

OPERA

Observational Products for End-Users from Remote Sensing Analysis

Product Specification Document
for the OPERA Radiometric
Terrain-Corrected SAR
Backscatter from Sentinel-1
Static Layers

Observational Products for End-Users from Remote Sensing Analysis (OPERA) Project

Product Specification Document for the OPERA Radiometric Terrain-Corrected SAR Backscatter from Sentinel-1 Static Layers

Version 1.0.2

JPL D-108764, Initial Revision

November 6, 2023

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This research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

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DOCUMENT CHANGE LOG

Revision	Cover Date	Sections Changed	ECR #	Reason, ECR Title, LRS #*
Preliminary (v0.1)	June 15 30, 2022	All	N/A	New document
v0.4.1	Aug 3, 2023	All	N/A	Update for Cal/Val Point Release 4.1 (R4.1)
v0.4.2	Aug 15, 2023	Sec. 4.3	N/A	Update metadata field names and descriptions
v1.0.0	Sept 12, 2023	Sec 4	N/A	Update for Release 5 (R5)
v1.0.1	Sept 25, 2023	Sec 4	N/A	Update for Release 5.1 (R5.1)
v1.0.2, Initial Rev.	Nov 6, 2023	Sec. 3.1, Sec. 4, Appendix A, Cleared through URS	OPERA- 60	Removed the product generation datetime from the file naming convention. Updated the description of metadata fields PRODUCT_VERSION and PRODUCT_SPECIFICATION_VERSION. Updated first paragraph of Appendix A. CL#23-6340

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1 INTRODUCTION

1.1 Document Purpose

This document provides a specification of the OPERA (Observational Products for End-users from Remote-sensing Analysis) Level-2 Radiometric Terrain-Corrected SAR backscatter from Sentinel-1 (RTC-S1) Static Layers (RTC-S1-STATIC) product to be generated by the OPERA Science Data System (SDS) and provided to the NASA's Alaska Satellite Facility (ASF) Distributed Active Archive Center (ASF.DAAC).

1.2 Document Organization

Section 2 provides an overview of the product, including its purpose.

Section 3 provides the structure of the product, including granule definition, file organization, spatial resolution, temporal and spatial organization of the content, the size and data volume.

Section 4 provides qualitative descriptions of the information provided in the product's GeoTIFF layers.

Appendix A provides a description of geolocation grids and projection systems used for the product.

Appendix B provides a listing of the acronyms used in this document.

1.3 Applicable and Reference Documents

The product described in this document responds to requirements imposed by applicable documents indicated below. In case of conflict between the applicable documents and this one, the OPERA Project shall review the conflict to find the most effective resolution.

Applicable Documents

- [AD1] NASA SNWG Cycle 2 – OPERA Program Level (Level 1) Requirements Document, Oct. 15, 2021
- [AD2] OPERA Level 2 Requirements, JPL D-107391, Rev A, Dec. 16, 2021
- [AD3] OPERA Product Description, JPL D-107389, Rev A, Dec. 14, 2021

Reference Documents

- [RD1] Product Specification Document for the OPERA Radiometric Terrain-Corrected SAR Backscatter from Sentinel-1, JPL D-108758, Rev A, November 6, 2023
- [RD2] Shiroma, Gustavo H. X. and Lavalley, Marco and Buckley, Sean M., “An Area-Based Projection Algorithm for SAR Radiometric Terrain Correction and Geocoding.” IEEE Transactions on Geoscience and Remote Sensing 60 (2022): 1–23. [[link](#)]
- [RD3] OPERA Algorithm Theoretical Basis Document for Radiometric Terrain-Corrected SAR Backscatter from Sentinel-1, JPL D-107393, Rev Preliminary, September 31, 2022.
- [RD4] Earth Science Data and Information System (ESDIS) Standards Office (ESO). “GeoTIFF File Format, ESDS-RFC-040v1.1.” Earthdata, 16 September 2019. <https://www.earthdata.nasa.gov/esdis/esco/standards-and-practices/geotiff>. Accessed 24 September 2023.
- [RD5] Cloud Optimized GeoTIFF: An imagery format for cloud-native geospatial processing. www.cogeotiff.org/. Accessed 24 September 2023.
- [RD6] “TIFF/IT for Image Technology.” *The National Digital Information Infrastructure and Preservation Program at the Library of Congress*, 3 Oct. 2006, www.loc.gov/preservation/digital/formats/fdd/fdd000072.shtml. Accessed 21 June 2022.

