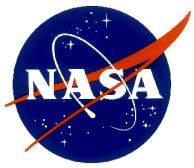
JPL D-110521



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 (A/B/C) data products of the NASA/JPL Surface Biology and Geology (SBG) Thermal Infrared (TIR) mission (aka "OTTER"). SBG-TIR L1 products provide corrected spacecraft attitude, calibrated at-sensor radiances and geolocation tags for 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 PPSD is an initial "Phase C" 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). Preliminary 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 a cooperative effort with the Italian Space Agency (Agenzia Spaziale Italiana; ASI), which produces SBG-TIR platform metadata and three Visual and Near-Infrared (VNIR) bands. Descriptions of ASI 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 is a "Designated Observable" (DO) identified in the National Academies of Sciences, Engineering and Medicine (NASEM) 2017 Decadal Survey. The Decadal Survey document presented a vision for combining the 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. To best address the topics areas, the SBG mission has been divided into two separate satellite platforms, supporting 1) hyperspectral shortwave (SWIR) collections, and 2) multispectral thermal (TIR) collections.

The SBG-TIR portion of the mission includes the thermal infrared multispectral instrument, also known as OTTER (Orbiting Terrestrial Thermal Emission Radiometer), is built by the NASA Jet Propulsion Laboratory. The OTTER platform and VIREO (Visible InfraRed Earth Observing) camera subsystem are built by Italian Space Agency (Agenzia Spaziale Italiana; ASI). OTTER instruments will measure the emitted radiance of the Earth surface to better understand the dynamics of Earth's changing surface geology and biology, focusing on ground/water temperature, snow reflectivity, active geologic processes, vegetation traits, and algal biomass. The collective SBG-TIR mission addresses these dynamic issues by accurately measuring the emitted radiance of Earth's surface in the visual-infrared (VNIR), mid-infrared (MIR), and thermal-infrared (TIR) spectral regions using the two multispectral radiometers. The TIR instrument measures radiance data in eight 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. The VNIR instrument provides red (0.655 μm) and near-infrared (0.835μm) spectral bands at matching 60m resolutions, plus a third high resolution 30m/pixel panchromatic band (600-900μm).

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 Radiometric Calibration Algorithm Theoretical Basis Document. JPL D-110522 (26JUL2023).
5. SBG-TIR Level 1 Geometric Calibration Algorithm Theoretical Basis Document. JPL D-110523 (02SEP2024).
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 data processing is divided into "Levels" corresponding to product maturity. Level 0 (raw) data primarily consist of spacecraft packets that have been pre-processed by the Ground Data System (GDS). Level 1 provides 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 and brightness temperature, 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 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 and Brightness Temperature at Sensor	RAS; BT
Fundamental **(Level 2)**	Surface Temperature and Emissivity	LSTE (incl WT, ST and SGC)
Fundamental **(Level 2)**	Cloud mask	CM
Plant Functional Traits Suite **(Level 3-4)**	Evapotranspiration (ET), Water Use Efficiency (WUE), Evaporative Stress Index (ESI)	ET WUE ESI
Geology Suite **(Level 3-4)**	Surface Mineralogy (TIR only) Elevated Temperature Features Volcanic Activity	SM ETF VA
Snow Physics Suite **(Level 3-4)**	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 Level 1 consists of three sub-parts A, B, and C. L1A is responsible for Radiometric Calibration involving the conversion of spectral DN to radiance. Radiance gain and offset coefficients for each spectral band are calculated and delivered to L1B, as described in the L1 Radiometric Calibration ATBD. L1A outputs are primarily engineering and archive products, and are not generally intended for public consumption.

