



OPERA

Observational Products for End-Users from Remote Sensing Analysis

Product Specification Document for
Disturbance Alert from Harmonized
Landsat and Sentinel-2

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

OPERA Level-3 Disturbance Alert from Harmonized Landsat-8 and Sentinel-2 A/B Product Specification

Version 1.0

JPL D-108277

February 12, 2024

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

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EPDM Electronic Signatures

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DOCUMENT CHANGE LOG

Revision	Cover Date	Sections Changed	ECR #	Reason, ECR Title, LRS #*
Preliminary	Feb 9, 2022	All	N/A	New document
V0.2 - Rev -	May 15, 2022	All	N/A	Version delivered to project for baselining.
V0.3	August 10, 2022		N/A	Updated the definition of the collection name, product name, updated signature page, prepare formatting for online release, and incorporated comments from project review
V0.4	August 16, 2022			Updated granule naming convention and metadata fields per OPERA PST and LP-DAAC
V0.5 - Rev A	October 4, 2022	Tables and Section 3.4		Added missing rows and corrected errors.
V0.5 - Rev B	February 16, 2023	All		Update product short names to DIST-ANN and DIST-ALERT, delete DEMfile and PROJECT attributes in the metadata, some typos
V0.6 - Rev B	September 8, 2023	Tables 4-1 and 4-2		Correct the start date of the disturbance day numbers for both DIST-ALERT and DIST-ANN layers
V1.0	February 12, 2024	All		Update the product from provisional version to validated version (V1), updates including both DIST-ALERT and DIST-ANN data layers and metadata

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LIST OF TBD ITEMS

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1 INTRODUCTION

1.1 Document Purpose

This document describes the specifications of the OPERA (Observational Products for End-users from Remote-sensing Analysis) Level-3 Disturbance product from Harmonized Landsat-8 and Sentinel-2 A/B (HLS) that are generated by the University of Maryland through OPERA and provided to the Land Processes Distributed Active Archive Center (LP-DAAC) for open distribution. This data product is referenced by the short names **DIST-ALERT** and **DIST-ANN**.

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 resolution, temporal and spatial organization of the content, as well as the typical file size and total data volume. Section 4 provides a detailed description of DIST-ALERT and DIST-ANN product layers and corresponding metadata. Appendix A provides a listing of the acronyms used in this document.

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 case of conflict between the applicable documents and this document, the 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, Oct 15, 2021
- [AD3] OPERA Product Description, JPL D-107389, Rev A, December 14, 2021

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Reference Documents

- [RD1] OPERA DIST Product Algorithm Theoretical Basis Document (ATBD) V1, 2024-02-26
- [RD2] ESO, "GeoTIFF File Format, ESDS-RFC-040v1.1," 16 September 2019. [Online]. Available: <https://earthdata.nasa.gov/esdis/eso/standards-and-references/geotiff>. [Accessed 14 October 2021]
- [RD3] COG, "Cloud Optimized GeoTIFF: An imagery format for cloud-native geospatial processing," [Online]. Available: <https://www.cogeo.org/>. [Accessed 14 October 2021]
- [RD4] Adobe, "TIFF," 2019. [Online]. Available: <https://adobeio-prod.adobemsg.com/open/standards/TIFF.html>. [Accessed 14 October 2021].
- [RD5] NGA, "Coordinate Systems," [Online]. Available: <https://earth-info.nga.mil/index.php?dir=coordsys&action=coordsys#mgrs> [Accessed 15 October 2021].

2 PRODUCT OVERVIEW

2.1 Product Background

The Disturbance product (DIST) maps per pixel vegetation disturbance (specifically, vegetation cover loss) from the Harmonized Landsat and Sentinel-2 (HLS) scenes. Vegetation disturbance is mapped when there is an estimated decrease in vegetation cover within an HLS pixel. The product also provides auxiliary generic disturbance information as determined from the variations of the reflectance through the HLS scenes to provide information about more general disturbance trends. The DIST product suite is composed of two products according to their temporal scope: (a) the DIST-ALERT product which is released at the cadence of HLS imagery and (b) the DIST-ANN product which summarizes the DIST-ALERT product, specifically confirmed changes, from the previous year. For more details please see the Algorithm Theoretical Basis Document [RD1].

