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Surface Biology and Geology (SBG) Thermal Infrared (TIR) Mission

Level 1
Preliminary Product Specification Document (PPSD)

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SBG-TIR Level 1 Preliminary Product Specification Document

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1.0 INTRODUCTION

1.1 Identification

This is the Preliminary Product Specification Document (PPSD) for Level 1 (L1) data products of the Surface Biology and Geology (SBG) Thermal Infrared (TIR) mission. SBG-TIR L1 products provide corrected spacecraft attitude, calibrated at-sensor radiances and geolocation tags of each pixel data acquired by the SBG-TIR radiometer instrument according to the algorithms described in the SBG-TIR L1 Geolocation Algorithm Theoretical Basis Document (ATBD) and the SBG-TIR L1 Calibration ATBD.

1.2 Purpose and Scope

The "Preliminary Product Specification Document" (PPSD) is an initial "Phase A" version of the Product Specification Document (PSD), describing the Standard and Low Latency Level 1 radiance, geolocation, and attitude products to be generated by the JPL SBG-TIR Science Data System (SDS). For this PPSD, these descriptions are largely based upon TIR product knowledge and experiences obtained through the ECOSTRESS Mission (https://ecostress.jp.nasa.gov). The SGB-TIR mission is also a cooperative effort with the Italian Space Agency (Agenzia Spaziale Italiana; ASI), which provides SBG-TIR platform metadata and Visual and Near-Infrared (VNIR) products. Descriptions of partner L1 products, as well as SBG-TIR Level 2, 3, and 4 products, are covered in separate documents.

1.3 Mission Overview

NASA's SBG mission was a Designated Observable (DO) identified in the National Academies of Sciences, Engineering and Medicine (NASEM) 2017 Decadal Survey. The Decadal Survey document presented a clear vision for the combined roles of visible to shortwave infrared imaging spectroscopy and multispectral or hyperspectral thermal infrared image data in addressing terrestrial and aquatic ecosystems and other elements of biodiversity, geology, natural hazards, the water cycle, and applied sciences topics relevant to many areas with societal benefits.

The SBG-TIR portion of the mission develops the TIR multispectral instrument, also known as OTTER (Orbiting Terrestrial Thermal Emission Radiometer), and built by the NASA Jet Propulsion Laboratory. The SBG-TIR instrument measures the emitted radiance of the Earth surface and uses that information to better understand the dynamics of Earth's changing surface geology and biology, ground/water temperature, snow reflectivity, active geologic processes, vegetation traits, and algal biomass. The SGB-TIR mission is also a cooperative effort with the Italian Space Agency (Agenzia Spaziale Italiana; ASI), which provides SBG-TIR platform metadata and Visual and Near-Infrared (VNIR) products. Descriptions of partner products are covered in separate documents.

The SBG-TIR mission addresses the following "Most Important" and "Very Important" priorities as highlighted by the Decadal Survey:

Most Important

Ecosystems

E1a: Quantify the distribution of the functional traits, functional types, and composition of vegetation and marine biomass, spatially and over time.

E1c: Quantify the physiological dynamics of terrestrial and aquatic primary producers.

E2a: Quantify the fluxes of CO_2 and CH_4 globally at spatial scales of 100 to 500 km and monthly temporal resolution with uncertainty <25% between land ecosystems and atmosphere and between ocean ecosystems and atmosphere.

Hydrology

H1c: Quantify rates of snow accumulation, snowmelt, ice melt, and sublimation from snow and ice worldwide at scales driven by topographic variability.

Solid Earth

S1a: Measure the pre-, syn-, and posteruption surface deformation and products of Earth's entire active land volcano inventory at a time scale of days to weeks.

Very Important

Ecosystems

E1a: Quantify the distribution of the functional traits, functional types, and composition of vegetation and marine biomass, spatially and over time.

Hydrology

H2a: Quantify how changes in land use, water use, and water storage affect evapotranspiration rates, and how these in turn affect local and regional precipitation systems, groundwater recharge, temperature extremes, and carbon cycling.

H4a: Monitor and understand hazard response in rugged terrain and land margins to heavy rainfall, temperature and evaporation extremes, and strong winds at multiple temporal and spatial scales. This socioeconomic priority depends on success of addressing H1b and H1c, H2a, and H2c.

Solid Earth

S1c: Forecast and monitor landslides, especially those near population centers.

S2b: Assess surface deformation (<10 mm), extent of surface change (<100 m spatial resolution) and atmospheric contamination, and the composition and temperature of volcanic products following a volcanic eruption (hourly to daily temporal sampling).

Climate

C3a: Quantify CO_2 fluxes at spatial scales of 100-500 km and monthly temporal resolution with uncertainty <25% to enable regional-scale process attribution explaining year-to-year variability by net uptake of carbon by terrestrial ecosystems (i.e., determine how much carbon uptake results from processes such as CO_2 and nitrogen fertilization, forest regrowth, and changing ecosystem demography.)

Weather

W3a: Determine how spatial variability in surface characteristics modifies regional cycles of energy, water and momentum (stress) to an accuracy of 10 W/m^2 in the enthalpy flux, and 0.1 N/m^2 in stress, and observe total precipitation to an average accuracy of 15% over oceans and/or 25% over land and ice surfaces averaged over a 100 × 100 km region and 2- to 3-day time period.

The SBG-TIR mission answers these questions by accurately measuring the emitted radiance of Earth's surface in the mid-infrared (MIR) and TIR spectral regions using a multispectral radiometer. The instrument measures radiance data in 8 spectral bands from 3.95 to 12.05 μm with approximately 60 meter spatial resolution at nadir and a nominal revisit time of 3 days at the equator.

1.4 Applicable and Reference Documents

"Applicable" documents levy requirements on the areas addressed in this document. "Reference" documents are identified in the text of this document only to provide additional information to readers. Unless stated otherwise, the document revision level is "Initial Release." Document dates are not listed, as they are redundant with the revision level.

1.4.1 Applicable Documents

1. SBG-TIR Project Science Data System Requirements (TBD)
2. SBG-TIR Science Data Management Plan (TBD)
3. ICD Between SBG-TIR SDS and LPDAAC (TBD)
4. SBG-TIR Level 1 Geolocation Algorithm Theoretical Basis Document (TBD)
5. SBG-TIR Level 1 Calibration Algorithm Theoretical Basis Document (Draft July 2023)
6. ICD Between SBG-TIR SDS and ASI-VNIR SDS (TBD)

1.4.2 Reference Documents

1. 2017-2027 Decadal Survey for Earth Science and Applications from Space (ESAS 2017) TBD

1.5 SBG-TIR Data Products

SBG-TIR Level 0 data primarily consist of spacecraft packets that have been pre-processed by the Ground Data System (GDS). Level 1 provides foundational calibration and geolocation products, including spacecraft engineering data, time-tagged raw sensor pixels (appended with their radiometric calibration coefficients), black body pixels (used to generate the calibration coefficients), geolocated and radiometrically calibrated at-sensor radiances (for each image pixel), and corrected spacecraft attitude data. Level 2 provides scientific-ready products such as the land surface temperature (LST) and emissivities of each spectral band retrieved from the at-sensor radiance data, and a cloud mask. Level 3 and L4 are more advanced scientific products derived from Level 2 data and external ancillary data. A summary Product Grouping list is shown in Table 1-1.