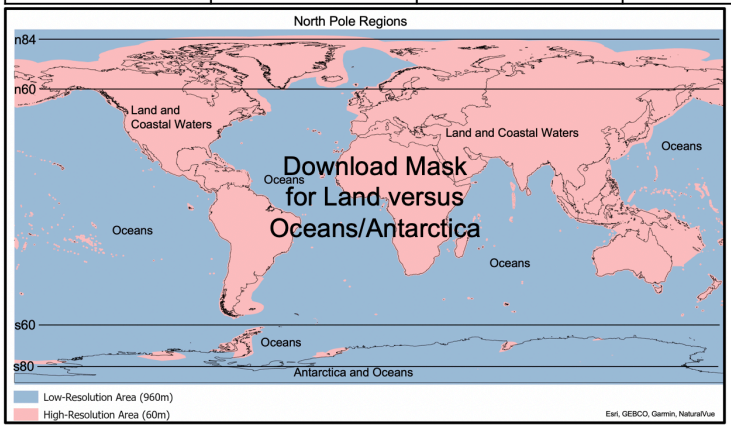
L1B applies the L1A radiance coefficients to each spectral band, then performs a Geometric calibration using ASI-corrected spacecraft altitude/ephemeris, DEM (elevation), and a map-referenced global orthobase, to calculate the precise map coordinate for each spectral pixel and insure the alignment of TIR images with VNIR image products. The process is described in the L1 Geometric Calibration ATBD. L1B products are swath-based, calibrated Top-of-Atmosphere (TOA) radiance products (Radiance at Sensor), with precise pixel-level geolocation. Swath pixel alignments are closest to the original sensor collection. These scenes consist of 71 concatenated along-track scans (with each scan 256 lines by 15168 sample pixels) of the instrument mirror. Each scan requires approximately 0.38489 seconds of imaging time followed by 1.62811 seconds of travel time to the next scan-start position (2.013seconds total), producing a full image (granule) containing 18176 lines by 15168 samples with ~1 pixel scan overlap (at nadir) in 143.0 seconds. The resulting image granules cover approximately 985km swath width by 981km swath length. 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 subsequent L1B product contains up to eight MIR and TIR swath radiance bands geolocated with matching latitude and longitude pixel metadata files, providing foundational radiometric and georeferenced spectral inputs for Level 2+ science products. Note that L1B imagery are downloaded at 60m/pixel resolution for Land and Coastal areas, but most of the global Oceans and Antarctica are averaged (on-board) and downloaded at 960m/pixel. Different region/resolution images are stored in L1B as separate files with a "fill code" for dis-similar resolution data.

L1C products include two mid-wave bands (MIR) and six TIR wavelengths converted from L1B TOA Radiance (RAS) to TOA Brightness Temperature (BT) providing a total of eight L1C TIR products (ASI VNIR products are separate). L1C products differ significantly from L1B in that they are gridded (resampled) to a map projection. Generally, users focused on spectral accuracy would use the (unresampled) L1B products provided in NetCDF format. L1C gridded products are provided in Cloud Optimized GeoTIFF (COG) format which makes them convenient for direct use with geographic information systems. L1C gridded products will also come in different pixel resolutions due to on-board pixel averaging. Each along-track scan (defined above) is checked against an on-board "Land/Water ask" (Figure 1-0). 100% "water" scans and most of Antarctica are treated the same and averaged to 960m pixels. A scan with (at least) one "land" mask pixel will be downloaded at the nominal 60m/pixel resolution (including a few special 60m "land" sities in Antarctica). During ground processing, when the 71 scans are combined into a full scene, variable resolution scans are expected to be provided as multiple separate L1B layers, but for L1C, Land and Coastal areas will be gridded into 60m Tiles with NaNs for non-land scans, and the Oceans/Antarctica products will be gridded as Full Scenes with all data (including land) resampled to 960m. To reduce the geometric distortions associated with latitude, Land and Coastal collections imaged at 60m pixel resolution will be gridded as L1C "Tile" products in UTM projection. These approximate 110x110km tiles follow the "Sentinel-2 Tiling Grid" design which divides the world (n84 to s80) into 60 separate projection zones (each +/-6 degrees of the Zone's Central Meridian) to preserve shape across latitudes. However, 960m Ocean and Antarctica imagery will not follow the "Tile" scheme because of their low resolution (and subsequent small size), and will be provided

as full scenes. These gridded full scenes will utilize the Geographic (Latitude/Longitude) projection except at the poles where they will be provided in Polar Stereographic projection. Ocean/Antarctica images crossing the n60/s60 latitude transition boundaries will be processed in both projections. Associated polar *metadata* coordinate files will be provided in both Polar Stereographic (Northings/Eastings) and Latitiude/Longitude coordinates. See Section 3 for detailed descriptions of the Level 1 products.

