OroraTech

Product User Guide

Level-1

Beta

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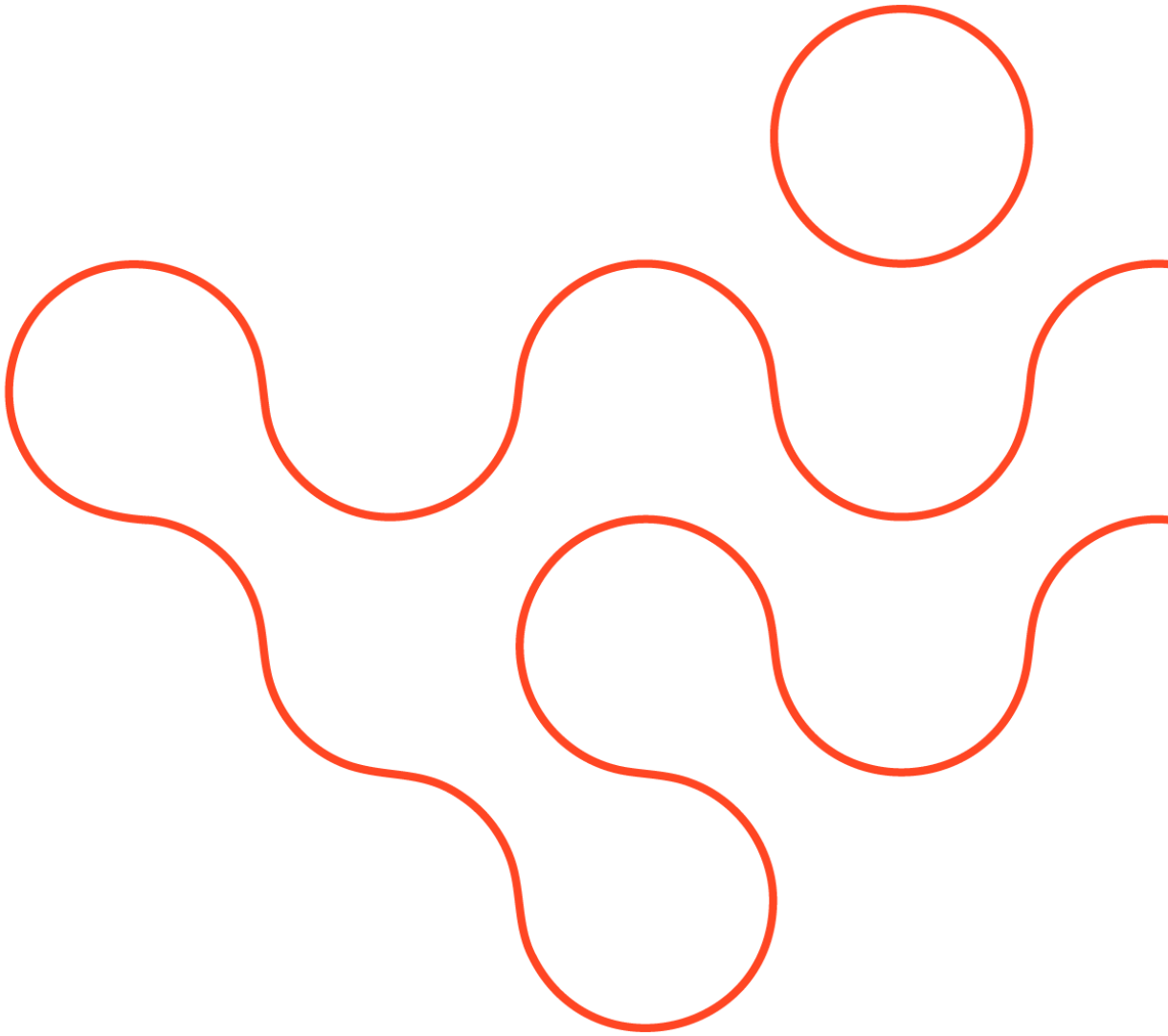

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1. Introduction

1.1. Purpose

This user guide document describes OroraTech's Level-1C product, detailing the product specifications, characteristics, data quality tiers, and associated metadata. Furthermore, it gives an overview of the satellite missions, and describes the data processors..

1.2. Product Maturity - Closed Beta Phase

Beta

The OroraTech Level-1 product is currently in a Closed Beta phase. Performance may vary, and the product may not be available at all times.

During this stage, we are continuously optimizing performance, accuracy, and coverage based on real-world data and user feedback.

However, the system is already operating at a level that delivers meaningful value to users, and we are actively working to further enhance its robustness and reliability ahead of full release.

All performance indicators throughout this description are described as targets. The product is delivered as-is.

1.3 Reference Documents

[RD-01] Rötzer et al., "On-Orbit Real-Time Wildfire Detection Under On-Board Constraints", https://arxiv.org/abs/2605.06273
[RD-02] Zanaga, D., et al. ESA WorldCover 10 M 2021 V200. v200, Zenodo, 28 Oct. 2022, https://doi.org/10.5281/zenodo.7254221
[RD-03] Copernicus DEM GLO-90, https://doi.org/10.5270/ESA-c5d3d65

2. Missions

2.1. Overview of the Missions

OroraTech operates thermal infrared (IR) satellite missions dedicated to the detection and monitoring of wildfires and other thermal events. The current system consists of the FOREST-2 mission and the OroraTech Phase-1 constellation (OTC-P1), both based on the Spire satellite platform and equipped with OroraTech's SAFIRE series thermal infrared instruments.