Table 1-1: SBG-TIR Product Groups

Area	Product	Short Name
Fundamental (Level 1)	Radiance at Sensor	RAS
Fundamental	Surface Temperature and Emissivity	LSTE (incl WT, ST and SGC)
Fundamental	Cloud mask	CM
Plant Functional Traits Suite	Evapotranspiration (ET),	ET
	Water Use Efficiency (WUE),	WUE
	Evaporative Stress Index (ESI)	ESI
Geology Suite		
	Surface Mineralogy (TIR only)	SM
	Elevated Temperature Features	ETF
	Volcanic Activity	VA
Snow Physics Suite		
	Snow temperature (use Fundamental LST&E)	ST
Aquatics Biology / Biogeochemistry Suite	Water temperature (use Fundamental LST&E)	WT

1.5.1 Level 1 Product Overview

SBG-TIR L1 provides: 1) Calibrated Top-of-Atmosphere (TOA) radiance products (Radiance at Sensor) that are fundamental for the preparation of Level 2+ products; and 2) Per-pixel georeference, which provides the foundation for subsequent Level 2+ mapping and geolocation. L1 includes up to eleven spectral bands, consisting of six nominal TIR wavelengths, two mid-wave bands (MIR), and three VNIR wavelengths supplied by ASI (See Section 3.1).

Level 1 geometric formats will be either Swath, Gridded Image, or Gridded Tile pixel files. The swath pixel alignments are the closest to the original sensor collection. These scenes consist of 69 concatenated along-track scans (where each scan is 256 lines by 15168 sample pixels) of the instrument mirror. Each scan requires approximately 0.39892 seconds of imaging time followed by 1.68514 seconds of travel time to the next scan-start position (2.08406 seconds total), producing a full image (granule) containing 17664 lines by 15168 samples with 1 pixel scan overlap (at nadir) in 143.8 seconds. The resulting image granule covers approximately 1000x1000km. Each of the 14-15 daily orbits start at the equatorial crossing of the ascending SBG-TIR platform's orbit (~12:30 pm local time). The swath L1B-Geolocation product contains matching Latitude and Longitude pixel files, and together with the swath L1B_Radiance product provides the foundational radiometric and georeferenced inputs for Level 2+ products. The L1C gridded products are resampled to a map grid with a fixed 60m pixel size, and are used to create 110x110km tile images following the "Sentinel-2 Tiling Grid" (or EASE2.0 grid in polar regions). The L1C product also contains three 60m VNIR bands resampled from ASI products. Swath and Gridded Image-Map products are provided in NetCDF format. Tiled products are provided in Cloud Optimized GeoTIFF (COG) format (UTM/WGS84). See Section 3 for detailed descriptions of the Level 1 products.

1.5.2 ASI-Supplied Inputs to Level 1 TIR

The Italian Space Agency (Agenzia Spaziale Italiana; ASI) manages the SBG-TIR spacecraft platform and the Visual Near-Infrared (VNIR) instrument that is co-boresited with the JPL-managed TIR instrument. ASI provides corrected orbital and geolocation metadata (for L1B products) and three ~30-50m VNIR radiance products for inclusion with the Level 1C Radiance (60m) standard product collection. The expected daytime inputs (and day/night platform metadata) from ASI include:

- Platform Uncorrected Ephemeris and Attitude Timing Metadata (Day and Night)
- Orbital VNIR Corrected/Uncorrected Ephemeris and Attitude Metadata (Day)
    - Uncorrected Attitude/quaternion Dataset
    - Uncorrected Attitude/time_j2000 Dataset
    - Uncorrected Ephemeris/eci_position Dataset
    - Uncorrected Ephemeris/eci_velocity Dataset
    - Uncorrected Ephemeris/time_j2000 Dataset
    - Corrected Attitude/quaternion Dataset
    - Corrected Attitude/time_j2000 Dataset
    - Corrected Ephemeris/eci_position Dataset
    - Corrected Ephemeris/eci_velocity Dataset
    - Corrected Ephemeris/time_j2000 Dataset
    - Quaternion Format: "NAIF/SPICE"
    - VNIR Camera Model (for reference)
- VNIR Level 1B Radiance (Geolocated; Swath format) – NetCDF format
    - Three daytime TOA Radiance Bands (~30-50m resolution)

- VNIR Level 1B Geolocation files (Swath format) – NetCDF format
    - Latitude; Longitude; Elevation/Height; Pixel Time of Acquisition (or equivalent)
- VNIR Level 1C Radiance (Geolocated; Gridded format) – GeoTIFF Images and Sentinel Tiles
    - Three daytime TOA Bands (~30-50m resolution) gridded images and tiles

1.5.3 Level 1 Standard Day, Night, and Low Latency Products

The three ASI-provided VNIR radiance bands will (only) be generated during the day. Therefore, daytime SBG-TIR L1C standard products will include three VNIR and eight TIR bands while only TIR bands will be available for nighttime collection products. These "standard" products are expected to be processed and delivered within 72 hours of their collection. However, a special subset of L1 products will be generated within 24 hours of collection to meet special time-critical science requirements. These "Low Latency" products will be processed using separate ASI and JPL production lines, and will not include integrated VNIR and TIR spectral bands or metadata. Therefore, they will differ slightly from the subsequent Standard products, and may not be archived after serving their short-term purposes. Note that L1B products do not contain VNIR data, and the Nighttime TIR collection will exclude the 10.3μm band). Figure 1-1 shows the Standard processing flow for SBG VNIR and TIR L1 standard products, and can be compared with the equivalent Low Latency product flow (Figure 1-2).