Figure 1-0: SBG-TIR L1B/L1C Image Sizes and Mask

Global Region	Geographic Coverage	VNIR/TIR Pixel GSD	L1B Swath Pixel Metadata Coordinates	L1C Gridded Projection Full Scene	L1C GRI/UTM Tile Dimensions
Land and Coastal Waters	N84 to S80 (Sentinel UTM Grid)	30m/pixel (Pan) 60m/pixel (VNIR/TIR)	Lat/Long 36352x30336 Lat/Long 18176x15168	N/A N/A	3660x3660 1830x1830
Oceans: Mid-Latitudes	N60 to S60	960m/pixel (Average 16x60m pxls)	Lat/Long 1136x948	Lat/Long	N/A
Oceans and Antarctica: Polar Latitudes	N90 to N60 S60 to S90	960m/pixel (Average 16x60m pxls)	Lat/Long **and** Polar Stereographic Northing/Eastings 1136x948	Polar Stereographic	N/A



Notes

1) Only L1C Land and Coastal regions (at 60m) are processed into gridded Tiles.
2) Only L1C Oceans/Antarctica regions (at 960m) are processed into gridded Full Scenes (no Tiles), as the Tile images would be very small and numerous.
3) L1C Ocean/Antarctica files touching either n60 or s60 latitude lines would be processed as separate files in both Lat/Long and Polar Stereographic projection.
4) L1B swath Land and Ocean data are processed by L0 as separate files at their downloaded (native) resolutions, with fill codes (e.g., -9998) as needed.

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 Visual Near-Infrared (VNIR) instrument co-boresited with the JPL-built and managed TIR instrument. ASI provides GRI-corrected orbital and geolocation (attitude and ephemeris) metadata (for L1B products), plus their L1B/L1C VNIR 30m and 60m radiance products. The expected daytime inputs (and day/night platform metadata) from ASI include:

- Platform Uncorrected and Corrected Ephemeris and Attitude Metadata (Day/Night)
  - Attitude/quaternion
  - Attitude/time_j2000
  - Ephemeris/eci_position
  - Ephemeris/eci_velocity
  - Ephemeris/time_j2000
  - Quaternion Format: “NAIF/SPICE”
- Orbital GRI-Corrected Ephemeris and Attitude/Timing Metadata (Day)
  - Attitude/quaternion
  - Attitude/time_j2000
  - Ephemeris/eci_position
  - Ephemeris/eci_velocity
  - Ephemeris/time_j2000
  - Quaternion Format: “NAIF/SPICE”

- VNIR Camera Model (for reference)
- VNIR Level 1B Radiance (Geolocated; Swath format) – NetCDF format
    - Three daytime TOA Radiance Bands (30m PAN and 60m VNIR resolution)
- VNIR Level 1B Geolocation Swath Metadata – NetCDF format
    - Latitude; Longitude; Elevation/Height; Pixel Time of Acquisition (or equivalent)
- VNIR Level 1C Radiance (Geolocated; Map Projected format) – GeoTIFF Images
    - Three daytime TOA Bands (30 and 60m resolution) gridded images and tiles
- VNIR Level 1C Tile and Scene Metadata – GeoTiff auxillary format

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. The daytime "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 VNIR inputs. Therefore, they will differ slightly from the subsequent Standard products, and may not be archived after serving their short-term purposes. In addition, SBG-TIR nighttime products will *not* contain the 10.3μm TIR band (due to download volume restrictions). Figure 1-1 shows the Standard processing flow for SBG VNIR and TIR L1 standard daytime 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

