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OPERA

Observational Products for End-Users from Remote Sensing Analysis

Product Specification Document for Surface Displacement Static Layers from Sentinel-1

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Observational Products for End-users from Remote sensing Analysis (OPERA) project

OPERA Level-3 Surface Displacement Static Layers from Sentinel-1 (DISP-S1-STATIC) Product Specification

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1 INTRODUCTION

1.1 Purpose

This document provides a description of the Observational Products for End-users from Remote sensing Analysis (OPERA) Level-3 Surface Displacement static layers product from Sentinel-1 (DISP-S1) to be generated by the OPERA Science Data System (SDS) and provided to the Alaska Satellite Facility (ASF) NASA's Distributed Active Archive Center (DAAC). Hereafter, this data product is referenced by the short name DISP-S1-STATIC.

1.2 Document Organization

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

Section 3 provides the structure of the product, including tile definition, file organization, spatial and temporal resolutions, and spatial organization of the product content.

Section 4 provides a qualitative description of the data layers and the metadata provided in the product.

Section 5 provides a detailed description of the individual fields within the DISP-S1-STATIC product e.g., their units, size, and coordinates.

Appendix A provides further details on the geographical grid and projection systems used to generate the product.

1.3 Applicable and Reference Documents

Applicable documents levy requirements on areas addressed in this document. Reference documents are cited to provide additional information to readers. In cases of conflict between the applicable documents and this document, the OPERA Project shall review the conflict to find the most effective resolution.

Applicable Documents
> NASA SNWG Cycle 2 – OPERA Program Level (Level 1) Requirements Document, Oct. 15, 2021.
> OPERA Level 2 Requirements JPL D-107391, Rev. B, Nov. 08, 2022.
> OPERA Product Description, JPL D-107389, Rev. A, Nov. 30, 2022
> OPERA CSLC-S1 Product Description, JPL D-108278, Rev. A, Sept. 11, 2023.
> OPERA DISP-S1 Product Specification, JPL D-108772, Feb. 28, 2025.

Reference Documents

[RD1]   "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.

[RD2]   Cloud Optimized GeoTIFF: An imagery format for cloud-native geospatial processing. www.cogeo.org/. Accessed 24 September 2023.

The latest official versions of this document should be obtained from https://www.jpl.nasa.gov/go/opera/about-opera. This document is a 'working version' with the primary purpose of describing the OPERA DISP-S1-STATIC generated by the OPERA Algorithm Development Team's (ADT) Final release delivery Release 6 (R6) to the OPERA SDS.

1.4 Applicable Software

The software generating the Final version of the DISP-S1 and DISP-S1-STATIC products is available on GitHub at disp-s1. The DISP-S1-STATIC products generated by the Final version of the SAS conform to the product specifications reported in this document.

2   PRODUCT OVERVIEW

2.1 Product Background

The OPERA Level 3 OPERA Level 3 Land-Surface Displacement Static Layers from Sentinel-1 data (DISP-S1-STATIC) serves as an ancillary product to the OPERA Level 3 Single Look Surface Displacement from Sentinel-1 product (DISP-S1). The DISP-S1-STATIC product is distributed separately from the DISP-S1 products, and it is only produced once (or a limited amount of times) for DISP-S1 products characterized by the same frame identification string i.e., for all the S1-A/B bursts covering the same geographical area on the ground.

Figure 2-1 shows the processing workflow used to generate a DISP-S1-STATIC product which includes the functionality to generate the CSLC-S1-STATIC product.