The latest official versions of OPERA documents should be obtained from <https://www.jpl.nasa.gov/go/opera/about-opera>. This document is a ‘live’ one with the primary purpose of developing and describing the RTC-S1-STATIC product for the OPERA Algorithm Development Team’s (ADT) Calibration/Validation delivery to the OPERA SDS.

1.4 Applicable Software

This document is being released with the Calibration/Validation delivery of the RTC-S1 Science Application Software (SAS) at this GitHub repository: <https://github.com/opera-adt/RTC> version 1.0.1 (v1.0.1). The products generated by this version of the SAS are consistent with this document.

2 PRODUCT OVERVIEW

2.1 Product Background

Radar-geometry layers such as incidence angle, local incidence angle, mask, number of looks, and radiometric terrain correction (RTC) area normalization factor (ANF) γ_0 to β_0 and RTC ANF γ_0 to σ_0 vary slightly over time for each position on the ground, and therefore are considered static for the project. These static layers are packaged into an RTC-S1-STATIC product for each burst ID, and are provided separately from the OPERA RTC-S1 product [RD1], as they are produced only once or a limited number of times, to account for changes in the DEM, in the S1 orbit, or in the static-layers generation algorithm. Static layers will also be provided as single-band COG files, with map grid matching RTC-S1 products with the same burst ID.

The standard OPERA RTC-S1 product is derived from the original Copernicus Sentinel-1 (S1) interferometric wide (IW) single-look complex (SLC) data, provided by the European Space Agency (ESA), with a temporal sampling coincident with the availability of S1 A/B SLC data. The OPERA RTC-S1-STATIC and RTC-S1 products are provided at a near global scope (land masses excluding Antarctica).

Each OPERA RTC-S1-STATIC product corresponds to a single S1 burst ID. The workflow for generating the RTC-S1-STATIC is the same used for generating the standard RTC-S1 product. It requires a run configuration (runconfig) file, three input products (Table 2-1), namely the S-1 SAFE file containing the burst to process, the associated S1 orbit ephemerides, and a reference DEM; an optional input consisting of a burst database provided by the OPERA ADT that is used to make sure that all RTC-S1 products with the same burst identification (burst ID) are projected over the same geographic grid. The DEM used for generating the standard OPERA RTC-S1 product is based on the Copernicus DEM 30m (GLO-30) and Copernicus DEM 90 (GLO-90) models.

The processing for generating OPERA RTC-S1 and RTC-S1-STATIC product follows a similar workflow consisting of six blocks B1-B6 (Figure 2-1). The field “product_type” in the runconfig selects the type of the output product “RTC_S1” (RTC-S1) or “RTC_S1_STATIC” (RTC-S1-STATIC). The steps that are disabled in the processing of RTC-S1-STATIC products are shown in dark blue color in the diagram.

In block B1, the workflow inputs, i.e., S1 SLCs (SAFE file), S1 orbit, and burst DB, are loaded into memory. For the RTC-S1-STATIC product, an artificial SLC filled with dummy values and with extended radar grid is created in B1, and the process continues to B3, skipping the radiometric calibration and thermal noise correction that are normally applied to S1 SLCs in the standard processing. In block B3, the layover/shadow mask is computed over the range-Doppler geometry and geocoded over the output grid. In the standard processing, the shadow pixels are

dilated by pre-defined window size (if not set by the user) and the azimuth and range shifts due to bistatic and static-troposphere delays are computed as look-up tables (LUTs). The processing of static layers bypasses the creation of delay LUTs. The layover/shadow mask, range and azimuth LUTs, along with the reference DEM are passed to ISCE3 for radiometric terrain correction (RTC) and geocoding [RD2][RD3]. Resulting layers are saved as cloud optimized GeoTIFFs (COGs) in block B5, and the full product metadata is saved in the HDF5 format in block B6 in the standard processing (not applicable for static layers).