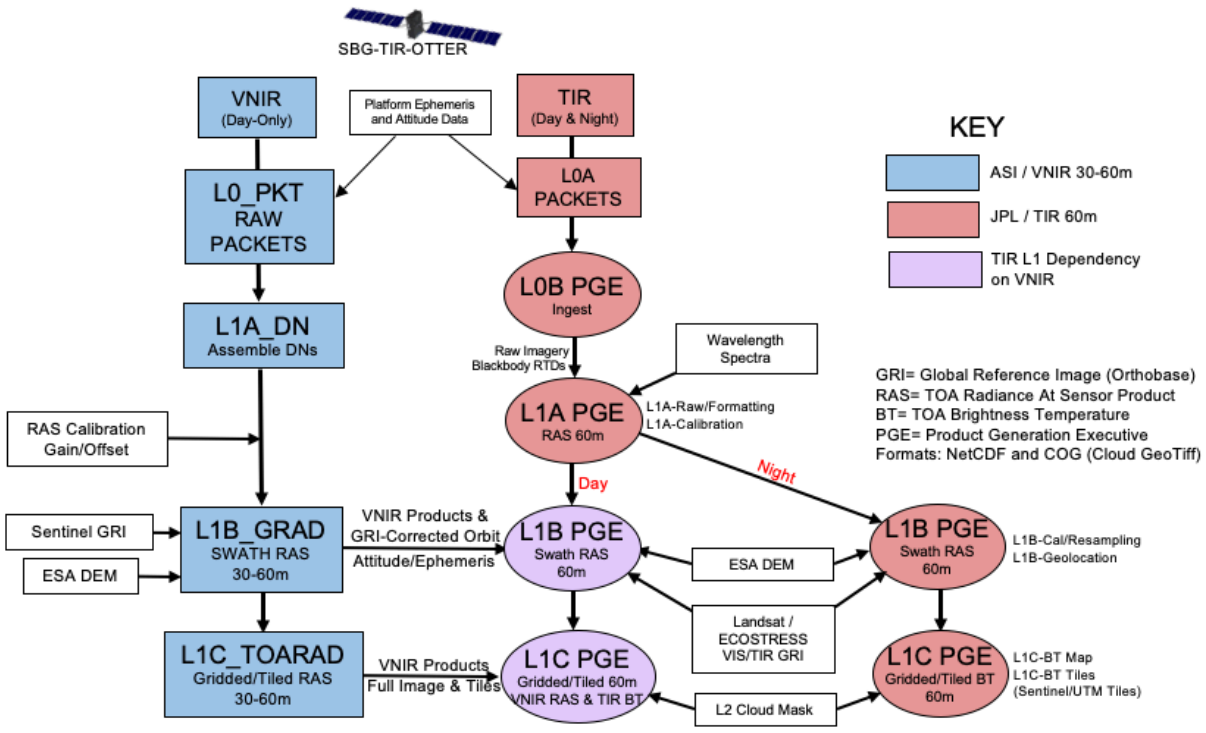


Figure 1-2: SBG-TIR Level 1 Low Latency Products Data Flow

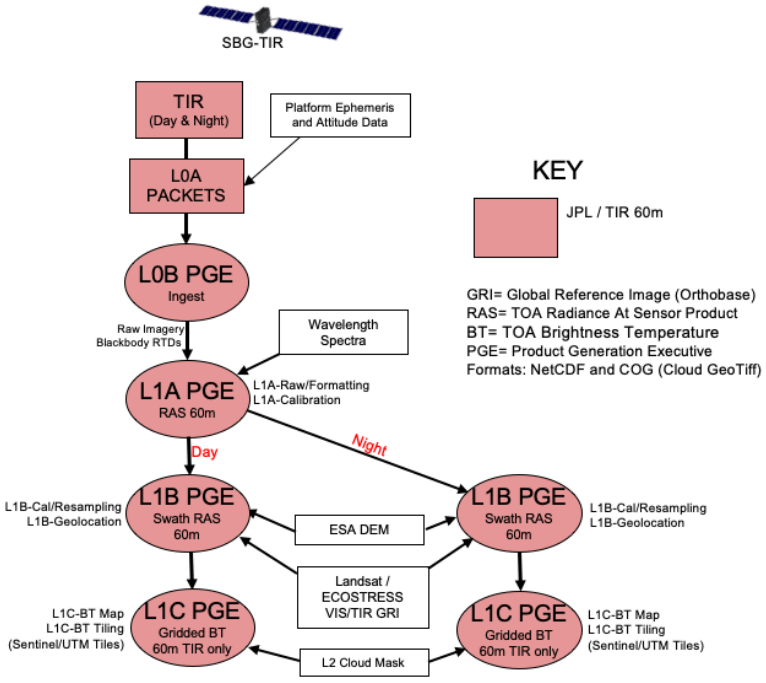


Table 1-2 provides a summary of the interplay between Standard and Low Latency products and Day versus Night processing. In addition, the following comments are provided for clarification:

- SBG-TIR L1B and L1C do *not* contain VNIR images.
- L1C Standard Daytime products are spatially aligned with VNIR data (but 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.
- L1B Night/Low Latency geolocation will use a derivative of the JPL Landsat7 TIR orthobase (as aligned/enhanced to match the European Sentinel-based Global Reference Image), while ASI will use the Sentinel GRI RED band for its' daytime VNIR processing.

Table 1-2: Standard and Low Latency Product Comparison

