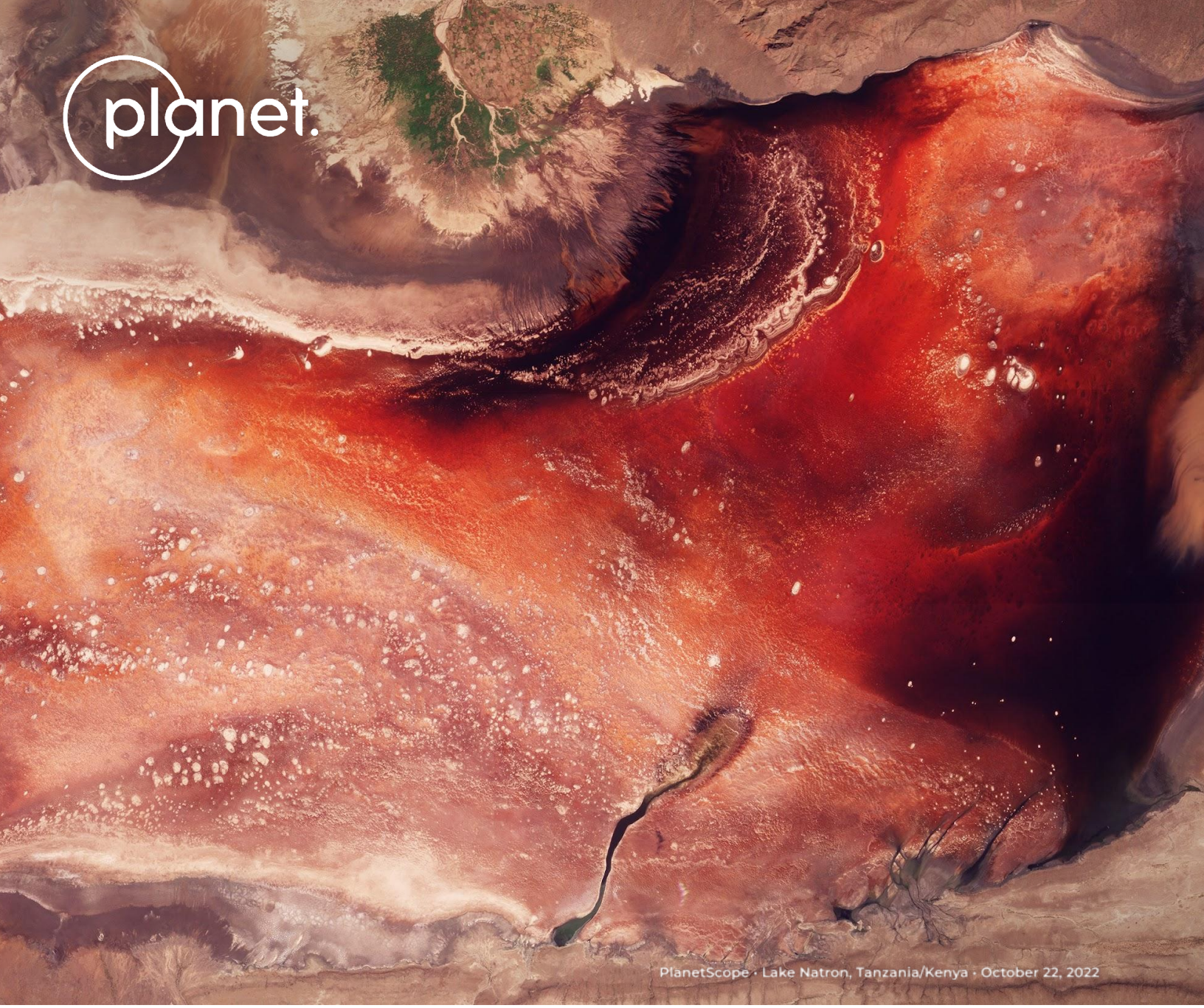



(All images acquired after November 29, 2023 will have a value of “0” in band 5)

# PlanetScope Product Specifications

TABLE OF CONTENTS

**Glossary** **4**

**1. Overview of Document** **9**

1.1. COMPANY OVERVIEW 9

1.2 DATA PRODUCT OVERVIEW 9

**2. Satellite Constellation and Sensor Overview** **10**

2.1 PLANETSCOPE SATELLITE CONSTELLATION AND SENSOR CHARACTERISTICS 10

Table 2-A: PlanetScope Constellation and Sensor Specifications 11

**3. PlanetScope Imagery Products** **12**

Table 3-A: PlanetScope Satellite Image Product Processing Levels 12

3.1 RADIOMETRIC INTERPRETATION 14

3.1.1 PLANETSCOPE NORMALIZATION AND HARMONIZATION 15

3.2 PLANETSCOPE BASIC ANALYTIC SCENE PRODUCT SPECIFICATION 15

Table 3-B: PlanetScope Analytic Basic Scene Product Attributes 15

3.3 PLANETSCOPE ORTHO PRODUCT SPECIFICATION 17

Table 3-C: PlanetScope Ortho Scene Product Attributes 17

3.3.1 PlanetScope Ortho Visual Scene Product Specification 18

Table 3-D: PlanetScope Visual Ortho Scene Product Attributes 18

3.3.2 PlanetScope Analytic Ortho Scene Product Specification 19

Table 3-E: PlanetScope Analytic Ortho Scene Product Attributes 19

3.4 RADIOMETRIC INTERPRETATION 20

3.5 PLANETSCOPE BASEMAP MOSAIC TILES PRODUCT SPECIFICATION 21

Table 3-F: Individual Quad Specifications 21

**4. Product Processing4. PRODUCT PROCESSING** **22**

4.1 PLANETSCOPE PROCESSING 22

Table 4-A: PlanetScope Processing Steps 22

Figure 4: PlanetScope Image Processing Chain 23

**5. Product Metadata** **24**

5.1 ORTHO SCENES 24

Table 5-A: PlanetScope Ortho Scene GeoJSON Metadata Schema 24

Table 5-B: PlanetScope Ortho Scene Surface Reflectance GeoTIFF Metadata Schema 27

5.2 BASIC SCENES 29

Table 5-C: PlanetScope Basic Scene GeoJSON Metadata Schema 29

**6. Product Delivery** **31**

6.1 PLANET APPLICATION PROGRAMMING INTERFACES (APIS) 31

6.2 PLANET EXPLORER GRAPHICAL USER INTERFACE (GUI) 31

6.3 PLANET ACCOUNT MANAGEMENT TOOLS 32

**Appendix A – Image Support Data** **33**

1. GENERAL XML METADATA FILE 33

Table A-1: General XML Metadata File Field Descriptions 33

2. UNUSABLE DATA MASK FILE 38

3. USABLE DATA MASK FILE 39

## Glossary

The following list defines terms used to describe Planet's satellite imagery products.

**Alpha Mask**
An alpha mask is an image channel with binary values that can be used to render areas of the image product transparent where no data is available.

**Application Programming Interface (API)**
A set of routines, protocols, and tools for building software applications.

**Atmospheric Correction**
The process of correcting at-sensor radiance imagery to account for effects related to the intervening atmosphere between the earth's surface and the satellite. Atmospheric correction has been shown to significantly improve the accuracy of image classification.

**Blackfill**
Non-imaged pixels or pixels outside of the buffered area of interest that are set to black. They may appear as pixels with a value of "0" or as "noData" depending on the viewing software.

**Digital Elevation Model (DEM)**
The representation of continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. DEMs are typically used to represent terrain relief.

**GeoJSON**
A standard for encoding geospatial data using JSON (see JSON below).

**GeoTIFF**
An image format with geospatial metadata suitable for use in a GIS or other remote sensing software.

**Ground Sample Distance (GSD)**
The distance between pixel centers, as measured on the ground. It is mathematically calculated based on optical characteristics of the telescope, the altitude of the satellite, and the size and shape of the CCD sensor.

**Graphical User Interface (GUI)**
Web based interfaces enable users to interact with Planet's imagery products without needing knowledge of how to use APIs or Application Programming Interfaces.

**JavaScript Object Notation (JSON)**
Text-based data interchange format used by the Planet API.

**Landsat 8**
Freely available dataset offered through NASA and the United States Geological Survey.

**Metadata**
Data delivered with Planet's imagery products that describes the products content and context and can be used to conduct analysis or further processing.

**Nadir**
The point on the ground directly below the satellite.

**Near-Infrared (NIR)**
Near Infrared is a region of the electromagnetic spectrum.

**Orthorectification**
The process of removing and correcting geometric image distortions introduced by satellite collection geometry, pointing error, and terrain variability.

**Ortho Tile**
Ortho Tiles are Planet's core product lines of high-resolution satellite images. Ortho tiles are available in two different product formats: Visual and Analytic, each offered in GeoTIFF format.

**PlanetScope**
The first three generations of Planet's optical systems are referred to as PlanetScope 0, PlanetScope 1, and PlanetScope 2.