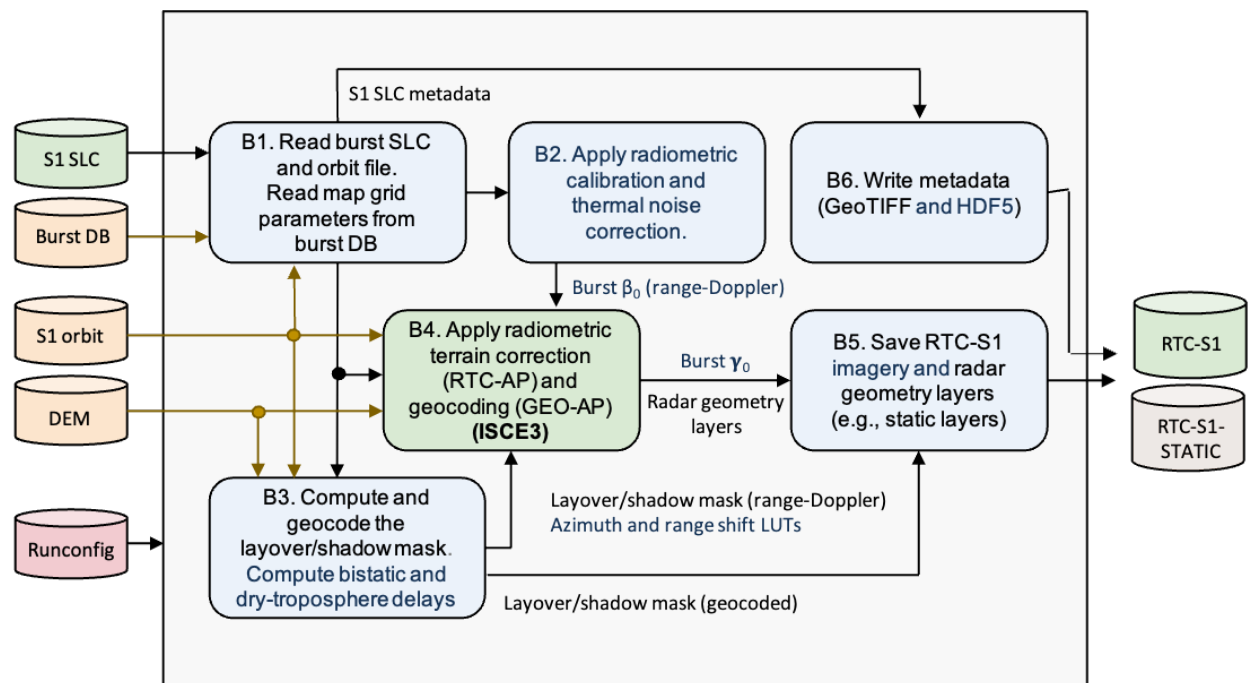


Figure 2-1 Diagram illustrating the OPERA RTC-S1 and RTC-S1-STATIC products’ workflow. The steps shown in dark blue color are only enabled in the production of OPERA RTC-S1 products.

Table 2-1 Input products and files for RTC-S1 product.

Product	Description	Granule Size
S1 SAFE file	The input S1 SAFE file	Variable
S1 orbit ephemerides	The input S1 orbit ephemerides	Variable
DEM	Reference DEM	Variable

Burst DB	Burst database in SQLite format	Fixed
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2.2 RTC-S1-STATIC Product Overview

The RTC-S1-STATIC product is a Level 2 product that contains static radar geometry layers associated with the RTC-S1 product. These layers are generated over pre-defined UTM/ Polar stereographic system map grid (Appendix A: Geocoded Product Grids) with a 30-meter spacing (Table 2-2).