Figure 1-1: SBG-TIR Level 1 Standard Products Data Flow

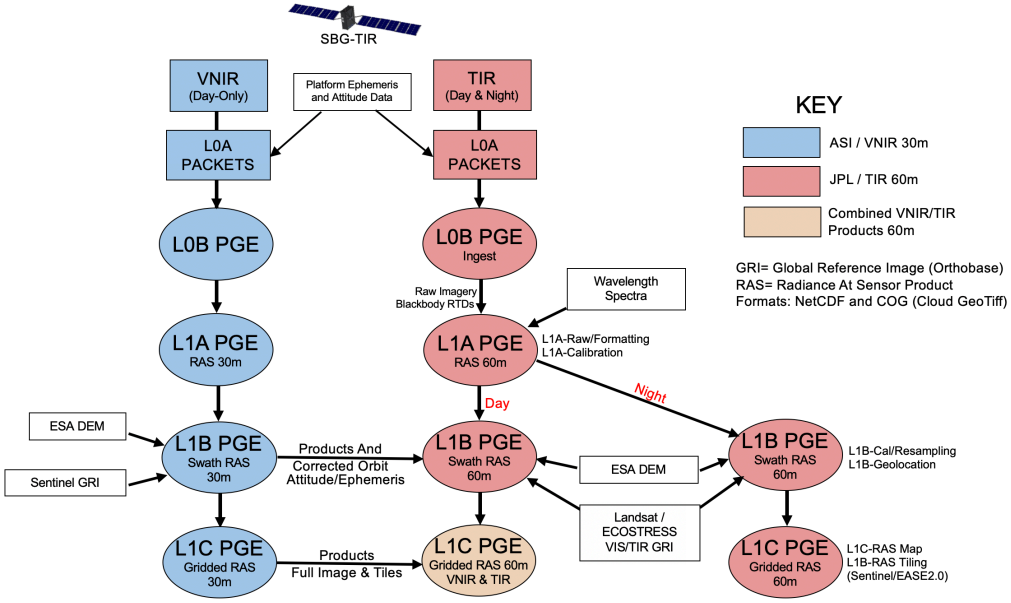


Figure 1-2: SBG-TIR Level 1 Low Latency Products Data Flow

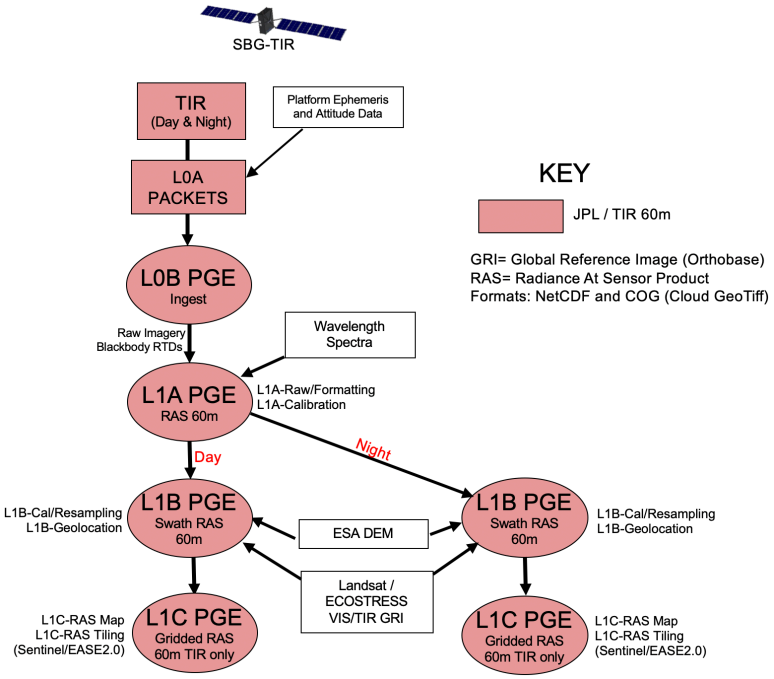


Table 1-2 provides a summary of interplay between Standard and Low Latency products and Day versus Night processing. In addition, the following comments are provided for clarification:

- L1B does not contain VNIR products.
- L1C Standard Daytime products contain VNIR data (Not L1C Night or Low Latency products).
- L1B contains (and L1C inherits) orbital correction metadata from ASI for Standard Daytime products, but not for Night or Low Latency products.
- JPL 60m TIR (and TIR/VNIR) products use the Landsat/ECOSTRESS TIR Global Reference Grid (GRI) orthobase. ASI 30m VNIR products use the Sentinel red band GRI.

Table 1-2: Standard and Low Latency Product Comparison

Product	Coverage	Resol (m)	Joint	Level	Gridded	Requires TIR and VNIR	Day/Night	Format
Standard Products								
L1B_RAD Radiance at Sensor	Global	60	N	L1B	N (Swath)	N	D and N	NetCDF
L1B Geolocation	Global	60	N	L1B	N (Swath)	N	D and N	NetCDF
L1C Radiance at sensor (rectified)	Global	60	Y	L1C	Y	Y	TIR: D and N VNIR: D only	COG
Low Latency Products								
L1B_RAD Radiance at Sensor	Global	60	N	L1B	N (Swath)	N	D and N	NetCDF
L1B Geolocation	Global	60	N	L1B	N (Swath)	N	D and N	NetCDF
L1C Radiance at Sensor (rectified)	Global	60	N	L1C	Y	N	TIR: D and N VNIR: None	COG

1.5.4 Level 1 Intermediate and Distributable Products

In addition to the previously discussed L1B and L1C products, there are a number of intermediate files. For example, the L1A_RAW_PIX and L1A_BB files are scene-specific extracts of orbital spectral and metadata designed for input to the L1A Calibration PGE. In turn, the L1A PGE outputs the L1A_PIX archive file containing all pre-processed calibration inputs ready for any future re-calibration. Table 1-3 provides a summary of Level 1 intermediate and distributable products.

Table 1-3: Level 1 Intermediate and Distributable Products

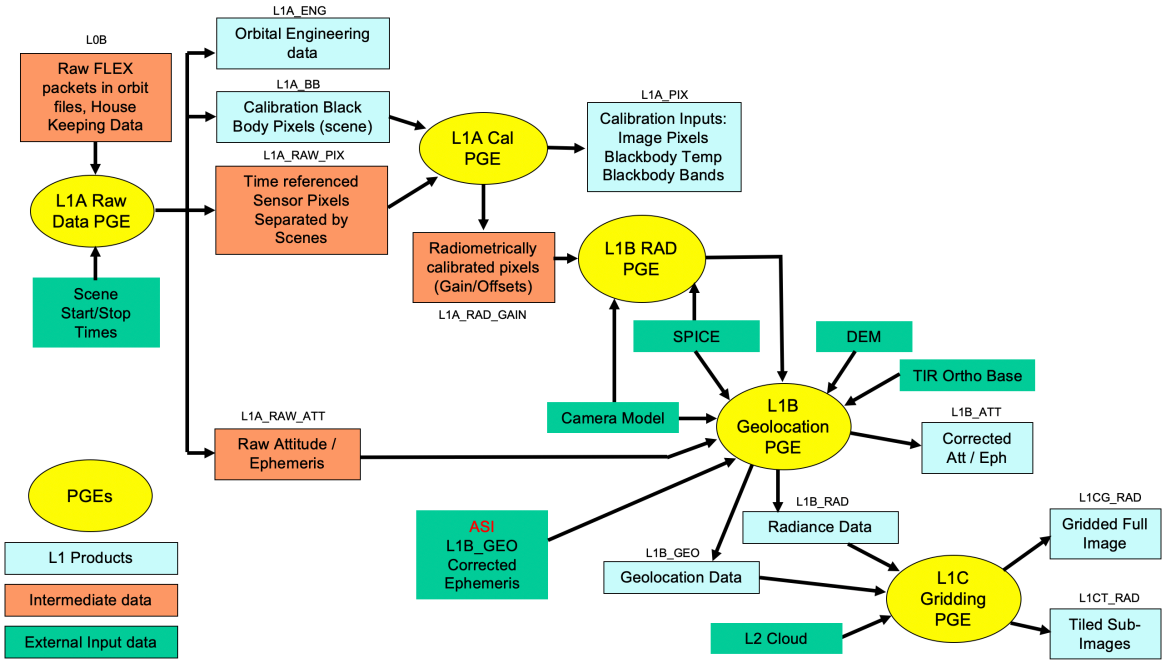
Product type	Description
L1A_ENG	Spacecraft orbital and instrument engineering data, including blackbody gradient coefficients and orbital timing
L1A_BB	Scene-specific instrument blackbody calibration pixels and timing
L1A_RAW_PIX	Scene-specific raw pixel spectral band data
L1A_PIX	Archive of all scene-specific inputs pre-processed as required for radiometric calibration, including raw pixel spectral band data, matching high/low blackbody pixels and temperature (Kelvin) values
L1A_RAW_ATT	Scene-specific raw attitude and ephemeris data
L1A_RAD_GAIN	Radiance gain and offset coefficients for each band
L1B_GEO	Swath image geolocation-tagged files, including latitude, longitude, height, sun angles, look angles, and related ancillary data.
L1B_RAD	Swath image radiometrically corrected radiance pixels, matched with L1B_GEO geolocation tags; 8 Radiance and data quality bands
L1B_ATT	Corrected spacecraft ephemeris and attitude data
L1C_GRID	Gridded L1B radiance full image at 60m/pixel in lat/long projection; 8 Radiance and data quality bands
L1C_TILE	Tiled L1B radiance imagery at 60m/pixel according to Sentinel UTM grid/tiling system; 8 Radiance and data quality bands