Product	Coverage	Resol (m)	Aligned	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 Brightness Temperature (Orthorectified)	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 Brightness Temperature (Orthorectified)	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

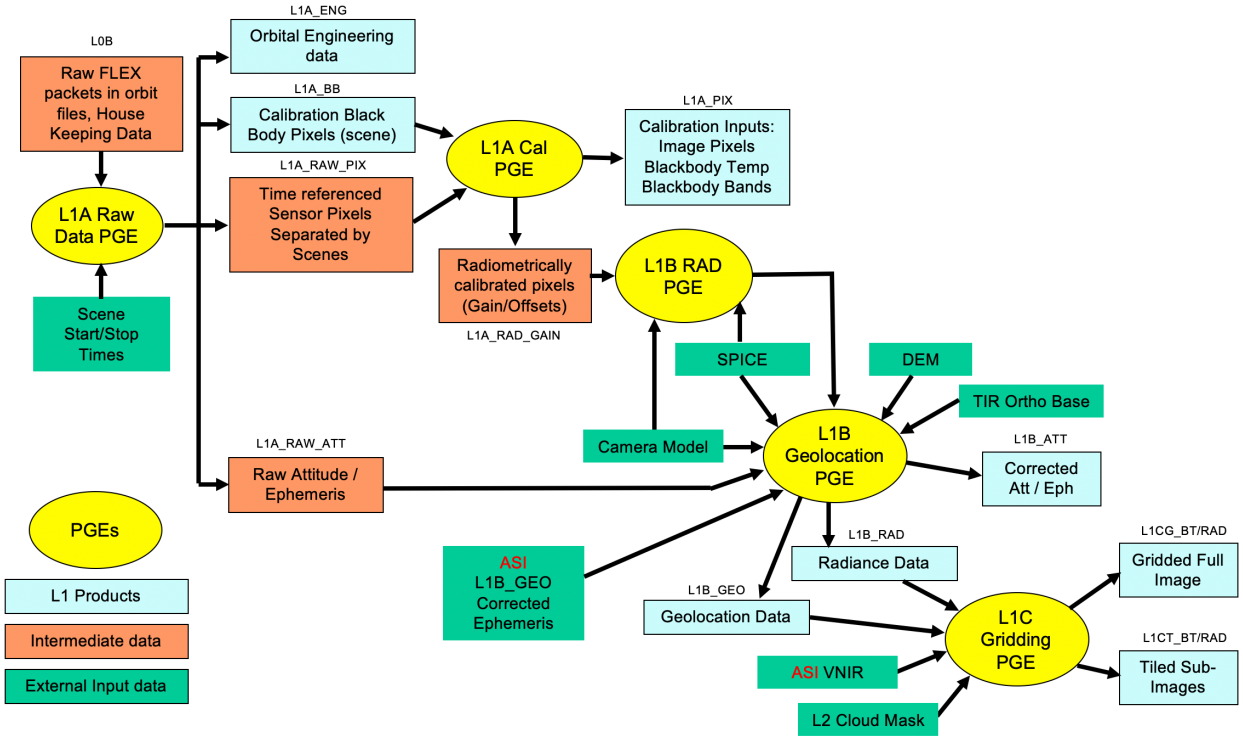
Product type	Description
L1A_ENG	Spacecraft orbital and instrument engineering data, including blackbody gradient coefficients and orbital timing
L1A_BB	Scene-specific instrument blackbody calibration pixels and timing
L1A_RAW_PIX	Scene-specific raw pixel spectral band data
L1A_PIX	Archive of all scene-specific 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 converted to Brightness Temperature; Full image in lat/long (or polar) projection; 960m resolution; Eight BT and Data Quality bands