RTC-S1 images are normalized to the backscatter coefficient γ_0 obtained from the original radar brightness β_0 through radiometric terrain correction. The RTC-S1-STATIC product includes an RTC area normalization factor (ANF) layer, provided with the same dimensions as the RTC-S1 imagery, that can be used to approximate the images to the β_0 convention. The RTC-S1 polarimetric imagery is distributed in a lexicographic polarimetric basis as individual cloud-optimized GeoTIFFs (COGs) [RD4][RD5], i.e., one GeoTIFF file per processed polarization.

Table 2-2 Pixel spacing of the RTC-S1 product.

Product	Pixel spacing in Northing (m)	Pixel spacing in Easting (m)
RTC-S1	30	30
RTC-S1-STATIC	30	30

3 PRODUCT ORGANIZATION

The RTC-S1-STATIC product is distributed as cloud-optimized GeoTIFF files (COGs) containing the layers such as local incidence angle, incidence angle, mask, number of looks, and RTC ANF gamma0 to beta0 and RTC ANF gamma0 to sigma0.

3.1 File Naming Convention

OPERA RTC-S1-STATIC granule names are designed to ensure unique and descriptive identification for the OPERA RTC-S1-STATIC products. The following file-naming convention is used:

OPERA_L2_RTC-S1-STATIC_
[BurstID]_[ValidityStartDate]_[Sensor]_[PixelSpacing]_[ProductVersion]_[LayerName].tif

- **BurstID:** Unique burst identification string consistent with ESA burst map convention in the form of T[TrackNumber]-[ID]-[SubSwath] (e.g, T069-147170-IW1)
- **ValidityStartDate:** The validity start date of the RTC-S1-STATIC product (format: YYYYMMDD)
- **Sensor:** The input product sensor, e.g., “S1A” representing Sentinel-1A
- **PixelSpacing:** Pixel spacing in meters
- **ProductVersion:** OPERA RTC-S1-STATIC product version number with four characters, including the letter “v” and two digits indicating the major and minor versions, which are delimited by a period
- **LayerName:** Name of the RTC-S1-STATIC product layer (e.g., “incidence_angle”).

Example:

OPERA_L2_RTC-S1-STATIC_T069-147170-IW1_20140403_S1A_30_v1.0_local_incidence_angle.tif

OPERA_L2_RTC-S1-STATIC_T069-147170-IW1_20140403_S1A_30_v1.0_incidence_angle.tif

OPERA_L2_RTC-S1-STATIC_T069-147170-IW1_20140403_S1A_30_v1.0_number_of_looks.tif

OPERA_L2_RTC-S1-STATIC_T069-147170-IW1_20140403_S1A_30_v1.0_mask.tif

OPERA_L2_RTC-S1-STATIC_T069-147170-IW1_20140403_S1A_30_v1.0_rtc_anf_gamma0_to_beta0.tif

OPERA_L2_RTC-S1-STATIC_T069-147170-IW1_20140403_S1A_30_v1.0_rtc_anf_gamma0_to_sigma0.tif

3.2 Temporal Organization

The OPERA RTC-S1-STATIC is expected to be generated only once or a limited number of times for each burst ID. The generation of new versions of static layers will be determined by the OPERA project considering changes in the DEM, in the S1 orbit, or processing algorithm.

3.3 Spatial Organization

The OPERA RTC-S1-STATIC are provided in the same grids as used for standard RTC-S1 products. Layers are arranged on a uniformly spaced, North-up and West-left grid – i.e., decreasing North or Y coordinate in the row direction and increasing East or X coordinate in the column direction following the row-major order convention of representing 2D raster arrays. Pixel-is-area convention (see Appendix A: Geocoded Product Grids) is used to tag the raster layers with coordinate information.

3.4 Spatial Sampling and Resolution

Some salient features of the output grid for the RTC-S1-STATIC product are:

1. All RTC-S1-STATIC will be located over the same geographical grid for each burst ID.
2. The geographical grid coordinates will be a multiple of the pixel spacing for easy comparison with RTC-S1 products.

3.4.1 Mosaicking

The spatial sampling of the output grid has been designed to facilitate the mosaicking of contiguous RTC-S1-STATIC products. See Appendix A: Geocoded Product Grids for details on the common output grid used for all L2 products.