1.5.5 Level 1 PGE Overview

Level-1 products are produced in a series of PGE (Product Generation Executive) steps as shown in Figure 1-3. The L1A_RAW PGE is responsible for extracting raw spectral density numbers (DN), blackbody DNs, and blackbody temperatures from orbital stream data into scene-specific files. The L1A_CAL PGE pre-processes raw scene-specific inputs into a calibration-ready form for (1) DN-to-Radiance calibration (see L1 Calibration ATBD) and (2) archiving (L1A_PIX; Table 3-11). Output radiance gain and offset coefficients are passed via the L1A_RAD_GAIN file (Table 3-13) to the L1B PGE. Note that L1A image bands are not co-registered (pixel-aligned) at this stage of processing. Band alignment (a minor polynominal adjustment) occurs along with other L1B pre-processing steps to align swath lines in a consistent manner. The L1B PGE then geolocates each individual swath radiance pixel and outputs matching Latitude and Longitude (and other) swath raster files. This geolocation process involves creating an intermediate geographic-projected (gridded) radiance file using the camera model, corrected ephemeris from ASI (Section 1.5.2) and/or the local TIR platform metadata, digital elevation model (DEM), and TIR orthobase (for co-registration matching). The swath radiance bands are output in the L1B_RAD product file

(Table 3-4) with the matching swath geolocation (latitude and longitude) data output in the L1B_GEO product file (Table 3-7). These products are finally combined and gridded to 60 meters/pixel (along with the three VNIR radiance bands) and output via the L1C_GRIDDING PGE as COG (Cloud Optimized GeoTiff) full-image bands (L1CG_RAD; where G=Gridded) in 1) Latitude/Longitude geographic projection, and as 2) 110x110km Sentinel Grid tiles in UTM projection (L1CT_RAD; where T=Tiled).

Figure 1-3: SBG-TIR Level 1 PGE Product Data Flow



2.0 DATA PRODUCT ORGANIZATION

2.1 Distributed File Formats

SBG-TIR image products are distributed in either (or both) of two formats: "Network Common Data Form 4" (netCDF-4), or "Cloud-Optimized GeoTIFF" (COG). Only the L1A, L1B and L2 swath products are provided in netCDF format as these foundational products are primarily intended for long-term scientific archiving. Most users are expected to utilize L1C and L2-L4 products in the map-projected (gridded) COG format in 110x110km sub-image tiles (UTM projection).

2.1.1 NetCDF4 Format

"NetCDF (Network Common Data Form) is a set of software libraries and machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data." The format is managed by Unidata for the University Corporation for Atmospheric Research (NCAR), https://www.unidata.ucar.edu/software/netcdf/, and extensively documented in the NetCDF Users Guide at https://docs.unidata.ucar.edu/nug/current/index.html. NetCDF files have the ".nc" file extension, and are compatible with a number of common access tools including NetCDF Viewer, Panoply, ArcGIS, Python (netCDF4-python; PyNIO module), and others. Many linux systems also have the command line "ncdump -h *file*.nc" tool installed. NetCDF4 filed also contain extensive metadata as described (by product file) in Section 3.

2.1.2 COG Format

Analysis-ready SBG products are distributed in a gridded and tiled form using the COG (Cloud Optimized GeoTiff) format https://www.cogeo.org/. While COG files are typically larger than regular GeoTIFF files, they have the ability to adjust viewing scales and more efficiently stream only the required portions of an image file. COG files use the same ".tif" suffix as regular GeoTiff files.

SBG L1CG gridded products are COG-formatted multi-band files in latitude/longitude map-projection. SBG L1CT files are COG-formatted image sub-tiles based on a modified form of the Military Grid Reference System (MGRS) tiling scheme as defined by NASA (https://hls.gsfc.nasa.gov/products-description/tiling-system/) and the ESA Sentinel-2 UTM grid (https://eatlas.org.au/data/uuid/f7468d15-12be-4e3f-a246-b2882a324f59). These tiles divide Universal Transverse Mercator (UTM) zones into square tiles 109760 m across, using a 60m cell size with 1800 rows by 1800 columns, totaling 3.24 million pixels per tile. This allows the end user to assume that each 60 meter SBG pixel will remain in the same location at each timestep observed in analysis. The COG format also facilitates end-user analysis as a universally recognized and supported format, compatible with open-source software, including QGIS, ArcGIS, GDAL, the Raster package in R, rioxarray in Python, and Rasters.jl in Julia.

Each SBG gridded or tiled COG product additionally contains a rendered browse image in GeoJPEG format with a .jpeg extension. This image format is universally recognized and supported, and the files are compatible with Google Earth. Each collection of tiled files also includes a separate .json file containing the Product Metadata and Standard Metadata in JSON format for the parent image granule.

3.0 SBG-TIR PRODUCT FILES

3.1 Product File Name Format

Product file names will have the form (TBD):

```
<SBG_Name>_<PROD_TYPE>_<OOOOO>_<SSS>_<YYYYMMDD>T<hhmmss>_<BBbb>_<VV>.<TYPE>
```

Where:

- SBG_Name: SBG-TIR name designation (TBD)
- PROD_TYPE: L1A/L1B products; Example=L1B_RAD
- OOOOO: Orbit number; starting at start of mission, ascending equatorial crossing
- SSS: Scene ID; starting at first scene of each orbit
- YYYYMMDD: Year, month, day of scene start time
- hhmmss: Hour, minute, second of scene start time
- BBbb: Build ID of software that generated product, Major+Minor (2+2 digits)
- VV: Product version number (2 digits)
- TYPE: File type extension=
  - nc or tif for the data file
  - nc.met or tif.met for the metadata file.