FOREST-2 was launched in June 2023 as part of the SpaceX Transporter-8 mission and is currently used for calibration and validation activities, algorithm development, and the provision of imagery to customers and partners. The satellite operates primarily in on-demand tasking mode.

The OroraTech Phase-1 constellation (OTC-P1) represents the operational deployment of OroraTech's wildfire monitoring system. The satellites of this constellation were launched in March 2025 during a dedicated Rocket Lab launch. The constellation is designed for the operational monitoring of wildfire activity and other thermal-event use cases.

Both missions are equipped with SAFIRE thermal infrared instruments consisting of two IR sensors with a combined swath width of approximately 410 km. The instruments acquire imagery in two spectral bands, including one long-wave infrared band (LWIR: L2) and one mid-wave infrared band (MWIR: M0). The imagery is provided with a ground sampling distance (GSD) of 200 m.

Within the Copernicus Contributing Missions (CCM) programme, the quality of OroraTech data products is periodically assessed by the Optical Mission Performance Cluster (OPT-MPC) under the Earth Data Assessment Programme (EDAP) framework. Product development and validation activities aim to ensure alignment of OroraTech data products with international remote sensing standards.

2.2. Mission Characteristics

2.2.1. Satellites

Table 1: *Mission satellite characteristics*

	FOREST-2	OTC-P1	
Number of satellites	1	8	
Status	Launched	Launched	
Start of operations	September 2023	Q1 2026	
End of operations	TBD	TBD	
Instrument	SAFIRE	SAFIRE	
Orbit	525 km, Sun-Synchronous Local Time at Descending Node (LTDN) at 13:30 as of 2023.	525x550km, Sun-synchronous Mean Local Time at Ascending Node (MLTAN) at 16:00±15 min as of 2026	
Inclination	97.7°	97.53°	
Revisit time monitoring (average)	7 days	0.5 days	
Revisit time tasking	Minimum at equator: 0.5 d Maximum at equator: 6.5 d Average at equator: 1.9 d	0.5 days	
Detector	Uncooled microbolometer	Uncooled microbolometer	
NORAD ID	56970	F004: 63357 F005: 63354 F006: 63353 F007: 63358	F008: 63355 F009: 63352 F010: 63356 F011: 63351
COSPAR ID / NSSDCA ID (International Designator)	2023-084AQ	F004: 2025-061G F005: 2025-061D F006: 2025-061C F007: 2025-061H	F008: 2025-061E F009: 2025-061B F010: 2025-061F F011: 2025-061A

2.2.2. Instruments

The instrument SAFIRE of all satellites is identical in terms of characteristics with some minor internal improvements.

Table 2: *SAFIRE characteristics.*

Instrument name	SAFIRE
Spectral bands	M0: 3.4 – 4.2 µm
	L2: 10.4 – 12.5 µm
GSD at Nadir	Design: 200 m Threshold (max.): 250 m
Product resolution	200 m
Swath	Per IR sensor: • Design: 210 km • Threshold (min.): 170 km Combined: • Design: 410 km • Threshold (min.): 330 km
Dynamic range	M0: 300 - 650 K
	L2: 260 - 640 K
Viewing angle	<50°

2.3. Observation Modes and Coverage Extent

FOREST-2 operates in on-demand tasking mode which is semi-automated for several use cases, such as regular acquisitions over customer areas, calibration sites or cross-overpasses with other satellite missions. Typical products per telescope cover 210 km in across-track direction and 450 km in along-track direction with a maximum length of ~1000 km.
OTC-P1 operates mainly in scanning mode covering larger areas. Additionally, any above mentioned tasking ability of FOREST-2 is also available with OTC-P1.

In nominal operation, all satellites can acquire images globally and with roll angles up to ±30° to decrease the revisit time. Furthermore, all nominal imaging recordings are processed directly after acquisition on the satellite to generate the NRT AF product, i.e. on-orbit fire detections [RD-01]. Additionally, for calibration purposes all satellites can point towards deep space and the Moon.

2.4. Data Quality Tiers and Target Performance

Data Quality Tiers are defined to classify products and imagers according to their compliance with target performance specifications. A dedicated evaluation framework and associated tooling are implemented to assess the proportion of products meeting the applicable criteria. Four distinct Data Quality Tiers are introduced, representing increasing levels of data quality and validation maturity. Tier 1 and Tier 3 will be defined in future.

Table 3: *Definition of Level-1C Data Quality Tiers*

		Tier 1	Tier 2	Tier 3	Tier 4
Absolute Radiometric Accuracy	**RMSE [K]**	To be defined	L2: <3 M0: <8	To be defined	One or more criteria are worse, or other artifacts
	RMSE [W/m²/sr/µm]		L2: <0.46[1] M0: <0.64[2]		
NEDT @ 300 K	**Level-1C [K]**		L2: <0.3 M0: <7		
Absolute Geolocation Accuracy	**Absolute Geolocation Accuracy CE90 [m]**		<800		
	Band-to-band registration CE90 [m]		<800		

[1] Represents 5% accuracy for a 300 K target.

[2] Represents 5% accuracy for a 400 K target.

The tier assignment is happening on per-product level, though some metrics may be only available on an imager or even constellation level:

- Absolute geolocation accuracy is currently assessed on a per-product basis. In case no ground control points (GCPs) are available the CE90 of all comparable products of the last month is used.
- Radiometric accuracy is presently evaluated using a common validation dataset aggregated across all imagers due to the small validation sample size per sensor. Future evolutions of the assessment framework foresee radiometric accuracy evaluation at individual imager level.

The evaluation methodology, validation datasets, and associated threshold definitions remain subject to refinement and may be updated in future processing baselines and calibration campaigns.