4 THE OPERA RTC-S1-STATIC PRODUCT

OPERA RTC-S1-STATIC layers are generated over UTM/ Polar Stereographic coordinates (see Appendix A: Geocoded Product Grids). The RTC-S1-STATIC product can be directly overlaid on a map or combined with other similar RTC-S1-STATIC products.

In this section, we briefly describe the layout of RTC-S1-STATIC data packaged into GeoTIFF files and associated metadata. The standard RTC-S1 product represents radar backscattering in γ_0 . Conversion to β_0 is accomplished by multiplying RTC-S1 imagery with the RTC area normalization factor (ANF) gamma0 to beta0 layer provided in the RTC-S1-STATIC product. Similarly, conversion to σ_0 is achieved by multiplying RTC-S1 imagery with the RTC area normalization factor (ANF) gamma0 to sigma0 layer provided in the RTC-S1-STATIC.

4.1 File format - GeoTIFF

OPERA RTC-S1-STATIC are distributed as single-band cloud optimized GeoTIFFs (COGs) [RD4] [RD5]. The GeoTIFF is a format to store georeferenced raster images and is widely used by remote-sensing communities. The GeoTIFF format is defined in the public domain as Tagged Image File Format (TIFF) [RD6] It enables the storage of compressed images with associated metadata that can be easily read by Geographic Information System (GIS) software, including the open Geospatial Data Abstraction Library (GDAL) and Quantum GIS (QGIS).

To save storage space, each GeoTIFF file is compressed using the DEFLATE algorithm.

4.2 RTC-S1-STATIC Layers

RTC-S1-STATIC layers are provided in the same map grid as the RTC-S1 product imagery. Static layers include the incidence angle, and local-incidence angle. number of looks, mask layer, RTC ANF gamma0 to beta0, and RTC ANF gamma0 to sigma0.

4.2.1 Local-incidence angle

Local-incidence angle is defined as angle between LOS vector and terrain normal vector at the target provided in the same geographic grid as the geocoded imagery.

4.2.2 Incidence angle

Incidence angle is defined as angle between LOS vector and the ellipsoid normal at the target provided in the same geographic grid as the geocoded imagery.

4.2.3 Mask

The mask layer contains the valid/invalid, layover, and shadow classification computed over the reference RTC-S1-STATIC burst orbit, and it is provided over the same geographic grid as the associated geocoded imagery. The mask layer contains 5 classes represented by an unsigned byte data type:

- Class 0: Valid sample not affected by layover or shadow
- Class 1: Valid sample affected by shadow
- Class 2 - Valid sample affected by layover
- Class 3: Valid sample affected by layover and shadow
- Class 255: Invalid sample (fill value)

4.2.4 Number of Looks

The radar imagery is obtained from the geocoding of S1 SLCs using an adaptive multi-looking algorithm. The algorithm uses an area-based projection approach to multi-look radar samples that intersect completely or partially with each geographical grid pixel according to topography and radar geometry. The number of looks layer indicates the number of radar samples used to compute each RTC-S1 imagery pixel and it is provided in the same geographic grid as the RTC-S1 product imagery.

4.2.5 Radiometric Terrain Correction (RTC) Area Normalization Factor (ANF) Gamma0 to Beta0

The radar backscatter is normalized to gamma0 γ_0 to reduce the dependence of the radar backscatter with the topography. The radiometric terrain correction (RTC) normalizes the original S1 backscatter from beta0 to gamma0. The RTC area normalization factor (ANF) gamma0 to beta0 provides the factors to normalize the gamma0 backscatter to beta0. This layer is provided in the same grid as the corresponding RTC-S1 imagery.

4.2.6 Radiometric Terrain Correction (RTC) Area Normalization Factor (ANF) Gamma0 to Sigma0

The RTC area normalization factor (ANF) gamma0 to sigma0 provides the factors to normalize the gamma0 backscatter to sigma0. This layer is provided in the same grid as the associated RTC-S1 imagery.