**Radiometric Correction**
The correction of variations in data that are not caused by the object or image being scanned. These include correction for relative radiometric response between detectors, filling non-responsive detectors and scanner inconsistencies.

**Reflectance Coefficient**
The reflectance coefficient provided in the metadata is used as a multiplicative to convert Analytic TOA Radiance values to TOA Reflectance.

**RapidEye**
RapidEye refers to the five-satellite constellation operating between 2009 and 2020.

**Scene**
A single image captured by a PlanetScope satellite.

**Sensor Correction**
The correction of variations in the data that are caused by sensor geometry, attitude and ephemeris.

**Sentinel-2**
Copernicus Sentinel-2 is a multispectral imaging satellite constellation operated by the European Space Agency.

**SkySat**
SkySat refers to Planet's high resolution satellite constellation in operation since 2014.

**Sun Azimuth**
The angle of the sun as seen by an observer located at the target point, as measured in a clockwise direction from the North.

**Sun Elevation**
The angle of the sun above the horizon.

**Sun Synchronous Orbit (SSO)**
A geocentric orbit that combines altitude and inclination in such a way that the satellite passes over any given point of the planet's surface at the same local solar time.

**Surface Reflectance (SR)**
Surface reflectance is the amount of light reflected by the surface of the earth. It is a ratio of surface radiance to surface irradiance, and as such is unitless, and typically has values between 0 and 1. The Surface Reflectance (SR) Product is derived from the standard Planet Analytic (Radiance) Product and is processed to top of atmosphere reflectance and then atmospherically corrected to (bottom of atmosphere) surface reflectance. Planet uses the 6S radiative transfer model with ancillary data from MODIS to account for atmospheric effects on the observed signal at the sensor for the PlanetScope constellation.

**Tile Grid System**
Ortho tiles are based on a worldwide, fixed UTM grid system. The grid is defined in 24 km by 24 km tile centers, with 1 km of overlap (each tile has an additional 500 m overlap with adjacent tiles), resulting in 25 km by 25 km tiles.

**Unusable Data Mask**

The unusable data mask is a raster image having the same dimensions as the image product, indicating on a pixel-by-pixel basis which pixels are unusable because they are cloud filled, outside of the observed area and therefore blackfilled, or the pixel value is missing or suspect (due to saturation, blooming, hot pixels, dust, sensor damage, etc). The unusable data mask is an 8-bit image, where each pixel contains a bit pattern indicating conditions applying to the imagery pixel. A value of zero indicates a "good" imagery pixel.

- Bit 0: Black fill - Identifies whether the area contains blackfill in all bands (this area was not imaged by the spacecraft). A value of "1" indicates blackfill.
- Bit 1: Cloud - This pixel is assessed to likely be an opaque cloud.
- Bit 2: Blue is missing or suspect.
- Bit 3: Green is missing or suspect.
- Bit 4: Red is missing or suspect.
- Bit 5: Red Edge is missing or suspect
- Bit 6: NIR is missing or suspect
- Bit 7: Coastal Blue and/or Green I and/or Yellow is missing or suspect

**Usable Data Mask**

The usable data mask is a raster image having the same dimensions as the image product, composed of 8 bands, where each band represents a specific usability class mask. The usability masks are mutually exclusive, and a value of one indicates that the pixel is assigned to that usability class.

- Band 1: clear mask (a value of “1” indicates the pixel is clear, a value of “0” indicates that the pixel is not clear and is one of the 5 remaining classes below)
- Band 2: snow mask
- Band 3: shadow mask
- Band 4: light haze mask
- Band 5: heavy haze mask (all images acquired after November 29, 2023 will have a value of “0” in band 5)
- Band 6: cloud mask
- Band 7: confidence map (a value of “0” indicates a low confidence in the assigned classification, a value of “100” indicates a high confidence in the assigned classification)
- Band 8: unusable data mask (see Unusable Data Mask above)

# 1. Overview of Document

This document describes Planet satellite imagery products. It is intended for users of satellite imagery interested in working with Planet's product offerings.

## 1.1. COMPANY OVERVIEW

Planet uses an agile aerospace approach for the design of its satellites, mission control, and operations systems; and the development of its web-based platform for imagery processing and delivery. Planet employs an "always on" image capturing method as opposed to the traditional tasking model used by most satellite companies today.

## 1.2 DATA PRODUCT OVERVIEW

Planet operates the PlanetScope (PS) and SkySat (SS) Earth-imaging constellations. Imagery is collected and processed in a variety of formats to serve different use cases, be it mapping, deep learning, disaster response, precision agriculture, or simple temporal image analytics to create rich information products.

PlanetScope satellite imagery is captured as a continuous strip of single frame images known as "scenes." Scenes are derived from multiple generations of PlanetScope satellites. Older-generation of PlanetScope satellites acquired a single RGB (red, green, blue) frame or a split-frame with a RGB half and a NIR (near-infrared) half, depending on the capability of the satellite. The new generation of PlanetScope satellites (PS2.SD and PSB.SD) acquire images with a multi-stripe frame with bands divided between RGBNIR (PS2.SD) or RGBNIR, red edge, green I, yellow and coastal blue (PSB.SD).

**Planet offers two geometry types (Basic & Ortho) for PlanetScope imagery**

The Basic Scene product is designed for users with advanced image processing and geometric correction capabilities. The product is not orthorectified or corrected for terrain distortions.

Ortho Scenes represent the single-frame image captures as acquired by a PlanetScope satellite with additional post processing applied.

**Planet also offers two primary radiometry options for PlanetScope imagery**

Visual products which are 3 band "RGB" which include color correction and sharpness enhancements to improve image interpretation with the human eye

Analytic Products (4 or 8 band) with options for delivery as scaled Top of Atmosphere Radiance (TOAR) or Surface Reflectance (SR). Analytic products are recommended for quantitative & modeling applications.

**PlanetScope imagery asset naming example**

An “ortho_analytic_8b_sr” is an orthorectified, 8-band, surface reflectance PlanetScope Scene.
A “basic_analytic_4b” is an unrectified, 4-band, top of atmosphere radiance PlanetScope Scene.
An “ortho_visual” is an orthorectified, 3-band, color corrected, sharpened PlanetScope Scene.

# 2. Satellite Constellation and Sensor Overview

## 2.1 PLANETSCOPE SATELLITE CONSTELLATION AND SENSOR CHARACTERISTICS

The PlanetScope satellite constellation consists of multiple launches of groups of individual satellites. Therefore, on-orbit capacity is constantly improving (in capability or quantity) as technology improvements are deployed at a rapid pace.

Each PlanetScope Dove satellite is a CubeSat ~3U form factor (10 cm by 10 cm by 30 cm). The complete PlanetScope constellation of approximately 130 satellites is able to image the entire land surface of the Earth every day (equating to a daily collection capacity of 200 million $km^2$/day). This capacity changes based on the number of satellites in orbit and throughout the season, as satellites image less in the northern hemisphere in the winter time because of a decrease in the amount of hours with sunlight.

PlanetScope satellites launched starting in November 2018 have sensor characteristics that enable improved spectral resolution. This second generation of PlanetScope satellites (known as Dove-R or PS2.SD) have a sensor plane divided into four separate horizontal stripes (one per radiometric band) along the track of the flight path. PlaneScope images from PS2.SD satellites are available starting from March, 2019 (sparsely) to April 22, 2022.

A third generation of PlanetScope sensors (known as SuperDove or PSB.SD) is currently in orbit and is producing daily imagery with 8 spectral bands (coastal blue, blue, green I, green, red, yellow, red edge and near-infrared). These satellites were launched in early 2020 and started producing imagery in mid-March 2020. PSB.SD PlanetScope satellites reached near daily cadence in August 2021. Starting from April 29, 2022 all new PlanetScope images have 8-bands and are derived from the PSB.SD sensors (SuperDoves) 8-Band Planet Scope images can be obtained using all Planet Platforms, Integrations and API. The item-type is PSScene.

Composite images from the second and third generation PlanetScope sensors are produced by an image registration process that involves compositing multiple frames ahead and behind an “anchor frame”. Band to band alignment is dependent on accurate ground-lock for the anchor frame and can vary according to scene content. For example, publication yield is observed to be lower in scenes over open water, mountainous terrain, or cloudy areas. Planet is always working to improve its publication rates and coverage and producing a higher volume of high quality imagery in challenging environments is an ongoing priority.

The band alignment quality threshold for image publication is based on across-track registration residuals, the publication criteria are currently set to 0.3 pixels (BGRN) for “standard” PlanetScope products (instruments

PS2.SD and PSB.SD), 0.5 (BGRN) to qualify for “test”. Whether a PlanetScope image is classified as “standard” or “test” can be determined by looking at image GeoJSON metadata property “quality_category”.