L1C_TILE	Gridded L1B Radiance converted to Brightness Temperature; Image subdivided as per Sentinel UTM Tiling system; 60m resolution; Eight BT 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 and output via the L1C_GRIDDING PGE as COG (Cloud Optimized GeoTiff) files.

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 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.

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 109800 m across, using a 60m cell size with 1830 rows by 1830 columns, totaling ~3.35 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_03980	MIR_Radiance (3.98 µm
B2_04800	MIR_Radiance (4.80 µm)
B3_08320	TIR_Radiance (8.32 µm)
B4_08630	TIR_Radiance (8.63 µm)
B5_09070	TIR_Radiance (9.07 µm)
B6_10300	TIR_Radiance (10.30 µm; Daytime Only)
B7_11350	TIR_Radiance (11.35 µm)
B8_12050	TIR_Radiance (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	
CoordinateReferenceSystem	String	Variable	
DataFormatType	String	variable	
DayNightFlag	String	variable	
EastBoundingCoordinate*	LongFloat	8	
FieldOfViewObstruction			
ImageLines	Int32	4	18176 (71x256)
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	
NetCDFVersionID	String	variable	
NorthBoundingCoordinate*	LongFloat	8	
PGEName	String	variable	L1B_GEO
PGEVersion	String	variable	
PlatformLongName	String	variable	
PlatformShortName	String	variable	
PlatformType	String	variable	Spacecraft
ProcessingLevelDescription	String	variable	Level 1 Geolocation Parameters
ProcessingLevelID	String	variable	1
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	
SISName	String	variable	
SISVersion	String	variable	
SceneID	String	variable	
ShortName	String	variable	L1B_GEO; (L1A_RAW, L1A_CAL, L1B_RAD)
SouthBoundingCoordinate*	LongFloat	8	
StartOrbitNumber	String	variable	
StopOrbitNumber	String	variable	
WestBoundingCoordinate*	LongFloat	8	
*Of Scene or Enclosing Gore (TBD)			