Band Ordering of L1A_PIX, L1A_BB, L1B_RAD L1CG, L1CT data:

B1	VNIR_Radiance 1 (Pan; L1CG/LICT Standard Day Product only)
B2	VNIR_Radiance 2 (TBD; L1CG/LICT Standard Day Product only)
B3	VNIR_Radiance 3 (TBD; L1CG/LICT Standard Day Product only)
B4	MIR_Radiance 4 (3.98 µm)
B5	MIR_Radiance 5 (4.81 µm)
B6	TIR_Radiance 6 (8.32 µm)
B7	TIR_Radiance 7 (8.63 µm)
B8	TIR_Radiance 8 (9.07 µm)

B9 TIR_Radiance 9 (10.30 µm; Daytime Only)
B10 TIR_Radiance 10 (11.35 µm)
B11 TIR_Radiance 11 (12.05 µm)

3.2 Swath Standard Metadata (NetCDF-4)

Each SBG swath product in NetCDF format will contain at least 3 groups of data: A standard metadata group that specifies the same type of contents for all products, a product specific metadata group that specifies those metadata elements that are useful for defining attributes of the product data, and the group(s) containing the product data.

Table 3-1 provides the standard metadata for L1B_RAD and L1B_GEO products. This may vary for other L1 products and as well as L2+ products. The standard metadata consists of the following:

Table 3-1: Standard Product Metadata

Name	Type	Size	Example
Group	**StandardMetadata**		
AncillaryInputPointer	String	variable	Group name of ancillary file list
AutomaticQualityFlag	String	variable	PASS/SUSPECT
AutomaticQualtiyFlagExplanation	String	variable	
BuildID	String	variable	
CampaignShortName	String	variable	Primary
CollectionLabel	String	variable	
DataFormatType	String	variable	
DayNightFlag	String	variable	
EastBoundingCoordinate	LongFloat	8	
FieldOfViewObstruction			
NetCDFVersionID	String	variable	
ImageLines	Int32	4	17664
ImageLineSpacing	Float32	4	60.0
ImagePixels	Int32	4	15168
ImagePixelSpacing	Float32	4	60.0
InputPointer	String	variable	
InstrumentShortName	String	variable	
LocalGranuleID	String	variable	
LongName	String	variable	
NorthBoundingCoordinate	LongFloat	8	
PGEName	String	variable	L1B_GEO; (L1A_RAW, L1A_CAL, L1B_RAD)
PGEVersion	String	variable	
PlatformLongName	String	variable	
PlatformShortName	String	variable	
PlatformType	String	variable	Spacecraft
ProcessingLevelID	String	variable	1
ProcessingLevelDescription	String	variable	Level 1 Geolocation Parameters
ProducerAgency	String	variable	JPL
ProducerInstitution	String	variable	Caltech
ProductionDateTime	String	variable	
ProductionLocation	String	variable	
RangeBeginningDate	String	variable	
RangeBeginningTime	String	variable	
RangeEndingDate	String	variable	
RangeEndingTime	String	variable	
RegionID	String	variable	

SceneID	String	variable	
ShortName	String	variable	L1B_GEO; (L1A_RAW, L1A_CAL, L1B_RAD)
SISName	String	variable	
SISVersion	String	variable	
SouthBoundingCoordinate	LongFloat	8	
StartOrbitNumber	String	variable	
StopOrbitNumber	String	variable	
WestBoundingCoordinate	LongFloat	8	

3.3 Swath Product-Specific Metadata (NetCDF-4)

Primary L1 products and metadata are described below.

3.3.1 L1A_ENG – Spacecraft and Engineering Data

Table 3-2: L1A_ENG Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	fill
Group	**Standard Metadata** (See Table 3-1)					
Group	**L1A_ENGMetadata** (Ancillary Files: None)					
Group	**rtdBlackbodyGradients** (Size Unlimited, 1 set per second, through entire orbit)					
RTD_Hot	Float32	Kelvin	5 temperature measurements from back of Hot Black Body (HBB)	TBD	TBD	N/A
RTD_Cold	Float32	Kelvin	5 temperature measurements from back of Cold Black Body (CBB)	TBD	TBD	N/A
Time_j2000	Float64	Seconds	J2000 times of temperature reading and HK packet	0	N/A	-9999

3.3.2 L1A_BB – FPA Blackbody Calibration DN

Table 3-3: L1A_BB Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	fill
Group	**L1A_BBMetadata**					
QAPercentMissingData	Float32	%	Percentage of data missing from L0B	0	100	N/A
BandSpecification	Float32	μm	Wavelength of BB pixel data in corresponding datasets for bands 3 through 10: 3.98, 4.81, 8.32, 8.63, 9.07, 10.30, 11.35, 12.07; 0=fill data	TBD	TBD	0
Group (Excludes VNIR)	**BlackBodyPixels** (Size 17664x2 sets per band, 64 pixels per set)					
b4_blackbody_hot	UInt16	DN	B4 Focal Plane DN of Hot BB	0	32767	0xffff
b4_blackbody_cold	UInt16	DN	B4 Focal Plane DN of Cold BB	0	32767	0xffff
b5_blackbody_hot	UInt16	DN	B5 Focal Plane DN of Hot BB	0	32767	0xffff
b5_blackbody_cold	UInt16	DN	B5 Focal Plane DN of Cold BB	0	32767	0xffff
b6_blackbody_hot	UInt16	DN	B6 Focal Plane DN of Hot BB	0	32767	0xffff
b6_blackbody_cold	UInt16	DN	B6 Focal Plane DN of Cold BB	0	32767	0xffff
b7_blackbody_hot	UInt16	DN	B7 Focal Plane DN of Hot BB	0	32767	0xffff
b7_blackbody_cold	UInt16	DN	B7 Focal Plane DN of Cold BB	0	32767	0xffff
b8_blackbody_hot	UInt16	DN	B8 Focal Plane DN of Hot BB	0	32767	0xffff

b8_blackbody_cold	UInt16	DN	B8 Focal Plane DN of Cold BB	0	32767	0xffff
b9_blackbody_hot	UInt16	DN	B9 Focal Plane DN of Hot BB	0	32767	0xffff
b9_blackbody_cold	UInt16	DN	B9 Focal Plane DN of Cold BB	0	32767	0xffff
b10_blackbody_hot	UInt16	DN	B10 Focal Plane DN of Hot BB	0	32767	0xffff
b10_blackbody_cold	UInt16	DN	B10 Focal Plane DN of Cold BB	0	32767	0xffff
b11_blackbody_hot	UInt16	DN	B11 Focal Plane DN of Hot BB	0	32767	0xffff
b11_blackbody_cold	UInt16	DN	B11 Focal Plane DN of Cold BB	0	32767	0xffff
Group	**rtdBlackbodyGradients** (copied from L1A_ENG file)					
RTD_HOT	Float32	Kelvin	5 temperature measurements from back of HBB	TBD	TBD	N/A
RTD_COLD	Float32	Kelvin	5 temperature measurements from back of CBB	TBD	TBD	N/A
Time_j2000	Float64	Seconds	J2000 times of temperature reading and HK packet	0	N/A	N/A