Table 2-A: PlanetScope Constellation and Sensor Specifications

CONSTELLATION OVERVIEW: PLANETSCOPE

| **Mission Characteristics** | **Sun-synchronous Orbit** | | |
|---|---|---|---|
| Instrument | **PS2** | **PS2.SD** | **PSB.SD** |
| Orbit Altitude (reference) | 450 - 580 km (~98° inclination) | | 475 - 525 km (~98° inclination) |
| Field of View | 3.0° (swath)<br>1.0° (scene length) | 3.0° (swath)<br>2.0° (scene length) | 4.0° (swath)<br>2.3° (scene length) |
| Max/Min Latitude Coverage | ±81.5° (dependent on season) | | |
| Equator Crossing Time | 7:30 - 11:30 am (local solar time) | | |
| Sensor Type | Four-band frame Imager with a split-frame VIS+NIR filter | Four-band frame imager with butcher-block filter providing blue, green, red, and NIR stripes | Eight-band frame imager with butcher-block filter providing coastal blue, blue, green I, green II, yellow, red, red-edge, and NIR stripes |
| Spectral Bands | Blue: 455 - 515 nm<br>Green: 500 - 590 nm<br>Red: 590 - 670 nm<br>NIR: 780 - 860 nm | Blue: 464 - 517 nm<br>Green: 547 - 585 nm<br>Red: 650 - 682 nm<br>NIR: 846 - 888 nm | Coastal Blue 431-452 nm<br>Blue: 465-515 nm<br>Green I: 513. - 549 nm<br>Green: 547. - 583 nm<br>Yellow: 600-620 nm<br>Red: 650 - 680 nm<br>Red-Edge: 697 - 713 nm<br>NIR: 845 - 885 nm |
| Ground Sample Distance (nadir) | 3.7 m-4.1 m (approximate, altitude dependent) | | 3.7 m-4.2 m (approximate, altitude dependent) |
| Off-Nadir Angle | 0° - 5° (latitude dependent) | | |
| Frame Size | 24 km x 8 km (approximate) | 24 km x 16 km (approximate) | 32.5 km x 19.6 km (approximate) |
| Maximum Image Strip per orbit | 20,000 km² | | |

| | | | |
|---|---|---|---|
| Revisit Time | | Daily at nadir | |
| Image Capture Capacity | | 200 million km²/day | |
| Imagery Bit Depth | | 12-bit | |
| Availability Date | July 2014 - April 2022 | March 2019 - April 2022 | March 2020 - present |

# 3. PlanetScope Imagery Products

PlanetScope imagery products are available as either individual Basic Scenes andOrtho Scenes. The Basic and Ortho Scenes can be obtained from the Planet API through the PSScene item-type.

Table 3-A: PlanetScope Satellite Image Product Processing Levels

PLANETSCOPE SATELLITE IMAGE PRODUCT PROCESSING LEVELS

| Name | Description | Product Level |
|---|---|---|
| PlanetScope Basic Analytic 4B Scene | Scaled Top of Atmosphere Radiance (at sensor) and sensor corrected 4 band (BGRN) product. The Basic Scene product is designed for users with advanced image processing and geometric correction capabilities. This product has scene based framing and is not projected to a cartographic projection. Radiometric and sensor corrections are applied to the data. | Level 1B |
| PlanetScope Basic Analytic 8B Scene | Scaled Top of Atmosphere Radiance (at sensor) and sensor corrected 8-band product. The Basic Scene product is designed for users with advanced image processing and geometric correction capabilities. This product has scene based framing and is not projected to a cartographic projection. Radiometric and sensor corrections are applied to the data. | Level 1B |
| PlanetScope Ortho Analytic 4B Scene | Orthorectified, scaled Top of Atmosphere Radiance (at sensor) 4-band image product suitable for analytic applications. This product has | Level 3B |

| | | |
|---|---|---|
| | scene based framing and projected to a cartographic projection. | |
| PlanetScope Ortho Analytic 4B SR | Orthorectified, Surface Reflectance 4-band image product suitable for analytic applications. This product has scene based framing and projected to a cartographic projection. | Level 3B |
| PlanetScope Ortho Analytic 8B Scene | Orthorectified, scaled Top of Atmosphere Radiance (at sensor) 8-band image product suitable for analytic applications. This product has scene based framing and projected to a cartographic projection. | Level 3B |
| PlanetScope Ortho Analytic 8B SR | Orthorectified, scaled Surface Reflectance 8-band image product suitable for analytic applications. This product has scene based framing and projected to a cartographic projection. | Level 3B |
| PlanetScope Ortho Visual Scene | Orthorectified, scaled Top of Atmosphere Radiance (at sensor) or Surface Reflectance 8-band image product suitable for analytic applications. This product has scene based framing and projected to a cartographic projection. | Level 3B |

The name of each acquired PlanetScope image is designed to be unique and allow for easier recognition and sorting of the imagery. It includes the date and time of capture, as well as the id of the satellite that captured it. The name of each downloaded image product is composed of the following elements:

```
<acquisition date>_<acquisition time>_<satellite_id>_<productLevel>_<bandProduct>.<extension>
```

Example:

```
20230207_143613_03_241c_3B_AnalyticMS_SR_8b.tif
```

```
20230207_143613_03_241c_3B_Visual.tif
```

The name of each searchable image product is composed of the following elements:

```
<acquisition date>_<acquisition time to 1/100th>_<satellite_id>
```

Example:

20230207_143613_03_241c

## 3.1 RADIOMETRIC INTERPRETATION

Analytic products are scaled to Top of Atmosphere Radiance first. Validation of radiometric accuracy of the on-orbit calibration has been measured at 10% using collects over all the RadCalNet sites. Surface Reflectance products are derived from TOAR precursors.

All PlanetScope satellite images are collected at a bit depth of 12 bits and stored on-board the satellites with a bit depth of up to 12 bits. Radiometric corrections are applied during ground processing and all images are scaled to a 16-bit dynamic range. This scaling converts the (relative) pixel DNs coming directly from the sensor into values directly related to absolute at-sensor radiances. The scaling factor is applied to minimize quantization error and the resultant single DN values correspond to 1/100th of a W/(m²*sr*µm). The DNs of the PlanetScope image pixels represent the absolute calibrated radiance values for the image.

Converting to Radiance and Top of Atmosphere Reflectance

To convert the pixel values of the Analytic products to radiance, it is necessary to multiply the DN value by the radiometric scale factor, as follows:

RAD(i) = DN(i) * radiometricScaleFactor(i), where radiometricScaleFactor(i) = 0.01

The resulting value is the at sensor radiance of that pixel in watts per steradian per square meter (W/m²*sr*µm).

To convert the pixel values of the Analytic products to Top of Atmosphere Reflectance, it is necessary to multiply the DN value by the reflectance coefficient found in the XML file. This makes the complete conversion from DN to Top of Atmosphere Reflectance to be as follows:

REF(i) = DN(i) * reflectanceCoefficient(i)

**Atmospheric Correction**

Surface reflectance is determined from top of atmosphere (TOA) reflectance, calculated using coefficients supplied with the Planet Radiance product.

The Planet Surface Reflectance product corrects for the effects of the Earth's atmosphere, accounting for the molecular composition and variation with altitude along with aerosol content. Combining the use of standard atmospheric models with the use of NASA & ESA supplied water vapor, ozone and aerosol data, this provides reliable and consistent surface reflectance scenes over Planet's varied constellation of satellites as part of our normal, on-demand data pipeline. However, there are some limitations to the corrections performed:

- In some instances there is no MODIS data overlapping a Planet scene or the area nearby. In those cases, AOD is set to a value of 0.226 which corresponds to a “clear sky” visibility of 23km, the `aot_quality` is set to the MODIS “no data” value of 127, and `aot_status` is set to ‘Missing Data - Using Default AOT’. If there

is no overlapping water vapor or ozone data, the correction falls back to a predefined 6SV internal model.
- The effects of haze and thin cirrus clouds are not corrected for.
- Aerosol type is limited to a single, global model.
- All scenes are assumed to be at sea level and the surfaces are assumed to exhibit Lambertian scattering - no BRDF effects are accounted for.
- Stray light and adjacency effects are not corrected for.

### 3.1.1 PLANETSCOPE NORMALIZATION AND HARMONIZATION

Planet provides a “harmonization” tool in all Planet platforms to perform a rigorous approximate transform of the Surface Reflectance measurements of the PS2 instrument PlanetScope satellites to the Surface Reflectance equivalents from PS2.SD and PSB.SD instrument PlanetScope satellites. This is done by using Sentinel-2 as the target sensor. Read technical details of normalizing data in Scene Level Normalization and Harmonization of Planet Dove Imagery.

To convert the PS2 instrument PlanetScope Surface Reflectance values to a PSB.SD equivalent measurement, use the “harmonization” tool. This tool is available in Planet Explorer, ArcGIS Pro Add-In and QGIS Plug-In when placing an order. Use the “harmonization” tool in the Orders API, Subscriptions API, and Google Earth Engine if you are downloading data through the API.

