image. Ancillaries include a reference to the calibration files
dimensions	A pair of values representing the across and along dimensions of the sensor in pixels

Table 8: Sensor properties

The *bands* element is an array of complex properties. Each processed band has an entry in this array.

This table describes the properties for each band.

Property	Description
name	Human readable name for the band. This is not guaranteed to be unique within the sensor
id	Identifier that the processing system uses internally to identify the band. This is guaranteed to be unique within the product
group	The group to which the band belongs. All bands of the same group will be combined into a single data file in an L1C product
image	Reference to the pixel data file for this band. In a L1A product the data from each band is contained in a separate image data file
qaMask	Reference to the image file containing the quality assessment mask for this band. In a L1A product the quality assessment mask for each band is contained a separate file
rpc	The rational polynomial coefficient file for this band. In a L1A product there is a separate RPC file for each band
viewingGeometry	The viewing geometry for this band. An array of pixel coordinate and incidence angle pairs. The viewing geometry is based on a systematic model only
radiometric	The radiometric section of the band
radiometric:units	The radiometric units that the pixel data represent. See Section 3 for details
radiometric:esun	The ESUN units and value that was used to process this band
radiometric:spectral	The spectral properties of the band, *centerWavelength* and *fullWidthHalfMax*
radiometric:earthSunDistance	The distance between the earth and the sun used to produce this L1A product in astronomical units
radiometric:solarElevation	Sun elevation angle. The angle from the tangent of the scene centre point to the sun. Measured from the horizon in degrees (-90° to 90°). Negative values indicate the sun is below the horizon, e.g. sun elevation of -10° means the data was captured during nautical twilight
radiometric:solarAzimuth	Sun azimuth angle. From the scene centre point on the ground, this is the angle between true north and the sun. Measured clockwise in degrees (0° - 360°)
geometric	The geometric section of the band
geometric:projection	The geometric projection of this band onto the Earth. EPSG projections are used in the form “EPSG:XXXXX”
geometric:dimensions	A pair of numbers representing the number of pixels across track and along track respectively

geometric:resolution	The target size of each pixel when projected onto the Earth across track and along track respectively. The along track value may be negative, to reflect the convention of the upper left corner of the image having coordinate [0, 0], while pixel rows are counted from the first row of the sensor. In this case the absolute value of the number is the along track GSD
geometric:geometry	A polygon representing the footprint on the band on Earth. Coordinates are for the projection above
sensor	The sensor section contains properties relating to the sensor acquisition mode
sensor:alongScanDirection	Also known as integration direction. This is the direction that the TDI system on the satellite integrated. This property will be set to either: POSITIVE: *sensorStartRow* and rows following it are summed NEGATIVE: *sensorStartRow* and rows preceding it are summed
sensor:sensorStartRow	The first row of the sensor that captured data for this band. This property is read from the satellite raw data
sensor:alongBinning	The number of sensor pixels that are combined by the sensor TDI system along track to generate a single image pixel
sensor:acrossBinning	The number of sensor pixels that are combined by the sensor TDI system across track to generate a single image pixel

Table 9: Sensor band properties

Geometry

The *geometry* section defines the full footprint of the image. It is formatted according to RFC 7946.

Property	Description
type	The type of shape that is described in the *coordinates* property
coordinates	A list of coordinates that describe the position of the image on the Earth

Table 10: Geometry properties of the session

4.2 NavAtt file

The *NavAtt* file contains values derived from the attitude and ephemeris data downlinked from the satellite. The values may have been filtered depending on the *FarEarth* workflow used to create the product.

See schema: NAVATT_V1_2.json

See sample: LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1_NAVATT.json

Property	Description
inertialFrame	The reference frame of the attitude quaternions
attitude	An array of timestamp and quaternion pairs. The timestamp seconds and nanoseconds are stored as separate values. The quaternion is formatted as a list of s, i, j, k unitless values
ephemeris	An array of timestamp and ephemeris values. The timestamp seconds and nanoseconds are stored as separate values. The ephemeris consists of instantaneous ECI and ECR position and velocity vectors

Table 11: Navatt properties

4.3 Scantimes file

The *scantimes* file contains values derived from the scan time data downlinked from the satellite. The values may have been filtered depending on the *FarEarth* workflow used to create the product.

See schema: SCANTIMES_V1_2.json

See sample: LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1_SCANTIME.json

The file contains scan times for each band listed in the *metadata* file (Section 4.1 Metadata file).

Property	Description
bandId	The band identifier
scanTimesByRow	An array of timestamps – one timestamp for every scanline in the band. The timestamp seconds and nanoseconds are stored as separate values. The scanlines are listed in the sequence they are captured. This means that the scanlines may be reversed depending on the *alongScanDirection.* This may not necessarily be consistent within an image as *FarEarth* caters for satellites that have sensors mounted with opposing scan directions

Table 12: Scantime properties

5 Level 1A quality assessment files

A Level 1A product has one *quality assessment* file per band listed in the *metadata* file (Section 4.1 Metadata file).

A *quality assessment* file is an image file containing the quality assessment mask for the band. Each pixel in the mask indicates the quality of the corresponding pixel in the band data. The mask is therefore in the same map projection as the band data. The possible pixel values of the mask are listed in Table 13.

See sample: LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1_MS_1_BLUE_1_QA.tif

Value	Meaning
0	No special information regarding this pixel
1	The pixel is undersaturated. The value of the pixel is below the minimum threshold of what the sensor is capable of measuring, therefore this pixel is uncertain
2	The pixel is oversaturated. The value of the pixel is above the maximum threshold of what the sensor is capable of measuring, therefore this pixel is uncertain

Table 13: Quality mask values

6 Level 1A thumbnail files

A *thumbnail* file is a low-resolution version of the actual product image. It is a small file meant to give you an overview of the product without the need to download the full data. A *FarEarth* product will contain at least one thumbnail. Multiple thumbnails may be included for example showing different band combinations, masks or other information as well. Thumbnails may have different file types.

See sample: LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1_RGB.png

7 Level 1A RPC files

RPC files are text files that contain the polynomials to georeference the image.

See sample: LANDSAT-9_OLI_20220804T083603_20220804T083634_L1A_R1C1_MS_1_BLUE_1_rpc.txt