3.4.3 L1B_RAD – Radiometrically Corrected and Resampled At-Sensor Radiances

Table 3-4: L1B_RAD Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	Fill
Group	**Standard Metadata** (See Table 3-1)					
Group	**Radiance** (Size 17664x15168 sets)					
radiance_4	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_5	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_6	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_7	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_8	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_9	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_10	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_11	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
data_quality_3	Int8	None		0	4	Table 3-5
data_quality_4	Int8	None		0	4	Table 3-5
data_quality_5	Int8	None		0	4	Table 3-5
data_quality_6	Int8	None		0	4	Table 3-5
data_quality_7	Int8	None		0	4	Table 3-5
data_quality_8	Int8	None		0	4	Table 3-5
data_quality_9	Int8	None		0	4	Table 3-5
data_quality_10	Int8	None		0	4	Table 3-5
data_quality_11	Int8	None		0	4	Table 3-5
Group	**FPIEencoder** (Size 69x15168)					
EncoderValue	Uint32	None	Mirror encoder value of each focal plane in each scan	0	1749247	0xffffffff
Group	**Time** (Size 8832, 69 sets of 128 repeated values)					
line_start_time_j2000	Float64	Second	J2000 time of first pixel in line	N/A	N/A	N/A
Group	**L1B_RADMetadata**					
RadScanLineOrder	String	None	One of “Reverse line order” or “Line order”. Indicates if we have reversed the order line order for each scan to produce image with separate scans aligned.	N/A	N/A	N/A
QAPercentMissingData	Float32	%	Percentage of data missing from L0B	0	100	N/A

BandSpecification	Float32	μm	Wavelength of BB pixel data in corresponding datasets for bands 3 through 10: 3.98, 4.81, 8.32, 8.63, 9.07, 10.30, 11.35, 12.07; 0=fill data	1.4	12.1	0
AncillaryFiles	Char	None				
CalibrationGainCorrection	Float32	None				
CalibrationOffsetCorrection	Float32	Watt/m2/sr/um				

Table 3-5: Data Quality Values

Data Quality/Condition	Value
Good	0
Backup (TBD)	1
Backup (TBD)	2
Missing/bad data	3
Not seen[1]	4

Table 3-6: Special Radiance Data Values

Data Condition	Value
Pixel not seen[1]	-9997.0
Backup (for TBD Artifacts)	-9998.0
Missing/bad data	-9999.0

3.3.4 L1B_GEO – Latitude and Longitude Geolocations, solar and view angles

Table 3-7: L1B_GEO Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	fill
Group	**Standard Metadata** (See Table 3-1)					
Group	**Geolocation** (Size 17664x15168 sets)					
height	Float32	Meter		N/A	N/A	N/A
land_fraction	Float32	%	Percentage of pixel that is land	0	100	-9999
latitude	Float64	Degrees		-90	90	N/A
line_start_time_j2000	Float64	Seconds	J2000 time of first pixel in line	N/A	N/A	N/A
longitude	Float64	Degrees		-180	180	N/A
Range (satellite to pixel)	Float64	Meters		N/A	N/A	N/A
solar_azimuth	Float32	Degrees		-180	180	N/A
solar_zenith	Float32	Degrees		-90	90	NA
view_azimuth	Float32	Degrees		-180	180	N/A
view_zenith	Float32	Degrees		-90	90	N/A
view_occusion	Float32	None		0	1	N/A
Projection	Char	None	"Well_Known Text" (WKT)	N/A	N/A	N/A
Group	**L1GEOMetadata**			-90	90	N/A
AverageSolarZenith	Float64	Degrees	Average solar zenith angle for scene			

[1] Push-Whisk sensor bands don't image a particular cross scan pixel at the same time. After band coregistration to the reference band, the difference can be large enough that the spacecraft has moved enough to miss a pixel at the edges of the scanner.

OrbitCorrection Performed	String	None	One of “True” or “False”. If “True”, image matching was performed with the global orthobase to correct navigation. If false, no correction was performed.	N/A	N/A	N/A
OverAllLandFraction	Float64	%	Overall land fraction for scene	0	100	N/A
AncillaryFiles	Char	None		N/A	N/A	N/A
DeltaTimeOfCorrectionAfterScene	Float64	Seconds		N/A	N/A	N/A
DeltaTimeOfCorrectionBeforeScene	Float64	Seconds		N/A	N/A	N/A
GeolocationAccuracyQA	Char	None	Best, Good, Suspect, Poor	N/A	N/A	N/A
GeolocationAccuracyQAExplanation	Char	None	Best - Image matching was performed for this scene. Good - Image matching from a nearby scene. Suspect - Matched somewhere in the orbit. Poor - No matches in the orbit.	N/A	N/A	N/A

3.3.5 L1B_ATT – Corrected spacecraft ephemeris and attitude data

Table 3-8: L1B_ATT Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	fill
Group	**Standard Metadata** (See Table 3-1)					
Group	**Ephemeris** (Size unlimited, once per second for entire orbit)					
time_j2000	Float64	Seconds	Seconds from J2000 epoch	N/A	N/A	N/A
eci_position	Float64	Meters	X, Y, Z Position in ECI coordinate	N/A	N/A	N/A
eci_velocity	Float64	m/s	X, Y, Z Velocity in ECI coordinates	N/A	N/A	N/A
Group	**Attitude** (Size unlimited, once per second for entire orbit)					
time_j2000	Float64	Seconds	Seconds from J2000 epoch	N/A	N/A	N/A
quaternion	Float64	None	Attitude quaternion (I, j, k, theta)	N/A	N/A	N/A
Group	**Uncorrected Ephemeris** (Size unlimited, once per second for entire orbit)					
time_j2000	Float64	Seconds	Seconds from J2000 epoch	N/A	N/A	N/A
eci_position	Float64	Meters	X, Y, Z Position in ECI coordinate	N/A	N/A	N/A
eci_velocity	Float64	m/s	X, Y, Z Velocity in ECI coordinates	N/A	N/A	N/A
Group	**Uncorrected Attitude** (Size unlimited, once per second for entire orbit)					
time_j2000	Float64	Seconds	Seconds from J2000 epoch	N/A	N/A	N/A
quaternion	Float64	None	Attitude quaternion (I, j, k, theta)	N/A	N/A	N/A
Group	**L1GEOMetadata**					
OrbitCorrectionPerformed	String	None	One of “True” or “False”. If “True”, image matching was performed with the global orthobase to correct navigation. If false, no correction was performed.	N/A	N/A	N/A
AncillaryFiles	Char	None				

3.4 Gridded Product Data (COG)

3.4.1 Algorithm Description

The L1CG RAD gridded product is processed by ingesting the L1B RAD and L2 CLOUD swath products, geolocating them using the L1B GEO product, and resampling them by nearest neighbor to a globally snapped 0.0006° grid. The L1B RAD product is resampled and repackaged as the L1CG RAD product, and it contains the cloud mask from L2 CLOUD as a quality layer. The L1CT RAD tiled products are subset from the L1CG RAD product and resampled to the 60 m UTM grid.

3.4.2 L1CG RAD and L1CT RAD Radiance Products

The L1CG RAD gridded radiance and L1CT RAD tiled radiance products distribute SBG top-of-atmosphere radiance in units of watts per square meter per steradian per micron in the `radiance_4` through `radiance_11` layers. The QC flags from the L1B RAD swath product are resampled here as `data_quality_4` through `data_quality_11`. The L1B data quality flags are defined in Table 3-6 (above). The dataset name, data type, and units of each data layer in the L1CG RAD and L1CT RAD radiance products are listed in Table 3-9.