Note: The harmonization process only applies to bands with a PS2 equivalent—specifically Blue, Green, Red, and Near-Infrared—and only for Surface Reflectance values.

## 3.2 PLANETSCOPE BASIC ANALYTIC SCENE PRODUCT SPECIFICATION

The PlanetScope Basic Analytic product is a Scaled Top of Atmosphere Radiance (at sensor) and sensor corrected product, providing imagery as seen from the spacecraft without correction for any geometric distortions inherent in the imaging process. It has a scene based framing, and is not mapped to a cartographic projection. This product line is available in GeoTIFF and NITF 2.1 formats.

This product has not been processed to remove distortions caused by terrain and allows analysts to derive information products for data science and analytics. It is designed for users with advanced image processing capabilities and a desire to geometrically correct the product themselves. The imagery data is accompanied by Rational Polynomial Coefficients (RPCs) to enable orthorectification by the user.

The geometric sensor corrections applied to this product correct for:

- Optical distortions caused by sensor optics
- Co-registration of bands

The table below describes the attributes for the PlanetScope Basic Analytic Scene product:

Table 3-B: PlanetScope Analytic Basic Scene Product Attributes

| PLANETSCOPE BASIC ANALYTIC SCENE PRODUCT ATTRIBUTES |
|---|

| Product Attribute | Description |
|---|---|
| Product Components and Format | The PlanetScope Basic Analytic product consists of the following file components:<br>• Image File – GeoTIFF format<br>• Metadata File – XML format<br>• Rational Polynomial Coefficients (RPC) - XML format<br>• Thumbnail File – GeoTIFF format<br>• Unusable Data Mask (UDM) File – GeoTIFF format<br>• Usable Data Mask (UDM2) File - GeoTIFF format |
| **Information Content** | |
| Analytic Bands | 4-band multispectral image (blue, green, red, near-infrared)<br>8-band multispectral image (coastal blue, blue, green I, green, red, yellow, red edge and near-infrared) - only available for PSB.SD |
| File Size | 500 - 700 MB (4-band multispectral image)<br>1.0 - 1.4 GB (8-band multispectral image) |
| Ground Sample Distance | Approximate, satellite altitude dependent<br>**PS2**: 3.0 m-4.1 m<br>**PS2.SD**: 3.0 m-4.1 m<br>**PS2.SD:** 3.7 m-4.2 m |
| **Processing** | |
| Pixel Size | Approximate, satellite altitude dependent<br>**PS2**: 3.0 m-4.1 m<br>**PS2.SD**: 3.0 m-4.1 m<br>**PS2.SD:** 3.7 m-4.2 m |
| Bit Depth | Analytic (DN): 12-bit<br>Analytic (Radiance - W m-2 sr-1 µm-1): 16-bit |
| Product Size | Nominal scene size is approximately (at 475 km altitude):<br>**PS2**: 24 km by 8 km<br>**PS2.SD**: 24 km by 16 km<br>**PSB.SD**: 32.5 km by 19.6 km<br>with some variability by satellite altitude. |
| Geometric Corrections | Spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data, and refined using GCPs. |
| Positional Accuracy | Less than 10 m RMSE at 90th percentile |
| Radiometric Corrections | • Conversion to absolute radiometric values based on calibration coefficients<br>• Radiometric values scaled by 100 to reduce quantization error<br>• Calibration coefficients are regularly monitored and updated with on-orbit calibration techniques. |
| Map Projection | N/A |

## 3.3 PLANETSCOPE ORTHO PRODUCT SPECIFICATION

PlanetScope Ortho Scene products are orthorectified and are designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. Ortho products have been processed to remove distortions caused by terrain and can be used for cartographic purposes.

The Ortho Scenes are delivered as 3-band visual (RGB) and analytic (4 band & 8 band) products. Ortho Scenes are radiometrically-, sensor-, and geometrically-corrected (optional atmospherically corrected to SR) products that are projected to a cartographic map projection. The geometric correction uses fine Digital Elevation Models (DEMs) with a post spacing of between 30 and 90 meters.

Ground Control Points (GCPs) are used in the creation of every image and the accuracy of the product will vary from region to region based on available GCPs. Computer vision algorithms are used for extracting feature points such as OpenCV's STAR keypoint detector and FREAK keypoint extractor. The GCP and tiepoint matching is done using a combination of RANSAC, phase correlation and mutual information.

The table below describes the attributes for the PlanetScope Ortho Scene product:

Table 3-C: PlanetScope Ortho Scene Product Attributes

GENERAL PLANETSCOPE ORTHO SCENE PRODUCT ATTRIBUTES

| **Product Attribute** | **Description** |
|---|---|
| Product Components and Format | PlanetScope Ortho Scene product consists of the following file components:<br>• Image File – GeoTIFF format<br>• Metadata File – XML format<br>• Thumbnail File – GeoTIFF format<br>• Unusable Data Mask (UDM) file – GeoTIFF format<br>• Usable Data Mask (UDM2) file - GeoTIFF format |
| Product Orientation | Map North up |
| Product Framing | Scene Based |
| Pixel Size (orthorectified) | 3 m |
| Bit Depth | Visual: 8-bit<br>Analytic (Radiance - W m-2 sr-1 µm-1): 16-bit<br>Analytic SR (Surface Reflectance): 16-bit |
| Product Size | Nominal scene size is approximately (at 475km altitude):<br>**PS2**: 25 km by 11.5 km<br>**PS2.SD**: 25 km by 23.0 km<br>**PSB.SD**: 32.5 km by 19.6 km<br>with some variability by satellite altitude. |
| Geometric Corrections | Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30 m to 90 m posting). |

| | |
|---|---|
| Atmospheric Corrections | Atmospheric effects are corrected using 6SV2.1 radiative transfer code. AOD, water vapor and ozone inputs are retrieved from MODIS near-real-time data (MOD09CMA, MOD09CMG and MOD08-D3). |
| Horizontal Datum | WGS84 |
| Map Projection | UTM |
| Resampling Kernel | Cubic Convolution |

### 3.3.1 PlanetScope Ortho Visual Scene Product Specification

The PlanetScope  Ortho Visual Scene product is orthorectified and color-corrected (using a color curve). This correction attempts to optimize colors as seen by the human eye providing images as they would look if viewed from the perspective of the satellite. This product has been processed to remove distortions caused by terrain and can be used for cartographic mapping and visualization purposes. This correction also eliminates the perspective effect on the ground (not on buildings), restoring the geometry of a vertical shot. Additionally, a correction is made to the sun angle in each image to account for differences in latitude and time of acquisition.

Ortho Visual scenes are designed to  be  visually appealing for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. The product can be used and ingested directly into a Geographic Information System.

Table 3-D: PlanetScope Visual Ortho Scene Product Attributes

| PLANETSCOPE VISUAL ORTHO SCENE PRODUCT ATTRIBUTES | |
|---|---|
| **Product Attribute** | **Description** |
| Information Content | |
| Visual Bands | 3-band natural color (red, green, blue) |
| Ground Sample Distance | Approximate, satellite altitude dependent<br>**PS2**: 3.0 m-4.1 m<br>**PS2.SD**: 3.0 m-4.1 m<br>**PS2.SD:** 3.7 m-4.2 m |
| **Processing** | |
| Pixel Size (orthorectified) | 3.0 m |
| Bit Depth | 8-bit |
| Geometric Corrections | Sensor-related effects are corrected using sensor telemetry and a sensor model. Spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to <10 m RMSE positional accuracy. |
| Positional Accuracy | Less than 10 m RMSE at 90th percentile |

| | |
|---|---|
| Color Enhancements | Color corrected, sharpened, and corrected for sun angle (for visual use) |

### 3.3.2 PlanetScope Analytic Ortho Scene Product Specification

The PlanetScope Analytic Ortho Scene products are orthorectified calibrated multispectral imagery products that have been processed with an emphasis on deriving quantitative information (e.g. data science and analytics). This product is designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. The product has been processed to remove distortions caused by terrain and can be used for many data science and analytic applications. The PlanetScope Ortho Analytic Scene is optimal for value-added image processing such as land cover classifications. The imagery has radiometric corrections applied to correct known sensor artifacts and to transform values to at-sensor radiance.