3. Product Description

3.1. Product Description

OroraTech's Level-1 product delivers multispectral top-of-atmosphere (TOA) spectral radiances and brightness temperatures (BT), which is ortho-rectified, geolocated and resampled onto a unified grid. Each ground point may be imaged in several overlapping frames along-track. These frames are accumulated in the Level-1 product to achieve the target product quality.

3.2. Product Versions

The product is shipped in two versions:

Near-real time (NRT):
Intended for users requiring minimal latency, this offering carries a risk of diminished data quality and reduced delivery reliability. Potential issues include data gaps or areas with higher noise, as certain information may not yet be downlinked when the product is generated. Radiometric quality may be reduced. Some refinement algorithms may have not been applied.

Non-time critical (NTC):
Intended for users who prioritize data excellence over speed, this option involves a longer waiting period. Requests for archived NTC items may trigger reprocessing with the most current algorithms to further minimize potential artifacts.

3.3. File Formats

To meet the needs of different user groups, the Level-1 product is offered in two formats:

- **Analytic Format (netCDF):**
  Tailored for scientific and analytical applications, the netCDF files provide comprehensive data access. They include multiple data arrays such as radiance, brightness temperature, geolocation, cloud mask and data quality flags. A detailed description of these arrays is provided in Section 3.4. Metadata relevant to the product is also embedded in the main group, as outlined in Section 3.5.
- **Visual Format (GeoTIFF):**
  Optimized for visualization and mapping, the GeoTIFF files contain brightness temperature data and embed key metadata as described in Section 3.5.

An imaged overpass may be distributed across multiple files to maintain manageable file sizes. Furthermore, a single overpass may contain data acquired by two imagers. Since the imagers may exhibit different performance characteristics, the data from each imager are provided in separate files.

3.4. Product Data Arrays

The main data arrays are radiance values and the corresponding per-pixel coordinates given in the latitude (lat) and longitude (lon) arrays. Additional information about the observation geometry is given in the remaining arrays.
The analytic product (netCDF file format) contains all data arrays. Those data arrays can be found in the high-level group with the same name as the data file. The visual product (geotiff file format) contains the variables marked with an asterisk.

Table 4: *Level-1C product data arrays.*

Variable	Dimensions	Data type	Units	Description
radiance	[rows, columns, band]	float64	W/m^2/sr/µm	Spectral radiances (TOA)
brightness_ temperature*	[rows, columns, band]	float64	Kelvin	Brightness temperatures (TOA)
lat*	[rows, columns]	float32	degrees north	Latitude per ground sample
lon*	[rows, columns]	float32	degrees east	Longitude per ground sample
height	[rows, columns]	float32	meter	Height above WGS84 ellipsoid
flags	[rows, columns, band]	uint16	-	Quality flags per ground sample and band
radiance_ uncertainty	[rows, columns, band]	float64	W/m^2/sr/µm	Per-pixel uncertainty of the spectral radiances. Currently under development and should be considered an underestimate.
brightness_ temperature_ uncertainty	[rows, columns, band]	float64	Kelvin	Uncertainties of the brightness temperatures. Currently under development and should be considered an underestimate.
observation_ time_offset_first	[rows, columns]	float32	seconds	First observation time of the ground location relative to acquisition_time_start
observation_	[rows,	float32	seconds	Last observation time of the

Variable	Dimensions	Data type	Units	Description
time_offset_last	columns]			ground location relative to acquisition_time_start
sensor_range	[rows, columns]	float32	meter	Distance from ground sample to sensor
sensor_azimuth_angle	[rows, columns]	float32	degrees	Azimuth angle of the ground-sample-to-sensor vector
sensor_zenith_angle	[rows, columns]	float32	degrees	Zenith angle of the ground-sample-to-sensor vector
solar_azimuth_angle	[rows, columns]	float32	degrees	Azimuth angle of the ground-sample-to-sun vector
solar_zenith_angle	[rows, columns]	float32	degrees	Zenith angle of the ground-sample-to-sun vector
columns	scalar	int64	-	Number of columns
rows	scalar	int64	-	Number of rows
bands	scalar	int64	-	Number of spectral bands

* data contained in visual format (geotiff)

3.4.1. Data Quality Flags

The flags array contains data quality flags which are further specified in Table 5. The data flags represent a bitmask with each bit representing a different flag. If no flag is set for a given pixel, the data is considered to be valid. Note, that more than one flag can be set for a pixel. An example is given in Fig. 1.

Table 5: *Level-1C quality flags.*

Bit	Flag	Description
0b00000001	OUTSIDE_BAND	Pixel was observed by at least one band, but not by all available bands.
0b00000010	DEAD_PIXEL	Detector pixel is operating outside of specifications.
0b00000100	OUTSIDE_FRAME	Pixel does not contain observation data.
0b00001000	SATURATED	Pixel value is saturated.
0b00010000	NOISE	Pixel is considered to be degraded in quality

0b00100000	CLOUD	Pixel is covered by a cloud.
0b01000000	FIRE	Fire detection (only used in on-orbit fire detection; [RD-01]
0b10000000	RADIOMETRIC_FAILURE	Problem encountered in the radiometric processor returning a NaN value.
0b0000001000000000	DRIFTING_PIXEL	Pixel that is saturated but not part of the cross-talk region and not a dead pixel (excluded from processing)
Remaining bits	reserved	Bits not used.