4.3 GeoTIFF metadata

All RTC-S1-STATIC product layers (GeoTIFF files) are saved with the same metadata, divided into four sections: 1) Product Identification, 2) Input Datasets, 3) Sentinel-1 IW SLC Parameters, and 4) RTC-S1-STATIC Processing Information.

4.3.1 Product Identification

Table 4-1 lists the product identification fields of the GeoTIFF metadata. The attribute `PRODUCT_VERSION` informs the version of the RTC-S1-STATIC product (structure and metadata), whereas the attribute `SOFTWARE_VERSION` describes the version of the software that generated the RTC-S1-STATIC product.

Table 4-1. GeoTIFF metadata: product identification.

Attribute	Description
LAYER_NAME	Product layer name
LAYER_DESCRIPTION	Product layer description
ABSOLUTE_ORBIT_NUMBER	Absolute orbit number
TRACK_NUMBER	Track number
PLATFORM	Name of the sensor platform (e.g., "Sentinel-1A")
INSTRUMENT_NAME	Name of the instrument used to collect the remote sensing data provided in this product (e.g., "Sentinel-1A CSAR")
PRODUCT_TYPE	The product type: "RTC-S1-STATIC"
PROJECT	The project name: "OPERA"
INSTITUTION	Institution that created this product: "NASA JPL"

CONTACT_INFORMATION	Contact information for producer of the product: "operasds@jpl.nasa.gov"
PRODUCT_VERSION	The product version (same as in the product filename): "1.0"
PRODUCT_SPECIFICATION_VERSION	Product specification version which represents the schema of this product: "1.0"
ACQUISITION_MODE	Acquisition mode: "IW"
CEOS_ANALYSIS_READY_DATA_PRODUCT_TYPE	CEOS Analysis Ready Data (CARD) product type
LOOK_DIRECTION	Look direction: "right"
ORBIT_PASS_DIRECTION	Orbit direction can be ascending or descending
PRODUCT_LEVEL	The product level: "L2". Product levels: <ul style="list-style-type: none"> - L0A: Unprocessed instrument data; - L0B: Reformatted, unprocessed instrument data; - L1: Processed instrument data in radar coordinates system; - L2: Processed instrument data in geocoded coordinates system
PROCESSING_TYPE	Processing type: "NOMINAL" or "URGENT" or "CUSTOM" or "UNDEFINED"
PROCESSING_DATETIME	RTC-S1 product processing date. Format: YYYY-MM-DDTHH:MM:SSZ.
RADAR_BAND	Acquired frequency band: "C"
CEOS_ANALYSIS_READY_DATA_DOCUMENT_IDENTIFIER	CEOS Analysis Ready Data (CARD) document identifier
PRODUCT_DATA_ACCESS	Location from where this product can be retrieved (URL or DOI)

BOUNDING_BOX	Bounding box of the product, in order of xmin, ymin, xmax, ymax
BOUNDING_BOX_EPSG_CODE	EPSG code used to represent BOUNDING_BOX coordinates
BOUNDING_BOX_PIXEL_COORDINATE_CONVENTION	Pixel coordinate convention used to represent BOUNDING_BOX coordinates: "edges/corners"
BURST_ID	Burst identification (burst ID)
SUB_SWATH_ID	Sub-swath identification
ZERO_DOPPLER_START_TIME	Azimuth start time of the product in the format YYYY-MM-DDThh:mm:ss.sZ
ZERO_DOPPLER_END_TIME	Azimuth stop time of the product in the format YYYY-MM-DDThh:mm:ss.sZ

4.3.2 Input Datasets

Table 4-2 describes the metadata fields that list the input datasets used to generate the RTC-S1-STATIC product.

Table 4-2. GeoTIFF metadata: input datasets.

Attribute	Description
INPUT_L1_SLC_GRANULES	List of input L1 SLC products used
INPUT_ORBIT_FILES	List of input orbit files used
INPUT_DEM_SOURCE	Description of the input DEM
INPUT_ANNOTATION_FILES	List of input annotation files used

4.3.3 Sentinel-1 IW SLC Parameters

Table 4-3 describes the metadata fields describing the input Sentinel-1 SLC parameters.