Table 3-E: PlanetScope Analytic Ortho Scene Product Attributes

| PLANETSCOPE ORTHO ANALYTIC SCENE PRODUCT ATTRIBUTES | |
|---|---|
| **Product Attribute** | **Description** |
| Analytic Bands | 3-band multispectral image (red, green, blue) - only available for PS2 images<br>4-band multispectral image (blue, green, red, near-infrared)<br>8-band multispectral image (coastal blue, blue, green I, green, red, yellow, red edge and near-infrared) - only available for PSB.SD |
| Ground Sample Distance | Approximate, satellite altitude dependent<br>**PS2**: 3.0 m-4.1 m<br>**PS2.SD**: 3.0 m-4.1 m<br>**PS2.SD:** 3.7 m-4.2 m |
| **Processing** | |
| Pixel Size (orthorectified) | 3.0 m |
| Bit Depth | Analytic (Radiance - W m-2 sr-1 µm-1): 16-bit<br>Analytic SR (Surface Reflectance): 16-bit |
| Geometric Corrections | Sensor-related effects are corrected using sensor telemetry and a sensor model. Spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to <10 m RMSE positional accuracy. |
| Positional Accuracy | Less than 10 m RMSE at 90th percentile |
| Radiometric Corrections | • Conversion to absolute radiometric values based on calibration coefficients<br>• Radiometric values scaled by 100 to reduce quantization error<br>• Calibration coefficients are regularly monitored and updated with on-orbit calibration techniques. |
| Atmospheric Corrections | • Conversion to top of atmosphere (TOA) reflectance values using at-sensor radiance and supplied coefficients |

- Conversion to surface reflectance values using the 6SV2.1 radiative transfer code and MODIS NRT data
- Reflectance values scaled by 10,000 to reduce quantization error

## 3.4 RADIOMETRIC INTERPRETATION

Analytic products are scaled to Top of Atmosphere Radiance. Validation of radiometric accuracy of the on-orbit calibration has been measured at 10% using collects over all the RadCalNet sites. Furthermore, each band is maintained within a range of +/- 2.5% from the band mean value across the constellation and over the satellite's lifetime.

### Converting to Radiance and Top of Atmosphere Reflectance

To convert the pixel values of the Analytic products to radiance, it is necessary to multiply the DN value by the radiometric scale factor, as follows:

RAD(i) = DN(i) * radiometricScaleFactor(i), where radiometricScaleFactor(i) = 0.01

The resulting value is the at-sensor radiance of that pixel in watts per steradian per square meter (W/m²*sr*µm).

Reflectance is generally the ratio of the reflected radiance divided by the incoming radiance. Note that this ratio has a directional aspect. To turn radiance into reflectance it is necessary to relate the radiance values (e.g. the pixel DNs multiplied with the radiometric scale factor) to the radiance the object is illuminated with. This is often done by applying an atmospheric correction software to the image, because this way the impact of the atmosphere to the radiance values is eliminated at the same time. But it would also be possible to neglect the influence of the atmosphere by calculating the Top Of Atmosphere (TOA) reflectance taking into consideration only the sun distance and the geometry of the incoming solar radiation. The formula to calculate the TOA reflectance not taking into account any atmospheric influence is as follows:

$$REF(i) = RAD(i)\frac{\pi * SunDist^2}{EAI(i) * \cos(SolarZenith)}$$

with:

- i = Number of the spectral band
- REF = reflectance value
- RAD = Radiance value
- SunDist = Earth-Sun Distance at the day of acquisition in Astronomical Units. Note: This value is not fixed, it varies between 0.983 289 8912 AU and 1.016 710 3335 AU and has to be calculated for the image acquisition point in time.
- EAI = Exo-Atmospheric Irradiance
- SolarZenith = Solar Zenith angle in degrees (= 90° – sun elevation)

This is pre-calculated for each band and provided in the XML file for the Thuillier solar irradiance model.

## 3.5 PLANETSCOPE BASEMAP MOSAIC TILES PRODUCT SPECIFICATION

All PlanetScope basemaps can be viewed at full resolution within the Planet graphical user interface (up to Zoom Level 15 or 16 in the Web Mercator Projection), giving a resolution of 4.77 m or 2.39 m at the Equator. The projection used in Planet basemaps has been selected to match what is typically used in web mapping applications. The basemap resolution improves at higher and lower latitudes. The Alpha Mask indicates areas of the quad where there is no imagery data available. Refer to the Planet Basemaps Product Specification for additional details.

Table 3-F: Individual Quad Specifications

INDIVIDUAL QUAD SPECIFICATIONS

| Attribute | Description |
|---|---|
| Sensors | PlanetScope |
| Pixel Size (resolution) | 4.77 m or 2.39 m |
| Image Bit Depth | 8 bits per pixel (Visual)<br>16 bits per pixel (Surface Reflectance) |
| Bands | Red, Green, Blue, Alpha (Visual)<br>Blue, Green, Red, NIR, Alpha (Surface Reflectance) |
| Projection | WGS84 Web Mercator (EPSG:3857) |
| Size | 4096 x 4096 pixels |
| Processing | Atmospheric correction (Surface Reflectance Basemaps only).<br>May be radiometrically balanced.<br>Seamlines may be minimized with tonal balancing. Geometrically aligned. |

# 4. Product Processing4. PRODUCT PROCESSING

## 4.1 PLANETSCOPE PROCESSING

Several processing steps are applied to PlanetScope imagery products, listed in the table below.

Table 4-A: PlanetScope Processing Steps

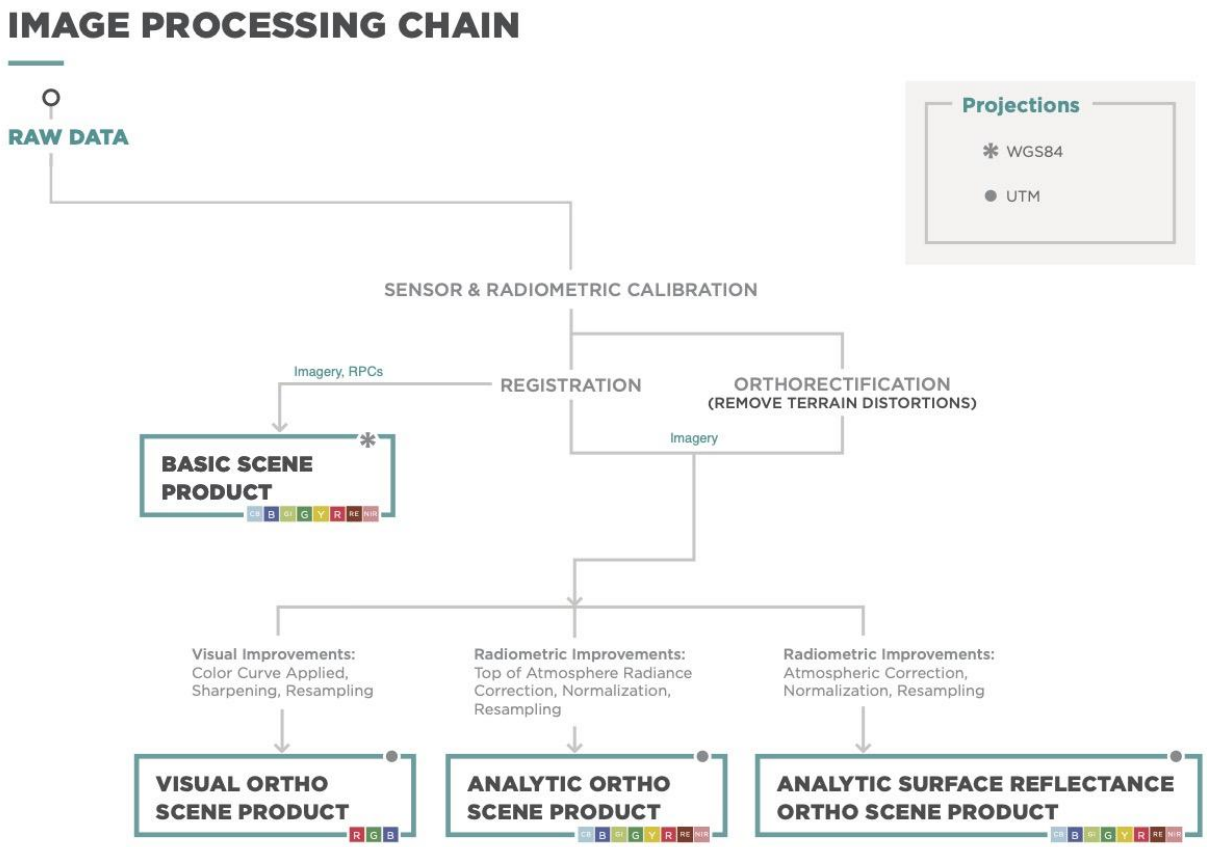
PLANETSCOPE PROCESSING STEPS

| Step | Description |
|---|---|
| Darkfield/Offset Correction | Corrects for sensor bias and dark noise. For each satellite, a model is created using pre-launch dark field data to correct for the temperature varying response and applied to scenes during processing based on the CCD temperature at acquisition time. |
| Flat Field Correction | Flat fields are collected for each optical instrument prior to launch. These fields are used to correct image lighting and CCD element effects to match the optimal response area of the sensor. Flat fields are routinely updated on-orbit during the satellite lifetime. |
| Camera Acquisition Parameter Correction | Determines a common radiometric response for each image (regardless of exposure time, number of TDI stages, gain, camera temperature and other camera parameters). |
| Absolute Calibration | As a last step, the spatially and temporally adjusted datasets are transformed from digital number values into physical based radiance values (scaled to $W/(m^2*str*\mu m)*100$). |
| Visual Product Processing | Presents the imagery as natural color, optimize colors as seen by the human eye. This process is broken down into 4 steps:<br>• Flat fielding applied to correct for vignetting.<br>• Nominalization - Sun angle correction, to account for differences in latitude and time of acquisition. This makes the imagery appear to look like it was acquired at the same sun angle by converting the exposure time to the nominal time (noon).<br>• Two filters applied: an unsharp mask for improving local dynamic range, and a sharpening filter for accentuating spatial features.<br>• Custom color curve applied post warping. |
| Orthorectification | This process is broken down into 2 steps:<br>• The rectification tiedown process wherein tie points are identified across the source images and a collection of reference images (ALOS, NAIP, OSM, Landsat) and RPCs are generated.<br>• The actual orthorectification of the scenes using the RPCs, to remove terrain distortions. The terrain model used for the orthorectification process is derived from multiple sources (SRTM, Intermap, and other local elevation datasets) which are periodically updated. Snapshots of the elevation datasets used are archived (helps in identifying the DEM that was used for any given scene at any given point). |