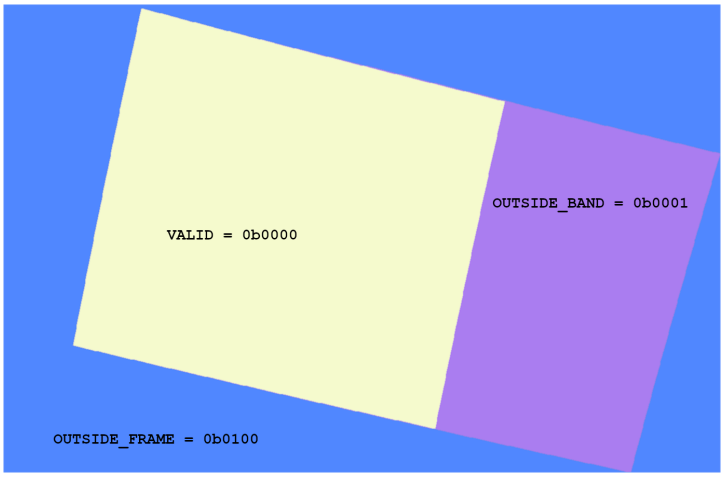


Figure 1: *Level-1C quality flags.*

3.4.2. Geometric Data Arrays

The definition of the geometric data arrays for sensor/solar azimuth and zenith angles is shown in Fig. 2. All values are calculated for the midpoint of the observation time range. The azimuth angle is in the range of 0° to 360° and is measured clockwise between north and the vector towards the satellite, i.e.

- north = 0°,
- east = 90°,
- south = 180° and
- west = 270°.

The sensor zenith angle is in the range of 0° to 90° and is the angle between local zenith and the vector towards the satellite, i.e.

- satellite at zenith above sample = 0°,
- satellite at horizon = 90°.

The solar zenith angle is defined in the same way as the sensor zenith angle, in this case angles range from 0° to 180°. Angles larger than 90° imply night time.

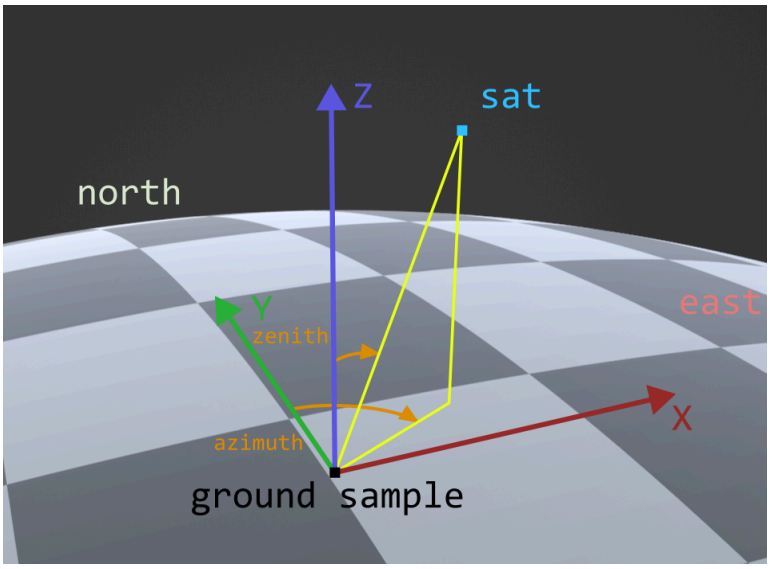


Figure 2: *Geometric parameters definition.*

3.5. Product Metadata

Next to the data arrays specified in Sec. 3.4, the Level-1C product contains metadata attributes further described in Tables 6 to 9.

3.5.1. Platform and general metadata

Table 6: *Platform metadata Level-1C product.*

Attribute	Unit	Description	Example value/format
title	-	Title of the product	"OroraTech Level-1C Data Product"
recording_id	-	Identifier of the observation	“1619ab32-24b5-4036-b460-4cc30df09292”
product_ access_url	-	URL for OT products	"https://ororatech.com/contact"
provider	-	Data provider	“OroraTech”
constellation	-	Name of satellite constellation	“FOREST”
mission	-	Name of the mission	“OTC-P1”
platform	-	Name of the satellite	“F005”
instrument	-	Name of the instrument	“SAFIRE”
product_level	-	Data processing level	“L1C”

Attribute	Unit	Description	Example value/format
sensor	-	Identifier of the sensor	“F005-IR1”
sensor_type	-	Spectral range of the sensor (IR or VIS)	“IR”
sensor_ description	-	Sensor description	“Dual thermal infrared telescope with microbolometer detectors working in push-frame configuration”
ground_sampling_ distance	meter	Value of the ground sampling distance	200
bands	-	List with names of the spectral bands	[“L2””, “M0”]
wavelengths	meter	Central wavelengths of the spectral bands	{“L2”: 1.15e-05, “M0”: 3.81e-06}
bandwidths	meter	Bandwidths (FWHM) of the spectral bands	{“L2”: 2.07e-06, “M0”: 7.68e-07}

3.5.2. Acquisition metadata

Table 7: *Acquisition metadata Level-1C product.*

Attribute	Unit	Description	Example value/format
acquisition_ time_start	-	Start time of the acquisition in ISO 8601 format	“2026-03-14T08:55:57.009103+00:00”
acquisition_ time_end	-	End time of the acquisition in ISO 8601 format	“2026-03-14T08:56:55.709733+00:00”
processing_version	-	Processor version	“1.0.0”
reference_ system	-	Geographic coordinate system of the grid	“EPSG:4326”
pixel_grid	-	Type of grid used for storing the pixel information	"ORBIT_ALIGNED_GRID" or “EPSG:4326_GRID”
footprints	-	Extent for each band specified as GeoJSON polygon with lon/lat coordinates (WGS84)	{“<band>”: <GeoJSON>}