The spatial coverage of DISP-S1 products is over North America which includes USA and US Territories within 200 km from the US border, Canada, and all mainland countries from the southern US border down to and including Panama.
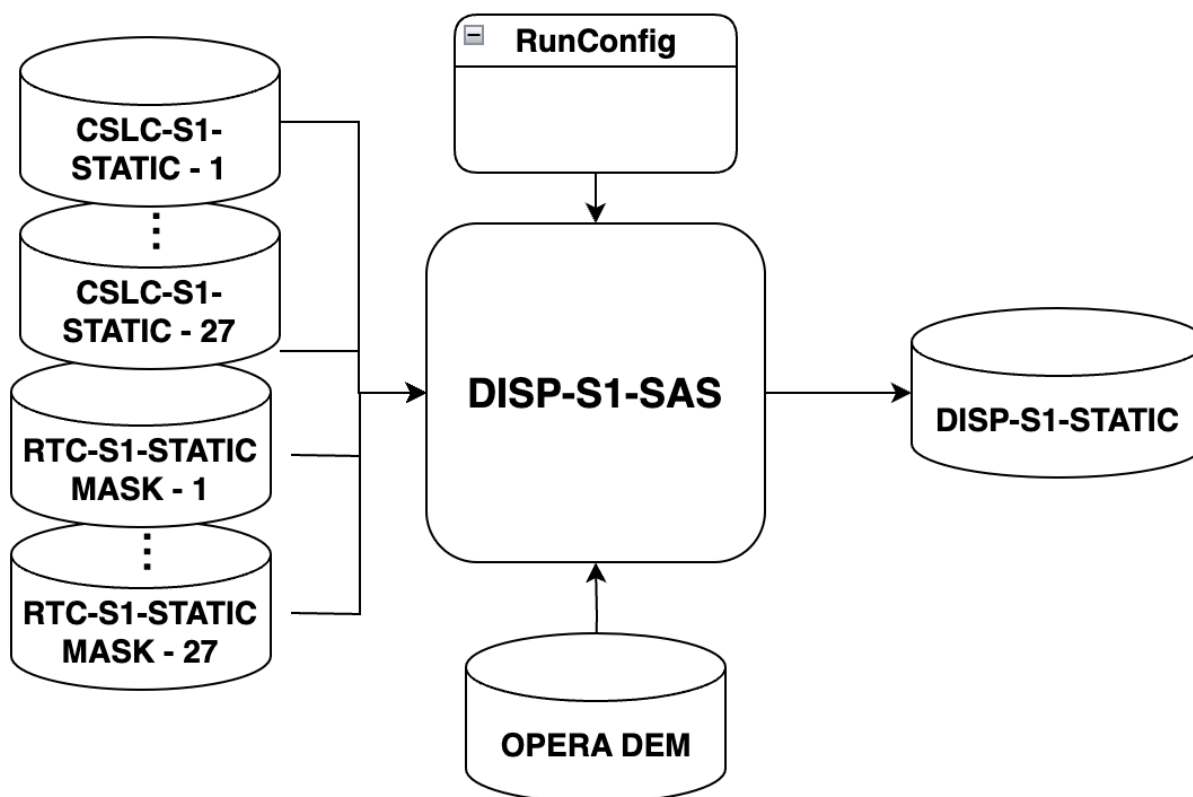
Figure 2-1 OPERA CSLC-S1 workflow diagram.

Input product	Description	Granule Size
CSLC-S1-STATIC	The input level 2 OPERA CSLC S1 Static layers files for the 27 bursts in the DISP-S1 frame	Variable
RTC-S1-STATIC MASK	The input level 2 OPERA RTC S1 Static layers files for the 27 bursts in the DISP-S1 frame	Variable
Copernicus DEM	GLO-30 Copernicus Digital Elevation Model	Variable

Table 2-1 Input products for DISP-S1-STATIC production.

2.2 DISP-S1-STATIC Product Overview

The DISP-S1-STATIC product is a Level 3 product that contains static radar geometry layers associated with the DISP-S1 product. These layers are generated over a pre-defined UTM map grid with a 30-meter spacing (Table 2-2).

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

Table 2-2 Pixel spacing of the DISP-S1-STATIC product.

3 PRODUCT ORGANIZATION

The DISP-S1-STATIC product is distributed as cloud-optimized GeoTIFF files (COGs) containing the layers line of sight east, north, vertical unit vectors, the digital elevation model (DEM), and the layover shadow mask.

3.1 File Naming Convention

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

OPERA_L3_DISP-S1-STATIC_
[FrameID]_[ValidityStartDate]_[Sensor]_[ProductVersion]_[LayerName].tif

- *FrameID*: Unique frame identification number as a 5-digit string in the format FXXXXX
- ValidityStartDate: The validity start date of the DISP-S1-STATIC product (format: YYYYMMDD)
- Sensor: The input product sensor, e.g., "S1A" representing Sentinel-1A
- ProductVersion: OPERA DISP-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 DISP-S1-STATIC product layer (e.g., "layover_shadow_mask")

Example:
OPERA_L3_DISP-S1-STATIC_F11115_20140403_S1A_v1.0_line_of_sight_enu..tif
OPERA_L3_DISP-S1-STATIC_F11115_20140403_S1A_v1.0_dem.tif
OPERA_L3_DISP-S1-STATIC_F11115_20140403_S1A_v1.0_layover_shadow_mask.tif

3.2 Spatial Organization

DISP-S1-STATIC products are distributed onto a uniformly spaced, north-south, and west-east aligned UTM/WGS84 grid with a 30 meter pixel spacing.