| | |
|---|---|
| Atmospheric Correction | Removes atmospheric effects. This process consists of 3 steps:<br>• Top of Atmosphere (TOA) reflectance calculation using coefficients supplied with the at-sensor radiance product.<br>• Lookup table (LUT) generation using the 6SV2.1 radiative transfer code and MODIS near-real-time data inputs.<br>• Conversion of TOA reflectance to surface reflectance for all combinations of selected ranges of physical conditions and for each satellite sensor type using its individual spectral response as well as estimates of the state of the atmosphere. |

The figure below illustrates the processing chain and steps involved to generate each of PlanetScope's imagery products.

Figure 4: PlanetScope Image Processing Chain



# 5. Product Metadata

## 5.1 ORTHO SCENES

The table below describes the GeoJSON metadata schema for PlanetScope Ortho Scene products:

Table 5-A: PlanetScope Ortho Scene GeoJSON Metadata Schema

PLANETSCOPE ORTHO SCENE GEOJSON METADATA SCHEMA

| Parameter | Description | Type |
|---|---|---|
| acquired | The time that image was taken in RFC 3398 format, in UTC. | string |
| anomalous_pixel | Percentage of anomalous pixels. Pixels that have image quality issues documented in the quality taxonomy | number |
| clear_percent | Percent of clear values in dataset. Clear values represents scene content areas (non-blackfilled*) that are deemed to be not impacted by cloud, haze, shadow and/or snow. | integer (0-100) |
| clear_confidence_percent | percentage value: per-pixel algorithmic confidence in 'clear' classification | integer (0-100) |
| cloud_percent | Percent of cloud values in dataset. Cloud values represent scene content areas (non-blackfilled) that contain opaque clouds which prevent reliable interpretation of the land cover content. | integer (0-100) |
| cloud_cover | Ratio of the area covered by clouds to that which is uncovered. | number (0 - 1) |
| ground_control | If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false. | boolean |
| gsd | The ground sampling distance of the image acquisition. | number |

| | | |
|---|---|---|
| heavy_haze_percent | Percent of heavy haze values in dataset. Heavy haze values represent scene content areas (non-blackfilled) that contain thin low altitude clouds, higher altitude cirrus clouds, soot and dust which allow fair recognition of land cover features, but not having reliable interpretation of the radiometry or surface reflectance. | integer (0-100) |
| instrument | The generation of the satellite telescope. | string (e.g.”PS2”, “PS2.SD”) |
| item_type | The name of the item type that models shared imagery data schema. | string (e.g. “PSScene) |
| light_haze_percent | Percent of light haze values in dataset. Light haze values represent scene content areas (non-blackfilled) that contain thin low altitude clouds, higher altitude cirrus clouds, soot and dust which allow reliable recognition of land cover features, and have up to +/-10% uncertainty on commonly used indices (EVI and NDWI). | integer (0-100) |
| pixel_resolution | Pixel resolution of the imagery in meters. | number |
| provider | Name of the imagery provider. | string (e.g. "planetscope","rapideye"") |
| published | The RFC 3339 timestamp at which this item was added to the API. | string |
| publishing_stage | Stage of publishing for an item. PSScene with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized | string |
| quality_category | Metric for image quality. To qualify for “standard” image quality an image must meet the following criteria: sun altitude greater than or equal to 10 degrees, off nadir view angle less than 20 degrees, and saturated pixels fewer than 20%. If the image does not meet these criteria it is considered “test” quality. | string: “standard” or “test” |
| satellite_azimuth | Spacecraft off track pointing direction, in degrees (0-360). | float |

| | | |
|---|---|---|
| satellite_id | Globally unique identifier of the satellite that acquired the underlying imagery. | string |
| shadow_percent | Percent of shadow values in dataset. Shadow values represent scene content areas (non-blackfilled) that are not fully exposed to the solar illumination as a result of atmospheric transmission losses due to cloud, haze, soot and dust, and therefore do not allow for reliable interpretation of the radiometry or surface reflectance. | integer (0-100) |
| strip_id | The unique identifier of the image stripe that the item came from. | string |
| snow_ice_percent | Percent of snow and ice values in dataset. Snow_ice values represent scene content areas (non-blackfilled) that are hidden below snow and/or ice. | integer (0-100) |
| sun_azimuth | Angle from true north to the sun vector projected on the horizontal plane in degrees. | number (0 - 360) |
| sun_elevation | Elevation angle of the sun in degrees. | number (0 - 90) |
| updated | The RFC 3339 timestamp at which this item was updated in the API. | string |
| view_angle | Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west. | number (-25 - +25) |
| visible_percent | Visible values represent the fraction of the scene content (excluding the portion of the image which contains blackfill) which is comprised of clear, light haze, shadow, snow/ice categories, and is given as a percentage ranging from zero to one hundred. | integer (0-100) |
| visible_confidence_percent | Average of confidence percent for clear_percent, light_haze_percent, shadow_percent and snow_ice_percent | integer (0-100) |

The PlanetScope Ortho Scenes Surface Reflectance product is provided as a 16-bit GeoTIFF image with reflectance values scaled by 10,000. Associated metadata describing inputs to the correction is included in a GeoTIFF TIFFTAG_IMAGEDESCRIPTION metadata header as a JSON encoded string.

The table below describes the metadata schema for Surface Reflectance products stored in the GeoTIFF header:

Table 5-B: PlanetScope Ortho Scene Surface Reflectance GeoTIFF Metadata Schema

PLANETSCOPE ORTHO SCENE SURFACE REFLECTANCE GEOTIFF METADATA SCHEMA

| Parameter | Description | Example |
|---|---|---|
| aerosol_model | 6S aerosol model used | continental |
| aot_coverage | Percentage overlap between MODIS data and the scene being corrected | 0.5625 |
| aot_method | Method used to derive AOD value(s) for an image. 'Map' indicates that per-pixel AOD values are used based on an interpolated map over the scene; 'fixed' indicates a single value for the entire image used when there is not enough data coverage to produce a map. | fixed |
| aot_mean_quality | Average MODIS AOD quality value for the overlapping NRT data in the range 1-10. This is set to 127 when no data is available | 1.0 |
| aot_source | Source of the AOD data used for the correction | mod09cma_nrt |
| aot_std | Standard deviation of the averaged MODIS AOD data | 0.033490001296168699 |
| aot_status | A text string indicating state of AOD retrieval. If no data exists from the source used, a default value 0.226 is used | Missing Data - Using Default AOT |
| aot_used | Aerosol optical depth used for the correction | 0.061555557780795626 |
| atmospheric_correction_algorithm | The algorithm used to generate LUTs | 6SV2.1 |
| atmospheric_model | Custom model or 6S atmospheric model used | water_vapor_and_ozone |
| luts_version | Version of the LUTs used for the correction | 3 |
| ozone_coverage | Percentage overlap between MODIS data and the scene being corrected | 0.53125 |

| | | |
|---|---|---|
| ozone_mean_quality | Average MODIS ozone quality value for the overlapping NRT data. This will always be 255 if data is present | 255 |
| ozone_method | Method used to derive ozone value(s) for an image. Currently only 'fixed' is used, indicating a single value for the entire image | fixed |
| ozone_source | Source of the ozone data used for the correction | mod09cmg_nrt |
| ozone_status | A text string indicating state of ozone retrieval. If no ozone data is available for the scene being corrected, the corrections falls back to a 6SV built-in atmospheric model | Data Found |
| ozone_std | Standard deviation of the averaged MODIS ozone data. | 0 |
| ozone_used | Ozone concentration used for the correction, in cm-atm | 0.255 |
| satellite_azimuth_angle | Always defined to be 0.0 degrees and solar zenith angle measured relative to it | 0.0 |
| satellite_zenith_angle | Satellite zenith angle, fixed to nadir pointing | 0.0 |
| solar_azimuth_angle | Sun azimuth angle relative to satellite, in degrees | 111.42044562850029 |
| solar_zenith_angle | Solar zenith angle in degrees | 30.26950393461825 |
| sr_version | Version of the correction applied. | 1.0 |
| water_vapor_coverage | Percentage overlap between MODIS data and the scene being corrected | 0.53215 |
| water_vapor_mean_quality | Average MODIS ozone quality value for the overlapping NRT data in the range 1-10. This is set to 127 when no data is available | 1.5294 |
| water_vapor_method | Method used to derive water vapor value(s) for an image. Currently only 'fixed' is used, indicating a single value for the entire image | fixed |
| water_vapor_source | Source of the water vapor data used for the correction | mod09cma_nrt |
| water_vapor_status | A text string indicating state of water vapor retrieval. If no water vapor data is available for the scene being corrected, the | Data Found |

| | | |
|---|---|---|
| | corrections falls back to a 6SV built-in atmospheric model | |
| water_vapor_std | Standard deviation of the averaged MODIS AOD data | 0.0587 |
| water_vapor_used | Water vapor concentration used for the correction in g/cm^2 | 4.0512 |