Table 4-3. GeoTIFF metadata: Sentinel-1 SLC parameters.

Attribute	Description
SOURCE_DATA_ACCESS	Location from where the source data can be retrieved (URL or DOI)
SOURCE_DATA_NUMBER_OF_ACQUISITIONS	Number of source data acquisitions: "1"
SOURCE_DATA_INSTITUTION	Institution that created input product: "ESA"
SOURCE_DATA_PROCESSING_CENTER	Source data processing center
SOURCE_DATA_PROCESSING_DATETIME	Processing date and time of the source data
SOURCE_DATA_SOFTWARE_VERSION	Version of the software used to create the source data (IPF version)
SOURCE_DATA_PRODUCT_LEVEL	Product level of the source data: "L1". Product levels: <ul style="list-style-type: none"> - L0A: Unprocessed instrument data; - L0B: Reformatted, unprocessed instrument data; - L1: Processed instrument data in radar coordinates system; - L2: Processed instrument data in geocoded coordinates system
SOURCE_DATA_SLANT_RANGE_SPACING	Distance in meters between consecutive range samples of the source data
SOURCE_DATA_ZERO_DOPPLER_TIME_SPACING	Time interval in the along-track direction of the source data
SOURCE_DATA_ZERO_DOPPLER_START_TIME	Azimuth start time of the input product in the format YYYY-MM-DDThh:mm:ss.sZ
SOURCE_DATA_ZERO_DOPPLER_END_TIME	Azimuth stop time of the input product in the format YYYY-MM-DDThh:mm:ss.sZ

4.3.4 Processing Information

Table 4-4 lists processing and other product parameters associated with the RTC-S1-STATIC product.

Table 4-4. GeoTIFF metadata: RTC-S1-STATIC processing parameters.

Attribute	Description
SOFTWARE_VERSION	The algorithm software version used to generate the RTC-S1-STATIC product. This document is consistent with SOFTWARE_VERSION 1.0.1
ISCE3_VERSION	Version of the ISCE3 framework used for processing
S1_READER_VERSION	Version of the OPERA s1-reader
AREA_OR_POINT	Indicates that pixel values are assumed to represent an area rather than points: "Area"
PROCESSING_INFORMATION_MULTILOOKING_APPLIED	Flag to indicate if pre-processing multilooking has been applied
PROCESSING_INFORMATION_FILTERING_APPLIED	Flag to indicate if post-processing filtering has been applied
PROCESSING_INFORMATION_STATIC_TROPOSPHERIC_GEOLOCATION_CORRECTION_APPLIED	Flag to indicate if the static tropospheric correction has been applied
PROCESSING_INFORMATION_WET_TROPOSPHERIC_GEOLOCATION_CORRECTION_APPLIED	Flag to indicate if the wet tropospheric correction has been applied
PROCESSING_INFORMATION_BISTATIC_DELAY_CORRECTION_APPLIED	Flag to indicate if the bistatic delay correction has been applied
PROCESSING_INFORMATION_DEM_INTERPOLATION_ALGORITHM	DEM interpolation method

PROCESSING_INFORMATION_DEM_EGM_MODEL	Earth Gravitational Model associated with the DEM
PROCESSING_INFORMATION_GEOCODING_ALGORITHM	Geocoding algorithm
PROCESSING_INFORMATION _RADIOMETRIC_TERRAIN_CORRECTION_ALGORITHM	Radiometric terrain correction (RTC) algorithm
PROCESSING_INFORMATION _RADIOMETRIC_TERRAIN_CORRECTION_ALGORITHM_REFERENCE	A reference to the radiometric terrain correction (RTC) algorithm applied
PROCESSING_INFORMATION _GEOCODING_ALGORITHM_REFERENCE	A reference to the geocoding algorithm applied
PROCESSING_INFORMATION _INPUT_BACKSCATTER_NORMALIZATION_CONVENTION	Backscatter normalization convention of the source data
PROCESSING_INFORMATION _OUTPUT_BACKSCATTER_NORMALIZATION_CONVENTION	Backscatter normalization convention of the radar imagery associated with this product
PROCESSING_INFORMATION _OUTPUT_BACKSCATTER_EXPRESSION_CONVENTION	Backscatter expression convention
PROCESSING_INFORMATION _OUTPUT_BACKSCATTER_DECIBEL_CONVERSION_EQUATION	Equation to convert provided backscatter to decibel (dB)
PROCESSING_INFORMATION _BURST_GEOGRID_SNAP_X	Burst geogrid snap for Coordinate X (W/E)
PROCESSING_INFORMATION _BURST_GEOGRID_SNAP_Y	Burst geogrid snap for Coordinate Y (S/N)