3.3 Spatial Sampling and Resolution

Some salient features of the output grid of DISP-S1-STATIC products:

1. The DISP-S1-STATIC product shares the same 30 meter geographical grid of all the DISP-S1 products characterized by the same frame identification string.
2. The corner coordinates of the geographical grid are multiples of the product pixel spacings in the Easting and Northing directions.

4 PRODUCT SPECIFICATION

OPERA DISP-S1-STATIC are distributed as cloud optimized GeoTIFFs (COGs) [RD2]. 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) [RD1] 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, and the line-of-sight unit vectors have been rounded to use only 16 bits of the Float32 data.

4.1 DISP-S1-STATIC Layers

DISP-S1-STATIC layers are provided in the same map grid as the DISP-S1 product imagery. Static layers include the line-of-sight (LOS) unit vectors, the digital elevation model used during CSLC processing, and the layover shadow mask of all bursts contained in the DISP-S1 frame.

4.1.1 Line-of-sight unit vector

The line of sight (LOS) unit vector is a 3-band raster containing the east, north, and vertical component of the unit vector. The convention is that the vector points from the ground pixel to the satellite (i.e. the vertical component in band 3 is positive).

4.1.2 Digital Elevation Model

The DEM raster is the OPERA DEM v1.1, derived from the Copernicus DEM, resampled to the same UTM grid as the DISP-S1 product.

4.1.3 Layover shadow mask

The layover shadow mask layer contains the valid/invalid, layover, and shadow classification computed over the reference DISP-S1-STATIC. The product stitches together the RTC-S1-STATIC mask imagery, which is computed on the same 30 meter grid as the DISP-S1 frames. 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   GeoTIFF metadata

All DISP-S1-STATIC product layers (GeoTIFF files) are saved with the same metadata, divided into: 1) Product Identification, 2) Input Datasets, and 3) DISP-S1-STATIC Processing Information.

4.2.1 Product Identification

Table 4-1 lists the product identification fields of the GeoTIFF metadata. The attribute PRODUCT_VERSION informs the version of the DISP-S1-STATIC product (structure and metadata), whereas the attribute SOFTWARE_VERSION describes the version of the software that generated the DISP-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: "DISP-S1-STATIC"
PROJECT	The project name: "OPERA"

INSTITUTION	Institution that created this product: "NASA JPL"
CONTACT_INFORMATION	Contact information for producer of the product: "opera-sds@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"
LOOK_DIRECTION	Look direction: "right"
ORBIT_PASS_DIRECTION	Orbit direction can be ascending or descending
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"
FRAME_ID	Frame identification (Frame ID)

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

4.2.2 Input Datasets

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

Table 4-2. GeoTIFF metadata: input datasets.

Attribute	Description
INPUT_L2_CSLC_STATIC_GRANULES	List of input L1 SLC products used
INPUT_DEM_SOURCE	Description of the input DEM

4.2.3 Processing Information

Table 4-3 lists processing and other product parameters associated with the DISP-S1-STATIC product.

Table 4-3. GeoTIFF metadata: DISP-S1-STATIC processing parameters.

Attribute	Description
SOFTWARE_VERSION	The algorithm software version used to generate the DISP-S1-STATIC product.
DOLPHIN_VERSION	Version of the Dolphin framework used for processing
AREA_OR_POINT	Indicates that pixel values are assumed to represent an area rather than points: "Area"

[AD3] APPENDIX A: GEOCODED PRODUCT GRIDS

OPERA DISP-S1 and DISP-S1-STATIC products are generated on a frame system, which groups together consecutive bursts from the input CSLC products. The projection system for a particular Frame ID is held constant through the product lifetime. Each product layer includes information indicating the projection used for the product.

a.   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 DISP-S1 Products

EPSG code	PROJ.4 string	Common Name	Geographical scope
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

b.   Grid Alignment

OPERA DISP-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).

[AD4] APPENDIX B: ACRONYMS

AD	Applicable Document
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
COMPASS	COregistered Multi-temPorAl Sar Slc (CSLC-S1 processor)
CSLC	Coregistered Single Look Complex
CSLC-S1	Coregistered Single Look Complex from Sentinel-1 A/B data
CSLC-S1-STATIC	Coregistered Single Look Complex Static Layers from Sentinel-1 A/B
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