## 5.2 BASIC SCENES

The table below describes the GeoJSON metadata schema for PlanetScope Basic Scene products:

Table 5-C: PlanetScope Basic Scene GeoJSON Metadata Schema

PLANETSCOPE BASIC SCENE GEOJSON METADATA SCHEMA

| Parameter | Description | Type |
|---|---|---|
| acquired | The time that image was taken in RFC 3398 format, in UTC. | string |
| anomalous_pixel | Percentage of anomalous pixels. Pixels that have image quality issues documented in the quality taxonomy (e.g. hot columns). This is represented spatially within the UDM. | number |
| cloud_cover | Ratio of the area covered by clouds to that which is uncovered. | number (0 - 1) |
| columns | Number of columns in the image. | number |
| epsg_code | The identifier for the grid cell that the imagery product is coming from if the product is an imagery tile (not used if scene). | number |
| ground_control | If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false. | boolean |
| gsd | The ground sampling distance of the image acquisition. | number |
| instrument | The generation of the satellite telescope. | string (e.g."PS2", "PS2.SD", "PSB.SD") |

| | | |
|---|---|---|
| item_type | The name of the item type that models shared imagery data schema. | string (e.g. “PSScene3Band”, ”PSScene4Band”) |
| provider | Name of the imagery provider. | string (e.g. "planetscope","rapideye"") |
| published | The RFC 3339 timestamp at which this item was added to the API. | string |
| publishing_stage | Stage of publishing for an item. SkySatScenes are first published in a "preview" stage and graduate to a "finalized" stage. | string |
| quality_category | Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: sun altitude greater than or equal to 10 degrees, off nadir view angle less than 20 degrees, and saturated pixels fewer than 20%. If the image does not meet these criteria it is considered “test” quality. | string: “standard” or “test” |
| satellite_azimuth | Spacecraft off track pointing direction, in degrees (0-360). | float |
| satellite_id | Globally unique identifier of the satellite that acquired the underlying imagery. | string |
| strip_id | The unique identifier of the image stripe that the item came from. | string |
| sun_azimuth | Angle from true north to the sun vector projected on the horizontal plane in degrees. | number (0 - 360) |
| sun_elevation | Elevation angle of the sun in degrees. | number (0 - 90) |
| updated | The RFC 3339 timestamp at which this item was updated in the API. | string |
| view_angle | Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west. | number (-25 - +25) |

# 6. Product Delivery

All imagery products are made available via Application Processing Interface (API) and Graphical User Interface (GUI).

## 6.1 PLANET APPLICATION PROGRAMMING INTERFACES (APIS)

Planet offers REST API access that allows listing, filtering, and downloading of data to anyone using a valid API key. The metadata features described in this document are all searchable via our Data API and downloadable via our Orders API.

Details on searching and ordering via Planet APIs are available in Planet's Developer Center. Links are also available below.

- Catalog Overview (Items Types & Assets Types)
- Search with Planet's Data API
- Order with Planet's Orders API

## 6.2 PLANET EXPLORER GRAPHICAL USER INTERFACE (GUI)

Planet Explorer is a web-based tool that can be used to search Planet's catalog of imagery, view metadata, and download full-resolution images. The interface and all of its features are built entirely on the externally available Planet API.

Planet Explorer allows users to:

1. **View Timelapse Mosaics**: A user can view Planet's quarterly and monthly mosaics, and can zoom in up to zoom level 12 (38 m / pixel per OpenStreetMap)
2. **Search**: A user can Search for any location or a specific area of interest by entering into the input box OR by uploading a geometry file (Shapefile, GeoJSON, KML, or WKT).
3. **Save Search**: The Save functionality allows a user to save search criteria based on area of interest, dates, and filters.
4. **Filter**: A user can filter by a specific date range and/or customizing metadata parameters (e.g. estimated cloud cover, GSD).
5. **Zoom and Preview Imagery:** Zoom and Preview allows a user to zoom in or out of the selected area and preview imagery.
6. **View Imagery Details**: A user can review metadata details about each imagery product.
7. **Download**: The Download icon allows a user to download imagery based on subscription type.

8. Draw Tools: These tools allow you to specify an area to see imagery results. The draw tool capabilities available are drawing a circle, drawing a rectangle, drawing a polygon, and/or limiting the size of the drawing to the size of loadable imagery.

9. Imagery Compare Tool: The Compare Tool allows you to compare sets of Planet imagery from different dates.

Planet will also enable additional functionality in the form of "Labs," which are demonstrations of capability made accessible to users through the GUI. Labs are active product features and will evolve over time based on Planet technology evolution and user feedback.

## 6.3 PLANET ACCOUNT MANAGEMENT TOOLS

As part of the Planet GUI, an administration and account management tool is provided. This tool is used to change user settings and to see past data orders. In addition, users who have administrator privileges will be able to manage users in their organization as well as review usage statistics.

The core functionality provided by account management tools are outlined below, and Planet may evolve Account Management tools over time to meet user needs:

1. User Accounts Overview: Every user account on the Planet Platform is uniquely identified by an email address. Each user also has a unique API key that can be used when interacting programmatically with the Platform.

2. Organization and Sub-organization Overview: Every user on the Planet Platform belongs to one organization. The Platform also supports "sub-organizations," which are organizations that are attached to a "parent" organization. An administrator of a parent organization is also considered an administrator on all sub-organizations.

3. Account Privileges: Every user account on the Planet Platform has one of two roles: user or administrator. An administrator has elevated access and can perform certain user management operations or download usage metrics that are not available to standard users. An administrator of a parent organization is also considered an administrator on all sub-organizations. Administrators can enable or disable administrator status and enable or disable users' access to the platform altogether.

4. Orders and Usage Review: This tool records all part orders made and allows users and administrators to view and download past orders. Usage metrics are also made available, including imagery products downloaded and bandwidth usage. Usage metrics are displayed for each individual API key that is part of the organization.

# Appendix A – Image Support Data

All PlanetScope Ortho Tile Products are accompanied by a set of image support data (ISD) files. These ISD files provide important information regarding the image and are useful sources of ancillary data related to the image. The ISD files are:

1. General XML Metadata File
2. Unusable Data Mask File
3. Usable Data Mask File

Each file is described along with its contents and format in the following sections.

## 1. GENERAL XML METADATA FILE

All PlanetScope Ortho Tile Products will be accompanied by a single general XML metadata file. This file contains a description of basic elements of the image. The file is written in Geographic Markup Language (GML) version 3.1.1 and follows the application schema defined in the Open Geospatial Consortium (OGC) Best Practices document for Optical Earth Observation products version 0.9.3, see http://www.opengeospatial.org/standards/gml.

The contents of the metadata file will vary depending on the image product processing level. All metadata files will contain a series of metadata fields common to all imagery products regardless of the processing level. However, some fields within this group of metadata may only apply to certain product levels. In addition, certain blocks within the metadata file apply only to certain product types. These blocks are noted within the table.

The table below describes the fields present in the General XML Metadata file for all product levels.