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 1 through 8: 3.98, 4.80, 8.32, 8.63, 9.07, 10.30, 11.35, 12.05; 0=fill data	TBD	TBD	0
Group	**BlackBodyPixels** (Size 18176x2 sets per band, 64 pixels per set)					
blackbody_hot_03980	UInt16	DN	B4 Focal Plane DN of Hot BB (saturated)	0	32767	0xffff
blackbody_cold_03980	UInt16	DN	B4 Focal Plane DN of Cold BB (saturated)	0	32767	0xffff
blackbody_hot_04800	UInt16	DN	B5 Focal Plane DN of Hot BB (saturated)	0	32767	0xffff
blackbody_cold_04800	UInt16	DN	B5 Focal Plane DN of Cold BB (saturated)	0	32767	0xffff
blackbody_hot_08320	UInt16	DN	B6 Focal Plane DN of Hot BB	0	32767	0xffff
blackbody_cold_08320	UInt16	DN	B6 Focal Plane DN of Cold BB	0	32767	0xffff
blackbody_hot_08630	UInt16	DN	B7 Focal Plane DN of Hot BB	0	32767	0xffff
blackbody_cold_08630	UInt16	DN	B7 Focal Plane DN of Cold BB	0	32767	0xffff
blackbody_hot_09070	UInt16	DN	B8 Focal Plane DN of Hot BB	0	32767	0xffff
blackbody_cold_09070	UInt16	DN	B8 Focal Plane DN of Cold BB	0	32767	0xffff
blackbody_hot_10300	UInt16	DN	B9 Focal Plane DN of Hot BB	0	32767	0xffff
blackbody_cold_10300	UInt16	DN	B9 Focal Plane DN of Cold BB	0	32767	0xffff
blackbody_hot_11350	UInt16	DN	B10 Focal Plane DN of Hot BB	0	32767	0xffff
blackbody_cold_11350	UInt16	DN	B10 Focal Plane DN of Cold BB	0	32767	0xffff
blackbody_hot_12050	UInt16	DN	B11 Focal Plane DN of Hot BB	0	32767	0xffff
blackbody_cold_12050	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

3.3.3 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 18176x15168 sets)					
radiance_03980	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_04800	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_08320	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_08630	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_09070	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_10300	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_11350	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
radiance_12050	Float32	Watt/m2/sr/um	TIR	N/A	N/A	Table 3-6
data_quality_03980	Int8	None		0	4	Table 3-5

data_quality_04800	Int8	None		0	4	Table 3-5
data_quality_08320	Int8	None		0	4	Table 3-5
data_quality_08630	Int8	None		0	4	Table 3-5
data_quality_09070	Int8	None		0	4	Table 3-5
data_quality_10300	Int8	None		0	4	Table 3-5
data_quality_11350	Int8	None		0	4	Table 3-5
data_quality_12050	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 1 through 8: 3.98, 4.80, 8.32, 8.63, 9.07, 10.30, 11.35, 12.05; 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

[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. Also, at extreme viewing angles, high elevation terrain may obscure adjacent/behind data.

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 18176x15168 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			
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
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 L1C gridded (projected) products are processed by ingesting the L1B 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 products are resampled and repackaged as L1CG BT products, and contain the cloud mask from L2 CLOUD as a quality layer. The L1CT BT tiled products are subset from the gridded product and resampled to the 60m UTM Sentinel grid. ASI-provided VNIR radiance products are passed through unchanged.

3.4.2 L1CG/L1CT Brightness Temperature (BT) Products

The L1CG BT (gridded/map-projected) and L1CT BT (gridded/tiled) products distribute SBG top-of-atmosphere Brightness Temperature via the “bt” layers. The QC flags from the L1B RAD swath product are resampled here as “data_quality” layers. 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 TIR L1CG RAD and L1CT RAD Brightness Temperature products are listed in Table 3-9.

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

Name	Type	Units	Size
bt_03980	float32	Kelvin	TBD
bt_04800			
bt_08320			
bt_08630			
bt_09070			
bt_10300			
bt_11350			
bt_12050			
data_quality_03980		QA	TBD

data_quality_04800	uint8		
data_quality_08320			
data_quality_08630			
data_quality_09070			
data_quality_10300			
data_quality_11350			
data_quality_12050			
cloud	uint8	mask	
water			