Attribute	Unit	Description	Example value/format
geospatial_lat_min	°	Minimum latitude value of the geospatial bounding box covered by the file	41.95
geospatial_lat_max	°	Maximum latitude value of the geospatial bounding box covered by the file	43.408
geospatial_lon_min	°	Minimum longitude value of the geospatial bounding box covered by the file	19.702
geospatial_lon_max	°	Maximum longitude value of the geospatial bounding box covered by the file	22.56
platform_orbit_direction	-	Direction of the satellite movement in orbit during acquisition	“ASCENDING” / “DESCENDING”
sensor_azimuth_angle	°	Center azimuth sensor angle, see definition in Sec 3.4.2.	79.89
sensor_zenith_angle (since V1.1.0)	°	Center zenith sensor angle, see definition in Sec 3.4.2.	32.293
solar_azimuth_angle (since V1.1.0)	°	Center azimuth solar angle, see definition in Sec 3.4.2.	259.183
solar_zenith_angle (since V1.1.0)	°	Center zenith solar angle, see definition in Sec 3.4.2.	51.216
ancillary_data	-	Ancillary data used for processing the product	["ESA WorldCover 10 m 2021 v200, DOI: 10.5281/zenodo.7254221", "Copernicus DEM GLO-90, DOI: 10.5270/ESA-c5d3d65"]

3.5.3. Radiometric metadata

Table 8: *Radiometric metadata Level-1C product.*

Attribute	Unit	Description	Example value/format
radiometric_quality_flag	-	Metric for good radiometric quality. A value of True indicates good quality.	True/False
radiometric_state	-	Metric for radiometric state of the product. Can have multiple values (list). It is only set if radiometric_quality_flag is False. Detailed explanation below in Sec 3.5.3.1.)	“uncalibrated” “payload_temperature_not_ available” “drift_correction_failed” “might_contain_reflection”
radiance_stats_per_band	W/m^2/sr/µm	Average, standard deviation, median and 90th percentile of the radiances per band	{“<band>”: {"mean": <value>, "std": <value>, "median": <value>, "percentile_90th": <value>}}
radiance_uncertainty_per_band	W/m^2/sr/µm	Average, standard deviation, median and 90th percentile of the radiance uncertainties per band	{“<band>”: {"mean": <value>, "std": <value>, "median": <value>, "percentile_90th": <value>}}
brightness_temperature_stats_per_band	Kelvin	Average, standard deviation, median and 90th percentile of the brightness temperatures per band	{“<band>”: {"mean": <value>, "std": <value>, "median": <value>, "percentile_90th": <value>}}
brightness_temperature_uncertainty_per_band	Kelvin	Average, standard deviation, median and 90th percentile of the brightness temperature uncertainties per band	{“<band>”: {"mean": <value>, "std": <value>, "median": <value>, "percentile_90th": <value>}}
units_per_band	-	Radiance unit specified for each spectral band	{“L2”: "W/m^2/sr/µm", “M0”: "W/m^2/sr/µm"}

3.5.3.1. Detailed explanation of radiometric_state attributes

`uncalibrated`

The product has not been radiometrically calibrated. Pixel values may represent detector counts instead of physical units. Significant stripe artifacts and reduced radiometric accuracy are expected.

`payload_temperature_not_available`

Temperature measurements from the payload were unavailable during processing. Default temperature values were used in the radiometric model, which may reduce radiometric accuracy.

`drift_correction_failed`

Temporal drift correction could not be applied successfully. Radiometric artifacts such as gradually increasing or decreasing temperatures along-track may be visible in the imagery.

`might_contain_reflection`

Viewing geometry between the sensor and the sun might create visible reflection artifacts, particularly in the M0 band.

3.5.4. Further product metadata

Table 9: *Measured product metadata Level-1C product.*

Attribute	Unit	Description	Example value/format
geolocation_ accuracy	meter	Statistical measures of the geolocation accuracy of the product (evaluated on the L2 band and the internal L1 band); ; Geolocation accuracy of the M0 band is currently not assessed operationally; *nan* if unknown, e.g. due to high cloud coverage	{"mean": <value>, "std": <value>, "median": <value>, "percentile_90th": <value>}
geolocation_refine ment_flag (since V1.1.0)	-	Flag if refinement was successful for this product. A value of True indicates a successful ground lock with GCPs and improvement of the	True/False

Attribute	Unit	Description	Example value/format
		geolocation accuracy.	
geometric_inputs_quality_flag (since V1.1.0)	-	Flag indicating good geometric input quality. A value of True indicates the all systems (e.g. GPS, ADCS, ...) were behaving nominal.	True/False
cloud_cover	-	Estimated cloud cover fraction (0 - 1)	<value>

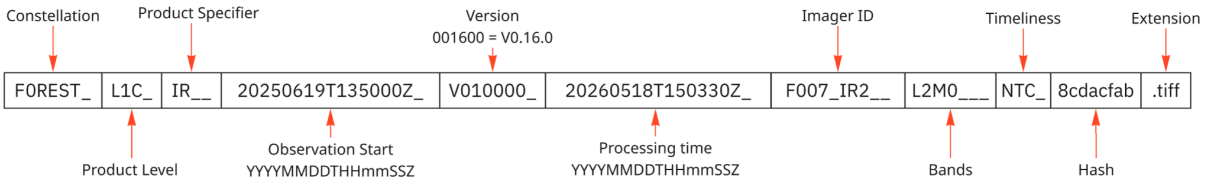
3.6. Product Naming Convention

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

<constellation>_<processing_level>_<product_specifier>_<observation_time>_<version>_<processed_time>_<imager_id>_<bands>_<timeliness>_<hash>.<extension>

Example:

`FOREST_L1C_IR__20250619T135000Z_V010000_20260518T150330Z_F007_IR2__L2M0___NTC_8cdacfab.tiff`



The elements of the file name are specified in Table 10. Some '_' were added to allow the product naming convention used by several products.