APPENDIX A: GEOCODED PRODUCT GRIDS

OPERA RTC-S1 and RTC-S1-STATIC products are generated on a burst system. The projection system for a particular burst ID is held constant through the product lifetime. Each product layer includes information indicating the projection used for the product.

Map Projections

OPERA’s SDS is able to ingest any Digital Elevation Model whose vertical datum represents height above the WGS84 Ellipsoid and the horizontal datum can be represented by a European Petroleum Standards Group (EPSG) code for generating geocoded product. Table B-00-1 lists the various projection systems used to output RTC-S1-STATIC products.

Table B-00-1. Projection Systems for L2 RTC-S1 Products

EPSG code	PROJ.4 string	Common Name	Geographical scope
3413	+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45 +k=1 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs	NSIDC Sea Ice Polar Stereographic North	Greenland and Northern Hemisphere Sea Ice (products with center latitude greater than 75 degrees)
32601-32660	+proj=utm +zone=X-32600 +datum=WGS84 +units=m +no_defs	UTM Zone North	Northern Hemisphere Land except Greenland
32701-32760	+proj=utm +zone=X-32700 +south +datum=WGS84 +units=m +no_defs	UTM Zone South	Southern Hemisphere Land

Grid Alignment

OPERA RTC-S1 products will use a “pixel is area” convention. The “pixel is area” convention, which is the default, uses northing and easting coordinates Y and X, with (0,0) denoting the upper-left corner of the image, and increasing X to the east, increasing Y to the south. The first pixel value fills the grid cell with the top-left position (0,0) and bottom-right position (1,1).

APPENDIX B: ACRONYMS

ADT	Algorithm Development Team
ARD	Analysis Ready Data
ASF	Alaska Satellite Facility
ASF.DAAC	NASA's Alaska Satellite Facility Distributed Active Archive Center
CARD	CEOS Analysis Ready Data
CEOS	Committee on Earth Observation Satellites
COG	Cloud optimized GeoTIFF
DAAC	Distributed Active Archive Center
DEM	Digital Elevation Model
ECEF	Earth Centered Earth Fixed
ESA	European Space Agency
Float32	Floating-point number of 32 bits
GDAL	Geospatial Data Abstraction Library
GeoTIFF	Georeferenced Tagged Image File Format
GIS	Geographic Information System
InSAR	Interferometric Synthetic Aperture Radar
ISCE3	InSAR Scientific Computing Environment Enhanced Edition
OPERA	Observational Products for End-users from Remote-sensing Analysis
MHz	Mega-Hertz
MOE	Medium-precision Orbit Ephemeris
QA	Quality Assurance
RTC	Radiometric Terrain Correction
RTC-S1	Radiometric Terrain Corrected SAR backscatter from Sentinel-1
RTC-S1-STATIC Layers	Radiometric Terrain Corrected SAR backscatter from Sentinel-1 Static
SAR	Synthetic Aperture Radar
SAFE	Standard Archive Format for Europe
SAS	Science Application Software
SDS	Science Data System
SLC	Single Look Complex
UInt8	Unsigned Integers of 8 bits
UInt16	Unsigned Integers of 16 bits
UPS	Universal Polar Stereographic
URI	Uniform Resource Identifier
UTM	Universal Transverse Mercator

WRS World Reference System
ZSTD Zstandard (compression algorithm)