Table 3-9: Listing of Raster Data Layers in L1CG and L1CT Products

Name	Type	Units	Size
radiance_4	float32	$W\ m^{-2}\ sr^{-1}\ {}^{u}m^{-1}$	12.96 mb
radiance_5			
radiance_6			
radiance_7			
radiance_8			
radiance_9			
radiance_10			
radiance_11			
data_quality_4	uint8	QA	3.24 mb
data_quality_5			
data_quality_6			
data_quality_7			
data_quality_8			
data_quality_9			
data_quality_10			
data_quality_11			
cloud		mask	
water			

The browse images for the L1CG RAD and L2T RAD products are generated as false-color composites.

3.4.3 COG Gridded Metadata

COG product file metadata is provided as a separate text file in JSON format. The information is also limited to the Standard Metadata as described in Table 3-1 (above).

3.5 Intermediate, Temporary, and Non-Delivered Products

The following groups define formats of various intermediate and temporary products generated and used by L1 PGEs, but are not standard products that are normally delivered to the DAAC.

3.5.1 L1A_RAW_PIX – Raw Scene Pixel Data

Table 3-10: L1A_RAW_PIX Product Data Definitions

Field Name	Type	Units	Field Data
Group	**Standard Metadata** (See Table 3-1)		
Group	**L1A_RAW_PIXMetadata**		
AncillaryFiles	Char	None	N/A
QAPercentMissingData	Float32	%	Number of missing pixels per total pixels in scene (17664x15168)
BandSpecification	Char	Micrometer	Center Band Wavelength
Group	**UncalibratedPixels** (Size 11264x5400 per band)		
pixel_data_4	UInt16	None	Band 4 MIR scene data
pixel_data_5	UInt16	None	Band 5 MIR scene data
pixel_data_6	UInt16	None	Band 6 TIR scene data
pixel_data_7	UInt16	None	Band 7 TIR scene data
pixel_data_8	UInt16	None	Band 8 TIR scene data
pixel_data_9	UInt16	None	Band 9 TIR scene data
pixel_data_10	UInt16	None	Band 10 TIR scene data
pixel_data_11	UInt16	None	Band 11 TIR scene data
Group	**Time** (Size 17664x1)		
line_start_time_j2000	Float64	Second	J2000 time of first focal plane of each scan (256 lines by 6 bands per scan)
Group	**FPIEencoder** (Size 69x15168)		
EncoderValue	Uint32	None	Mirror encoder value of each focal plane in each scan (256 lines by 8 bands)

3.5.2 L1A_PIX – Calibration-Ready Raw Input Data

Table 3-11: L1A_PIX Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	fill
Group	**Standard Metadata** (See Table 3-1)					
Group	**L1A_PIXMetadata**					
QAPercentMissingData	Float32	%	Percentage of data missing from L0B	0	100	N/A
BandSpecification	Float32	μm	Wavelength of BB pixel data in corresponding datasets for bands 3 through 10: 3.98, 4.81, 8.32, 8.63, 9.07, 10.30, 11.35, 12.07; 0=fill data	3.98	12.07	0
AncillaryFiles	Char	None				
Group (Excludes VNIR)	**UncalibratedDN** (Size 17664x15168 sets)					
b4_image	Int16	DN	Band 4 Raw image Pixel Data	0	32767	Table 3-6
b5_image	Int16	DN	Band 5 Raw image Pixel Data	0	32767	Table 3-6
b6_image	Int16	DN	Band 6 Raw image Pixel Data	0	32767	Table 3-6
b7_image	Int16	DN	Band 7 Raw image Pixel Data	0	32767	Table 3-6
b8_image	Int16	DN	Band 8 Raw image Pixel Data	0	32767	Table 3-6
b9_image	Int16	DN	Band 9 Raw image Pixel Data	0	32767	Table 3-6
b10_image	Int16	DN	Band 10 Raw image Pixel Data	0	32767	Table 3-6
b11_image	Int16	DN	Band 11 Raw image Pixel Data	0	32767	Table 3-6
Group	**BlackbodyTemp** (1 set for image frame)					
fpa_hot	Float32	Kelvin	Calibrated Hot Blackbody Focal Plane	TBD	TBD	N/A
fpa_cold	Float32	Kelvin	Calibrated Cold Blackbody Focal Plane	TBD	TBD	N/A
Group (Excludes VNIR)	**BlackbodyBandDN** (1 set for image frame)					
b4_hot	Float32	DN	B4 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b4_cold	Float32	DN	B4 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b5_hot	Float32	DN	B5 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b5_cold	Float32	DN	B5 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b6_hot	Float32	DN	B6 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b6_cold	Float32	DN	B6 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b7_hot	Float32	DN	B7 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b7_cold	Float32	DN	B7 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b8_hot	Float32	DN	B8 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b8_cold	Float32	DN	B8 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b9_hot	Float32	DN	B9 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b9_cold	Float32	DN	B9 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b10_hot	Float32	DN	B10 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b10_cold	Float32	DN	B10 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b11_hot	Float32	DN	B11 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b11_cold	Float32	DN	B11 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
Group	**FPIEencoder** (Size 69x15168)					
EncoderValue	Uint32	None	Mirror encoder value of each focal plane in each scan	0	1749247	0xffffffff
Group	**Time** (Size 17664x1, 469 scans, 256 repeated values per scan)					
line_start_time_j2000	Float64	Second	J2000 time of first pixel in line	N/A	N/A	N/A

3.5.3 L1A_RAW_ATT – Uncorrected Spacecraft Ephemeris and Attitude Data

Table 3-12: L1A_RAW_ATT Product Data Definitions

Field Name	Type	Units	Field Data
Group	**Standard Metadata** (Table 3-1)		
Group	**Ephemeris** (Size unlimited, one set per second for entire orbit)		
time_j2000	Float64	Seconds	Seconds from J2000 epoch
eci_position	3*Float64	Meters	X, Y, Z Position in ECI coordinates
eci_velocity	3*Float64	m/s	X, Y, Z Velocity in ECI coordinates
Group	**Attitude**		
Time_j2000	Float64	Seconds	Seconds from J2000 epoch
Quaternion	4*Float64	None	Attitude quaternion (I, j, k, theta)

3.5.4 L1A_RAD_GAIN – Gain and Offset Coefficients

Table 3-13: L1A_RAD_GAIN Product Data Definitions

Field Name	Type	Units	Field Data	valid min	valid max	fill
Group	**L1A_PIXMetadata**					
QAPercentMissingData	Float32	%	Percentage of data missing from L0B	0	100	N/A
BandSpecification	Float32	μm	Wavelength of BB pixel data in corresponding datasets for bands 3 through 10: 3.98, 4.81, 8.32, 8.63, 9.07, 10.30, 11.35, 12.07; 0=fill data	3.98	12.07	0