Table A-1: General XML Metadata File Field Descriptions

GENERAL XML METADATA FILE FIELD DESCRIPTIONS

| Field | Description |
|---|---|
| “metaDataProperty” Block | |
| EarthObservationMetaData | |
| Identifier | Root file name of the image |
| acquisitionType | Nominal acquisition |
| productType | Product level listed in product filename |

| | |
|---|---|
| status | Status type of image, if newly acquired or produced from a previously archived image |
| **downlinkedTo** | |
| acquisitionStation | X-band downlink station that received image from satellite |
| acquisitionDate | Date and time image was acquired by satellite |
| **archivedIn** | |
| archivingCenter | Location where image is archived |
| archivingDate | Date image was archived |
| archivingIdentifier | Catalog ID of image |
| **processing** | |
| processorName | Name of ground processing system |
| processorVersion | Version of processor |
| nativeProductFormat | Native image format of the raw image data |
| **license** | |
| licenseType | Name of selected license for the product |
| resourceLink | Hyperlink to the physical license file |
| versionIsd | Version of the ISD |
| orderId | Order ID of the product |
| tileId | Tile ID of the product corresponding to the Tile Grid |
| pixelFormat | Number of bits per pixel per band in the product image file |
| **“validTime” Block** | |
| **TimePeriod** | |
| beginPosition | Start date and time of acquisition for source image take used to create product, in UTC |
| endPosition | End date and time of acquisition for source image take used to create product, in UTC |
| **“using” Block** | |
| **EarthObservationEquipment** | |
| **platform** | |
| shortName | Identifies the name of the satellite platform used to collect the image |

| | |
|---|---|
| serialIdentifier | ID of the satellite that acquired the data |
| orbitType | Orbit type of satellite platform |
| **instrument** | |
| shortName | Identifies the name of the satellite instrument used to collect the image |
| **sensor** | |
| sensorType | Type of sensor used to acquire the data. |
| resolution | Spatial resolution of the sensor used to acquire the image, units in meters |
| scanType | Type of scanning system used by the sensor |
| **acquistionParameters** | |
| orbitDirection | The direction the satellite was traveling in its orbit when the image was acquired |
| incidenceAngle | The angle between the view direction of the satellite and a line perpendicular to the image or tile center |
| illuminationAzimuthAngle | Sun azimuth angle at center of product, in degrees from North (clockwise) at the time of the first image line |
| illuminationElevationAngle | Sun elevation angle at center of product, in degrees |
| azimuthAngle | The angle from true north at the image or tile center to the scan (line) direction at image center, in clockwise positive degrees. |
| spaceCraftView Angle | Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with “+” being East and “-” being West |
| acquisitionDateTime | Date and Time at which the data was imaged, in UTC. Note: The imaging times will be somewhat different for each spectral band. This field is not intended to provide accurate image time tagging and hence is simply the imaging time of some (unspecified) part of the image. |
| **“target” Block** | |
| **Footprint** | |
| **multiExtentOf** | |
| posList | Position listing of the four corners of the image in geodetic coordinates in the format:<br>ULX ULY URX URY LRX LRY LLX LLY ULX ULY<br>where X = latitude and Y = longitude |
| **centerOf** | |
| pos | Position of center of product in geodetic coordinate X and Y, where X = latitude and Y = longitude |
| **geographicLocation** | |
| **topLeft** | |

| | |
|---|---|
| latitude | Latitude of top left corner in geodetic WGS84 coordinates |
| longitude | Longitude of top left corner in geodetic WGS84 coordinates |
| **topRight** | |
| latitude | Latitude of top right corner in geodetic WGS84 coordinates |
| longitude | Longitude of top right corner in geodetic WGS84 coordinates |
| **bottomLeft** | |
| latitude | Latitude of bottom left corner in geodetic WGS84 coordinates |
| longitude | Longitude of bottom left corner in geodetic WGS84 coordinates |
| **bottomRight** | |
| latitude | Latitude of bottom right corner in geodetic WGS84 coordinates |
| longitude | Longitude of bottom right corner in geodetic WGS84 coordinates |
| **“resultOf” Block** | |
| **EarthObservationResult** | |
| **browse** | |
| **BrowseInformation** | |
| type | Type of browse image that accompanies the image product as part of the ISD |
| referenceSystemIdentifier | Identifies the reference system used for the browse image |
| fileName | Name of the browse image file |
| **product** | |
| fileName | Name of image file. |
| productFormat | File format of the image product |
| **spatialReferenceSystem** | |
| epsgCode | EPSG code that corresponds to the datum and projection information of the image |
| geodeticDatum | Name of datum used for the map projection of the image |
| projection | Projection system used for the image |
| projectionZone | Zone used for map projection |
| resamplingKernel | Resampling method used to produce the image. The list of possible algorithms is extendable |
| numRows | Number of rows (lines) in the image |

| | |
|---|---|
| numColumns | Number of columns (pixels) per line in the image |
| numBands | Number of bands in the image product |
| rowGsd | The GSD of the rows (lines) within the image product |
| columnGsd | The GSD of the columns (pixels) within the image product |
| radiometricCorrectionApplied | Indicates whether radiometric correction has been applied to the image |
| geoCorrectionLevel | Level of correction applied to the image |
| elevationCorrectionApplied | Indicates the production elevation model used for ortho |
| atmosphericCorrectionApplied | Indicates whether atmospheric correction has been applied to the image |
| atmosphericCorrectionParameters | |
| mask | |
| MaskInformation | |
| type | Type of mask file accompanying the image as part of the ISD |
| format | Format of the mask file |
| referenceSystemIdentifier | EPSG code that corresponds to the datum and projection information of the mask file |
| fileName | File name of the mask file |
| cloudCoverPercentage | Estimate of cloud cover within the image |
| cloudCoverPercentageQuot-ationMode | Method of cloud cover determination |
| unusableDataPercentage | Percent of unusable data with the file |
| The following group is repeated for each spectral band included in the image product | |
| bandSpecificMetadata | |
| bandNumber | Number (1-8) by which the spectral band is identified. |
| startDateTime | Start time and date of band, in UTC |
| endDateTime | End time and date of band, in UTC |
| percentMissingLines | Percentage of missing lines in the source data of this band |
| percentSuspectLines | Percentage of suspect lines (lines that contained downlink errors) in the source data for the band |
| binning | Indicates the binning used (across track x along track) |
| shifting | Indicates the sensor applied right shifting |
| masking | Indicates the sensor applied masking |

| | |
|---|---|
| radiometricScaleFactor | Provides the parameter to convert the scaled radiance pixel value to radiance  Multiplying the Scaled Radiance pixel values by the values, derives the Top of Atmosphere Radiance product. This value is a constant, set to 0.01 |
| reflectanceCoefficient | The value is a multiplicative, when multiplied with the DN values, provides the Top of Atmosphere Reflectance values |

## 2. UNUSABLE DATA MASK FILE

The unusable data mask file provides information on areas of unusable data within an image (e.g. cloud and non-imaged areas).

The pixel size after orthorectification will be 3.0m for PlanetScope Scenes. It is suggested that when using the file to check for usable data, a buffer of at least 1 pixel should be considered. Each bit in the 8-bit pixel identifies whether the corresponding part of the product contains useful imagery:

- **Bit 0**: Identifies whether the area contains blackfill in all bands (this area was not imaged). A value of "1" indicates blackfill.
- **Bit 1**: Identifies whether the area is cloud covered. A value of "1" indicates cloud coverage. Cloud detection is performed on a decimated version of the image (i.e. the browse image) and hence small clouds may be missed. Cloud areas are those that have pixel values in the assessed band (Red, NIR or Green) that are above a configurable threshold. This algorithm will:
    - Assess snow as cloud
    - Assess cloud shadow as cloud free
    - Assess haze as cloud free
- **Bit 2**: Identifies whether the area contains missing (lost during downlink) or suspect (contains down-link errors) data in Blue Band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".
- **Bit 3**: Identifies whether the area contains missing (lost during downlink and hence blackfilled) or suspect (contains downlink errors) data in the Green Band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".
- **Bit 4**: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Red Band A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".
- **Bit 5**: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Red-Edge band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".

- Bit 6: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Near-Infrared band. A value of “1” indicates missing/suspect data. If the product does not include this band, the value is set to “0”.

- Bit 7: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Coastal Blue and/or Green I and/or Yellow Band. A value of “1” indicates missing/suspect data. If the product does not include this band, the value is set to “0.”

The UDM information is found in band 8 of the Usable Data Mask file.

## 3. USABLE DATA MASK FILE

The usable data mask file provides information on areas of usable data within an image (e.g. clear, snow, shadow, light hazeand cloud).

The pixel size after orthorectification will be 3.0m for PlanetScope Scenes. The usable data mask is a raster image having the same dimensions as the image product, comprised of 8 bands, where each band represents a specific usability class mask. The usability masks are mutually exclusive, and a value of one indicates that the pixel is assigned to that usability class. Read more on Planet’s Developer Center - UDM2.

- Band 1: clear mask (a value of “1” indicates the pixel is clear, a value of “0” indicates that the pixel is not clear and is one of the 5 remaining classes below)
- Band 2: snow mask
- Band 3: shadow mask
- Band 4: light haze mask
- Band 5: heavy haze mask (all images acquired after November 29, 2023 will have a value of “0” in band 5)
- Band 6: cloud mask
- Band 7: confidence map (a value of “0” indicates a low confidence in the assigned classification, a value of “100” indicates a high confidence in the assigned classification)
- Band 8: unusable data mask

File Naming
The UDM2 file will follow the naming conventions as in the example below.

Example: 20180921_102852_0f34_1A_udm2.tif (**basic_udm2** asset)
20180921_102852_0f34_3B_udm2.tif (**ortho_udm2** asset)