Table 10: *Level-1C file name elements.*

Attribute	Example value/format
constellation	"FOREST"
product level	"L1C"
product specifier	"IR"
observation start in UTC	"YYYYMMDDTHHmmSSZ"
version	"V001600" = V0.16.0
processing time in UTC	"YYYYMMDDTHHmmSSZ"
imager ID	"F007_IR2"
bands	"L2M0"
timeliness	NRT/NTC/XXX (if neither nor)
hash	First 8 hex characters of the SHA256 hash of the file contents
extension	nc4 / tiff

3.7. Product Generation

This section gives an overview of the processing steps involved in generating a Level-1C product.

Radiometric Calibration

Applies detector and sensor calibration.

Drifts of the detector electronics are removed. Defective pixels are masked with NaN. A thermal model is applied to reduce the self-emission of internal camera components, based on several temperature sensors located on the camera components. To convert the frames from digital numbers to spectral radiances, flatfields and gains are applied. Radiances are converted to brightness temperatures using the spectral response functions for each band.

All calibration parameters are measured before the launch and routinely updated on orbit during the satellite's lifetime.

Geometric Calibration

Appends orthorectified geolocation.

Per-pixel geolocation is calculated using an optical model combined with position and attitude telemetry, while accounting for terrain-induced distortions. The observation data is resampled into a common grid and averaged for overlapping frames. For a nominal imaging recording a typical target grid pixel consists of an average of 5 to 10 individual measurements. Ground control points (GCPs) in the band L2 are identified and used to measure and improve geolocation accuracy of each scene. The geolocation of the M0 band is evaluated against L2 geolocations periodically.

Some scenes may fail to achieve ground lock due to factors such as cloud cover, complex terrain, open water, or inaccuracies in satellite telemetry. In such cases, only approximate geolocation derived from telemetry is available. To prevent misinterpretation or analytical errors, users are advised to rely on imagery that has been successfully rectified. Scenes without refined geolocation are flagged in the metadata, with their geolocation accuracy reported as *NaN*. To prevent the creation of overly large OTCP-1 target files, a single recording may be divided into two or more separate files.

Cloud Mask

The product's cloud mask uses a single-band cloud-masking algorithm to infer cloud coverage for the L2 band using the computed radiance in the Level-1C data. The algorithm is based on a CNN architecture that leverages both absolute radiance and spatial context to detect pixels covered by clouds. The corresponding quality flag is documented in Table 5 and is denoted "CLOUD".

4. Data Delivery via STAC API

The STAC-API provides the following metadata. As the STAC-API is still in development, it is still up to changes.

4.1. General Metadata

Table 11: *General STAC metadata*

Field	Description	Example
type	Type of metadata, for items this must be 'Feature'.	'Feature'
stac_version	User stac version.	v1.1.0
stac_extensions	A list with the STAC extensions used in the item.	[projection extension, file extension, processing extension, view extension, sat extension, raster extension, eo extension, product extension]
id	A unique ID of the item.	"1c8f6319-9e6d-4b76-acee-9490148709ec_48aa49bd93cd2004c7754370a0e74e547abd9c13bfe9ab2afefbd8115c4d6a3d"
geometry	A geometry containing the polygon footprint of the image.	{"type": "MultiPolygon", "coordinates": [[[[5.679549100601674, 45.305849174239256], ...]]]}
bbox	A list with the coordinates of the image bounding box.	[1.983115774802878, 39.800216127762525, 5.679549100601674, 45.53321085034817]
collection	The id of the collection, where the item belongs.	

4.2. Provided properties

Table 12: STAC metadata properties of Level 1

Field	Description	Example
gsd	Minimum Ground Sample Distance at the sensor, in meters (m), must be greater than 0.	200

Field	Description	Example
instruments	List of satellite instruments.	["SAFIRE"]
platform	Unique name of the specific platform to which the instrument is attached.	"F002"
constellation	Unique name of the satellite constellation, the platform is part of.	"FOREST-2"
datetime	Date and time of the assets in UTC.	"2025-12-30T14:46:19.046Z"
start_datetime	Start date and time of the assets in UTC.	"2025-12-30T14:46:19.046Z"
end_datetime	End date and time of the assets in UTC.	"2025-12-30T14:47:28.069Z"
eo:cloud_cover	Estimate of cloud as a percentage (0-100).	47.12
view:azimuth	Viewing azimuth angle. The angle measured from the sub-satellite point (point on the ground below the platform) between the scene center and true north. Measured clockwise from north in degrees (0-360). Equivalent to sensor_azimuth_angle in metadata.	74.79
view:incidence_angle	The incidence angle is the angle between the vertical (normal) to the intercepting surface and the line of sight back to the satellite at the scene center. Measured in degrees (0-90). Equivalent to sensor_zenith_angle in metadata.	53.35
view:sun_azimuth	Sun azimuth angle. From the scene center point on the ground, this is the angle between truth north and the sun. Measured clockwise in degrees (0-360). Equivalent to solar_azimuth_angle in metadata.	125.87
view:sun_elevation	Sun elevation angle. The angle from the tangent of the scene center point to the sun. Measured from the horizon in degrees (-90-90). Negative values indicate the sun is below the horizon, e.g. sun elevation of -10° means the data was captured during nautical twilight. Definition as “90°-solar_zenith_angle” regarding metadata.	-44.87
product:type	The product type.	Level-1C
product:timeliness	Product timeliness classification.	NTC
processing: datetime	Processing date and time of the assets in UTC.	"2026-02-12T14:26:02.217937Z"
processing: version	The version of the processing software.	"0.16.3"