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 (18176x15168)
BandSpecification	Char	Micrometer	Center Band Wavelength
Group	**UncalibratedPixels** (Size 11264x5400 per band)		
pixel_data_03980	UInt16	None	Band 1 MIR scene data
pixel_data_04800	UInt16	None	Band 2 MIR scene data
pixel_data_08320	UInt16	None	Band 3 TIR scene data
pixel_data_08630	UInt16	None	Band 4 TIR scene data
pixel_data_09070	UInt16	None	Band 5 TIR scene data
pixel_data_10300	UInt16	None	Band 6 TIR scene data
pixel_data_11350	UInt16	None	Band 7 TIR scene data
pixel_data_12050	UInt16	None	Band 8 TIR scene data
Group	**Time** (Size 18176x1)		
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 1 through 8: 3.98, 4.80, 8.32, 8.63, 9.07, 10.30, 11.35, 12.05; 0=fill data	3.98	12.05	0
AncillaryFiles	Char	None				
Group	**UncalibratedDN** (Size 18176x15168 sets)					
b1_03980	Int16	DN	Band 1 Raw image Pixel Data	0	32767	Table 3-6
b2_04800	Int16	DN	Band 2 Raw image Pixel Data	0	32767	Table 3-6
b3_08320	Int16	DN	Band 3 Raw image Pixel Data	0	32767	Table 3-6
b4_08630	Int16	DN	Band 4 Raw image Pixel Data	0	32767	Table 3-6
b5_09070	Int16	DN	Band 5 Raw image Pixel Data	0	32767	Table 3-6
b6_10300	Int16	DN	Band 6 Raw image Pixel Data	0	32767	Table 3-6
b7_11350	Int16	DN	Band 7 Raw image Pixel Data	0	32767	Table 3-6
b8_12050	Int16	DN	Band 8 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	**BlackbodyBandDN** (1 set for image frame)					
b1_03980_hot	Float32	DN	B1 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b1_03980_cold	Float32	DN	B1 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b2_04800_hot	Float32	DN	B2 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b2_04800_cold	Float32	DN	B2 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b3_08320_hot	Float32	DN	B3 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b3_08320_cold	Float32	DN	B3 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b4_08630_hot	Float32	DN	B4 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b4_08630_cold	Float32	DN	B4 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b5_09070_hot	Float32	DN	B5 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b5_09070_cold	Float32	DN	B5 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b6_10300_hot	Float32	DN	B6 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b6_10300_cold	Float32	DN	B6 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b7_11350_hot	Float32	DN	B7 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b7_11350_cold	Float32	DN	B7 Focal Plane Averaged DN for Cold BB	0	32767	Table 3-6
b8_12050_hot	Float32	DN	B8 Focal Plane Averaged DN for Hot BB	0	32767	Table 3-6
b8_12050_cold	Float32	DN	B8 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 18176x1, 469 scans, 256 repeated values per scan)					
line_start_time_j2000	Float64	Seconds	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 1 through 8: 3.98, 4.80, 8.32, 8.63, 9.07, 10.30, 11.35, 12.05; 0=fill data	3.98	12.05	0

Field Name	Type	Units	Field Data
Group	**Standard Metadata** (See Table 3-1)		
Group	**Gain** (Size 18176x15168)		
b1_03980_gain	Float32	Watt/m2/sr/um/DN	Band 1 Gain
b2_04800_gain	Float32	Watt/m2/sr/um/DN	Band 2 Gain
b3_08320_gain	Float32	Watt/m2/sr/um/DN	Band 3 Gain
b4_08630_gain	Float32	Watt/m2/sr/um/DN	Band 4 Gain
b5_09070_gain	Float32	Watt/m2/sr/um/DN	Band 5 Gain
b6_10300_gain	Float32	Watt/m2/sr/um/DN	Band 6 Gain
b7_11350_gain	Float32	Watt/m2/sr/um/DN	Band 7 Gain
b8_12050_gain	Float32	Watt/m2/sr/um/DN	Band 8 Gain
Group	**Offset** (Size 18176x15168)		
b1_offset	Float32	Watt/m2/sr/um/DN	Band 1 Offset
b2_offset	Float32	Watt/m2/sr/um/DN	Band 2 Offset
b3_offset	Float32	Watt/m2/sr/um/DN	Band 3 Offset
b4_offset	Float32	Watt/m2/sr/um/DN	Band 4 Offset
b6_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

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
GRI	Global Reference Image
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