Field Name	Type	Units	Field Data
Group	**Standard Metadata** (See Table 3-1)		
Group	**Gain** (Size 17664x15168)		
b4_gain	Float32	Watt/m2/sr/um/DN	Band 4 Gain
b5_gain	Float32	Watt/m2/sr/um/DN	Band 5 Gain
b6_gain	Float32	Watt/m2/sr/um/DN	Band 6 Gain
b7_gain	Float32	Watt/m2/sr/um/DN	Band 7 Gain
b8_gain	Float32	Watt/m2/sr/um/DN	Band 8 Gain
b9_gain	Float32	Watt/m2/sr/um/DN	Band 9 Gain
b10_gain	Float32	Watt/m2/sr/um/DN	Band 10 Gain
b11_gain	Float32	Watt/m2/sr/um/DN	Band 11 Gain
Group	**Offset** (Size 17664x15168)		
b4_offset	Float32	Watt/m2/sr/um/DN	Band 4 Offset
b5_offset	Float32	Watt/m2/sr/um/DN	Band 5 Offset
b6_offset	Float32	Watt/m2/sr/um/DN	Band 6 Offset
b7_offset	Float32	Watt/m2/sr/um/DN	Band 7 Offset
b8_offset	Float32	Watt/m2/sr/um/DN	Band 8 Offset
b9_offset	Float32	Watt/m2/sr/um/DN	Band 9 Offset
b10_offset	Float32	Watt/m2/sr/um/DN	Band 10 Offset
b11_offset	Float32	Watt/m2/sr/um/DN	Band 11 Offset

3.5.5 L1B_GEO_QA – Quality data for L1B_GEO PGE

Table 3-14: L1B_GEO_QA Product Data Definitions

Field Name	Type	Units	Field Data
Group	**Average**		
Average Metadata	Float64	None	Various averages for each scene. First column is solar zenith angle, second is land fraction
Input File List	String	None	Full list of input files, including paths, that we ran with
Group	**Standard Metadata** (See Table 3-1)		
Group	**Accuracy Estimate**		
Accuracy Before Correction	Float64	Meter	Accuracy estimate for each scene before correction
Final Accuracy	Float64	Meter	Accuracy estimate after correction
Scene	String	None	List of scenes included in accuracy estimate
Group	**L1GEOMetadata**		
OrbitCorrectionPerformed	String	None	One of "True or "False". If “True”, we were able to use image matching with our global orthobase to correct the reported navigation. If false, we are using uncorrected navigation data.
AncillaryFiles	Char	None	
Group	**Logs**		
Encountered Exception	String	None	One of "True" or "False". True if we encountered an exception in processing
Overall Log	String	None	Log file for full process
Group	**Logs/Tiepoint Logs**		
Scene 1	String	None	Log file for Scene 1 Tiepoint
Scene 2	String	None	Log file for Scene 2 Tiepoint
…	String	None	Log file for each scene
Group	**Orbit**		
Attitude Correction	Float64	Arcseconds	
Attitude Time Point	Float64	Seconds	J2000 time of attitude correction
Position Correction	Float64	Meters	
Position Time Point	Float64	Seconds	J2000 time of position correction
Group	**PythonObject**		
igccol_initial	String	None	XML file describing initial igccol
igccol_initial_desc	String	None	Text describing initial igccol
igccol_sba	String	None	XML file describing igccol after sba
igccol_sba_desc	String	None	Text describing igccol after sba
tpcol	String	None	XML file describing initial tie-points
tpcol_desc	String	None	Text describing initial tie-points
tpcol_sba	String	None	XML file describing tie-points after sba

tpcol_sba_desc	String	None	Text describing tie-points after sba
Group	**Tiepoint**		
Scene	String	None	List of scenes we collect tie-point for
Tiepoint Count	int32	None	Count of tie-points for each scene
Group	**Tiepoint/Scene 1**		
Tiepoints Dataset	float64	None	Tie-points collected for scene 1
Group	**Tiepoint/Scene 2**		
Tiepoints Dataset	float64	None	Tie-points collected for scene 2
Group	**Tiepoint/Scene….**		
Tiepoints Dataset	float64	None	Tie-points collected for each scene

APPENDIX A: ABBREVIATIONS AND ACRONYMS

ARS	Agricultural Research Service
ASD	Algorithm Specifications Document
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ATBD	Algorithm Theoretical Basis Document
CCB	Change Control Board
CDR	Critical Design Review
CF	Climate and Forecast (metadata convention)
CM	Configuration Management
CONUS	Continental United States
COTS	Commercial Off The Shelf
DAAC	Distributed Active Archive Center
dB	DeciBel
DCN	Document Change Notice
deg	Degrees
deg/sec	Degrees per Second
DEM	Digital Elevation Model
DN	Data Number
EASE	Equal Area Scalable Earth
ECI	Earth Centered Inertial coordinate system
ECR	Earth Centered Rotating coordinate system
ECS	EOSDIS Core System
ECOSTRESS	ECOsystem Spaceborne Thermal Radiometer on Space Station
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESDIS	Earth Science Data and Information System
ESDT	Earth Science Data Type
FOV	Field of View
FSW	Flight Software
GB	gigabytes, 10^9 bytes
GDS	Ground Data System
GHA	Greenwich Hour Angle
GHz	Gigahertz, 10^9 hertz
GMAO	Global Modeling and Assimilation Office
GMT	Greenwich Mean Time

GPP	Gross Primary Production
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HK	Housekeeping (telemetry)
HRSL	Hydrology and Remote Sensing Laboratory
Hz	Hertz
HSD	Health and Status Data
I&T	Integration and Test
ICD	Interface Control Document
I/O	Input/Output
IOC	In-Orbit Checkout
IPA	Inter-Project Agreement
JPL	Jet Propulsion Laboratory
K	Kelvin
KHz	Kilohertz
Km	kilometer, 1000 meters
L0 – L4	Level 0 through Level 4
LAN	Local Area Network
LEO	Low Earth Orbit
LOE	Level of Effort
LOM	Life of Mission
LP	Land Processes
LSTE	Land Surface Temperature and Emissivity
m	meter
MB	megabytes, 10^6 bytes
Mbps	Mega bits per second
MHz	Megahertz
MMR	Monthly Management Review
MOA	Memorandum of Agreement
MODIS	Moderate Resolution Imaging Spectroradiometer
MOS	Mission Operations System
m/s	meters per second
ms	milliseconds
MS	Mission System
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Protection
NCSA	National Center for Supercomputing Applications
netCDF	Network Common Data Format
NISN	NASA Integrated Services Network
NOAA	National Oceanic and Atmospheric Administration
OA	Operations Agreement
ODL	Object Description Language
OODT	Object Oriented Data Technology
ORR	Operational Readiness Review
ORT	Operational Readiness Test
PDR	Preliminary Design Review
percent	%, per hundred
PR	Problem Report
PSD	Product Specifications Document

PT-JPL	Priestly-Taylor-JPL
QA	Quality Assurance
rad	radians (or RADiance)
RDD	Release Description Document
RFA	Request For Action
S/C	Spacecraft
SBG	Surface Biology and Geology
SCP	Secure Copy
SDP	Software Development Plan
SDS	Science Data System
sec, s	seconds
SITP	System Integration and Test Plan
SMP	Software Management Plan
SOM	Software Operators Manual
TAI	International Atomic Clock
T_b	Brightness Temperature
TBD	To Be Determined
TBS	To Be Specified
TOA	Time of Arrival
TPS	Third Party Software
USDA	United State Department of Agriculture
USGS	United States Geological Society
UTC	Coordinated Universal Time
V&V	Verification and Validation
XML	Extensible Markup Language