Field	Description	Example
processing: lineage	Processing software that was used to create the resource.	"DG-Img2Map-IR2"
processing:level	Processing level	“L1C”
processing:facility	Processing organization	“OroraTech”
sat:platform_ international_ designator	International satellite identifier.	"2023-084AQ"
sat:orbit_state	The state of the orbit. Either ascending or descending for polar orbiting satellites.	“ascending“ or "descending"

4.3. Information provided with every asset

Table 13: Asset STAC metadata

Field	Description	Example
href	Link to data file.	
roles	List specifying the kind of data.	["data"]
title	A general title for the asset.	"FOREST_L1C_IR__20250619T135000Z_V010000_20260518T150330Z_F007_IR2__L2M0____NTC_8cdacfab.tiff"
type	The product type.	"image/tiff; application=geotiff" or "application/netcdf"
proj:shape	Number of pixels in Y and X directions for the default grid.	[3688, 1107]
proj:bbox	A list with the coordinates of the image bounding box.	[1.651223466340945, 38.7525423823065, 6.255479104963935, 45.66847597446195]

Field	Description	Example
proj:transform	The affine transformation coefficients for the default grid. https://github.com/stac-extensions/projection?tab=readme-ov-file#fields	[1.651223466340945, 0.0024232924413805207, 0.0, 45.66847597446195, 0.0, -0.0018010243729571472]
proj:code	Authority and specific code of the data source (e.g., EPSG:3857). NULL for data in satellite projection.	"EPSG:4326"
nodata	Value representing no data pixels.	"nan"
data_type	Data type of pixel values.	"float32"
raster:spatial_resolution	Spatial resolution of raster.	“200.0”
raster:scale	Scaling factor applied to pixel values.	“1.0”
raster:offset	Offset applied to pixel values.	“0”
bands	Spectral band definitions including wavelengths.	name: "L2", eo:center_wavelength: “1.1554e-05”, eo:full_width_half_max: “2.154e-06”, eo:common_name: “lwir”
file:checksum	File checksum (sha256).	"44f14ee3fcf21de15473f2e77eb21bfb340892ce4d9fbae496e37ead0e30e693"
file:size	File size in bytes.	212346880
file:local_path	Internal file path.	"FOREST_L1C_IR__20250619T135000Z_V010000_20260518T150330Z_F007_IR2__L2M0___NTC_8cdacfab.tiff"

4.4. Thumbnail

Additionally a small preview thumbnail is provided.

Table 14: Thumbnail STAC metadata

Field	Description	Example
href	Link to the thumbnail file.	

Field	Description	Example
roles	List specifying the kind of data.	["thumbnail"]
title	A general title for the asset.	“FOREST_L1C_IR__20250619T135000Z_V010000_20260518T150330Z_F007_IR2__L2M0___NTC_8cdacfab.png”
type	The product type.	"image/png”

5. Product Ordering Methods

To order data products, please use the contact form on the OroraTech website: https://ororatech.com/contact or contact us under support@ororatech.com.

6. Data Usage License

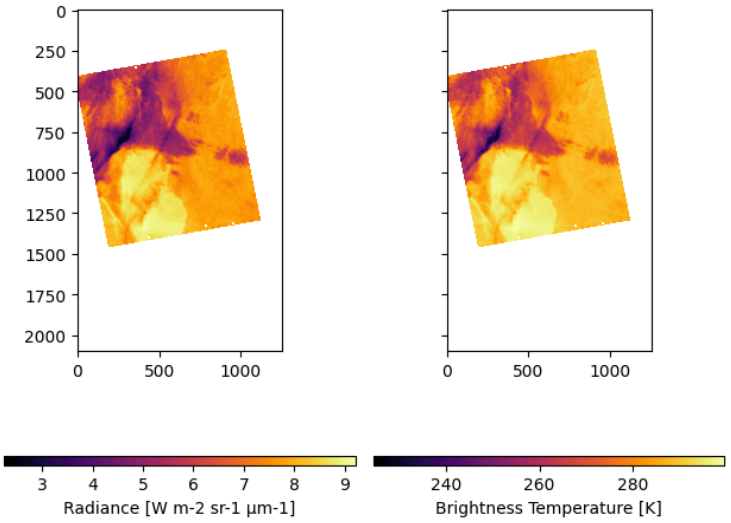
OroraTech Level-1 data must be used in accordance with the terms outlined in the data usage license, which is specified in each contract. Please refer to your contract for details.

In case of any questions, or if you are interested in subscribing to a contract and obtaining the license, please use our contact form https://ororatech.com/contact or email us directly at support@ororatech.com.

7. Python Examples

7.1. Loading Radiance Values of a Level-1C product

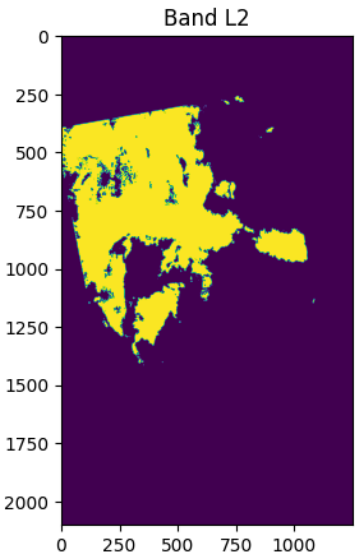
```python
import netCDF4 as nc
import numpy as np
import matplotlib.pyplot as plt
ds =
nc.Dataset('FOREST_L1C_IR__20250619T135000Z_V010000_20260518T150330Z_F007_IR2__L
2M0___NTC_8cdacfab.nc4')

# Data Access
data_radiance = np.array(ds["radiance"])
data_bt = np.array(ds["brightness_temperature"])

# Plotting
fig, axs = plt.subplots(nrows=1, ncols=2, sharey=True)
im0 = axs[0].imshow(data_radiance[:,:,0], cmap="inferno")
im1 = axs[1].imshow(data_bt[:,:,0], cmap="inferno")
cbar = fig.colorbar(im0, ax=axs[0], orientation='horizontal', pad=0.2,
aspect=40)
cbar.set_label("Radiance [W m-2 sr-1 µm-1]")
cbar2 = fig.colorbar(im1, ax=axs[1], orientation='horizontal', pad=0.2,
aspect=40)
cbar2.set_label("Brightness Temperature [K]")
plt.tight_layout()
```



7.2. Loading the cloud masks of a Level-1C product

Python

```
import os
import netCDF4
import glob
import numpy as np
import matplotlib.pyplot as plt
import json

filename=
‘FOREST_L1C_IR__20250619T135000Z_V010000_20260518T150330Z_F007_IR2__L2M0___NTC_8
cdacfab.nc4'
ds = netCDF4.Dataset(filename)
var_flags = ds["flags"]
flag_meanings = var_flags.flag_meanings.split(' ')
flag_values = var_flags.flag_values
flag_cloud = flag_values[flag_meanings.index("CLOUD")]
a_mask_cloud = np.bitwise_and(var_flags[:], flag_cloud) != 0
bands = json.loads(ds.bands)
plt.imshow(a_mask_cloud[:, :, 0])
plt.title(f"Band L2")
plt.show()
```

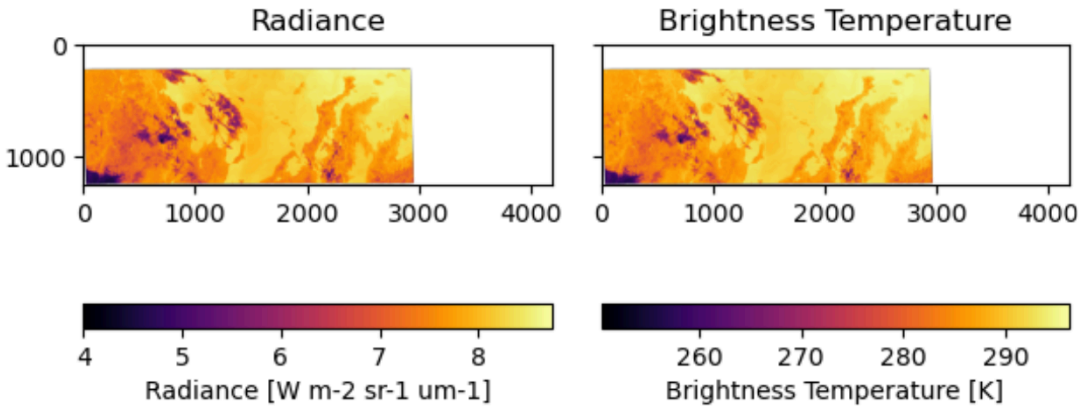


7.3. Loading Values of a Level-1C product via STAC API

Python

```python
import os
import base64
import requests
import netCDF4 as nc
import numpy as np
import matplotlib.pyplot as plt
import pystac_client

# Settings
username = os.getenv("OT_STAC_USERNAME")
password = os.getenv("OT_STAC_PASSWORD")
url_api = <link>
collection = "l1-test"

userpass = f"{username}:{password}"
b64_userpass = base64.b64encode(userpass.encode()).decode()

# Create the STAC client
catalog = pystac_client.Client.open(
    url=url_api,
    headers={
        "Authorization": f"Basic {b64_userpass}"
    }
)

# Search for one Level-1C item
search = catalog.search(
    collections=[collection],
    datetime=["2025-02-01", "2026-05-20"],
    bbox=[19.42, 35.17, 22.34, 41.67],
    max_items=3, # number of items to be downloaded
    limit=100, # size per API call; larger pagination may be faster
)

item = next(search.items())

# Access the netCDF asset
asset = item.assets["netcdf"]

# Download the netCDF file locally
filename = os.path.basename(asset.href)
response = requests.get(
    asset.href,
    headers={"Authorization": f"Basic {b64_userpass}"},
    stream=True
```

```
)
response.raise_for_status()

with open(filename, "wb") as f:
    for chunk in response.iter_content(chunk_size=8192):
        f.write(chunk)

# Open the Level-1C product
ds = nc.Dataset(filename)

# Data access
data_radiance = np.array(ds["radiance"])
data_bt = np.array(ds["brightness_temperature"])

# Plotting
fig, axs = plt.subplots(nrows=1, ncols=2, sharey=True)

im0 = axs[0].imshow(data_radiance[:, :, 0], cmap="inferno")
im1 = axs[1].imshow(data_bt[:, :, 0], cmap="inferno")

cbar0 = fig.colorbar(im0, ax=axs[0], orientation="horizontal")
cbar0.set_label("Radiance [W m-2 sr-1 um-1]")

cbar1 = fig.colorbar(im1, ax=axs[1], orientation="horizontal")
cbar1.set_label("Brightness Temperature [K]")

axs[0].set_title("Radiance")
axs[1].set_title("Brightness Temperature")

plt.tight_layout()
plt.show()
```



End of document