Figure 2-1 shows the DIST product workflow. Currently, the input dataset for generating each DIST-ALERT product is the HLS product version 2.0. HLS products provide surface reflectance (SR) data from the Operational Land Imager (OLI) aboard the Landsat 8 and Landsat 9 remote sensing satellites and the Multi-Spectral Instrument (MSI) aboard the Sentinel-2 A/B remote sensing satellites. The combined system provides observations over land masses excluding Antarctica every 2 to 4 days. HLS products are distributed over projected map coordinates aligned with the Military Grid Reference System (MGRS) [RD5]. Each tile covers 109.8 km squared divided into 3660 rows and 3660 columns at 30 m pixel spacing. Each tile overlaps neighbors by 4,900 m in each direction.

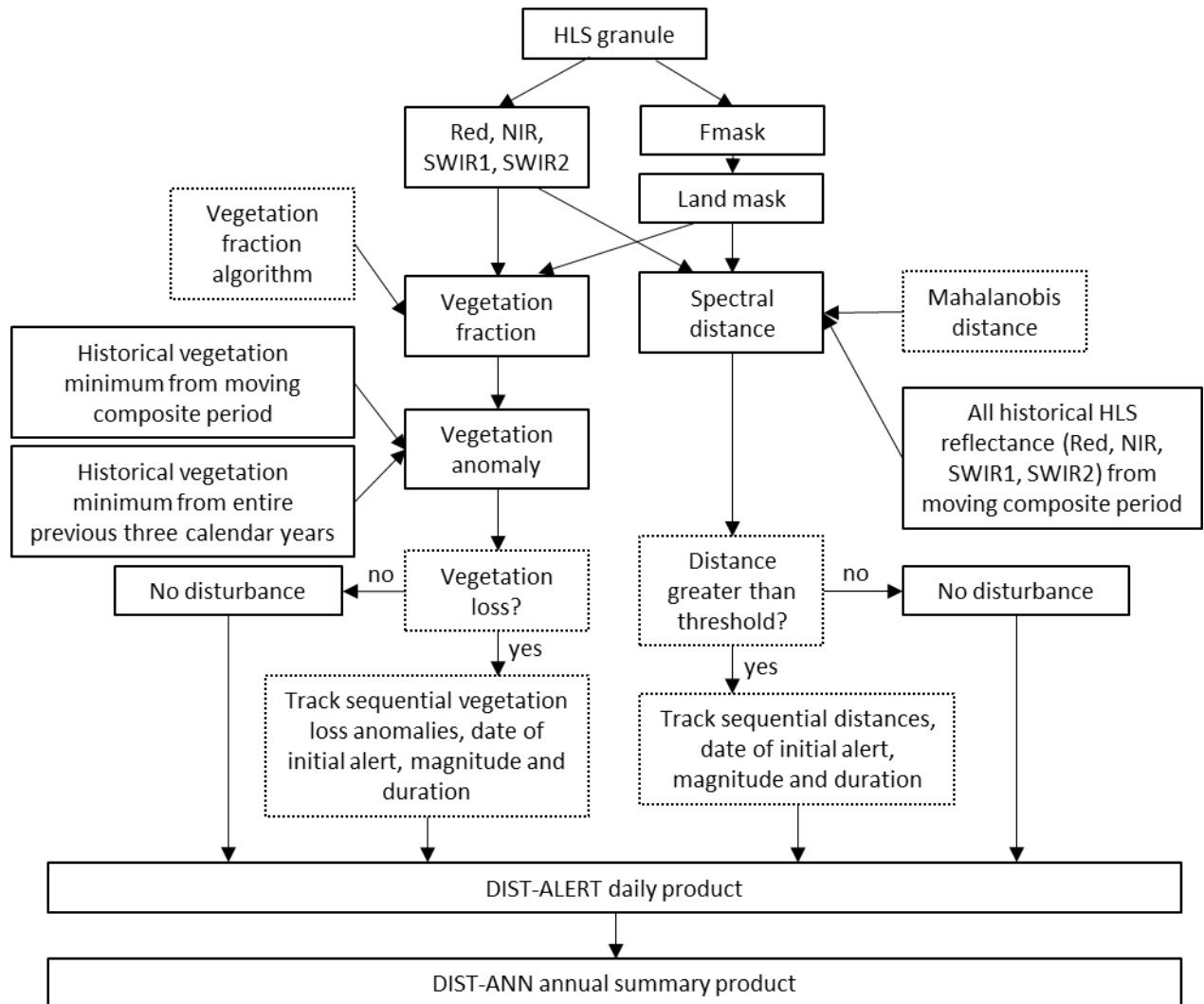


Figure 2-1. OPERA DIST workflow diagram

Table 2-1. Product Dependency Diagram

Product	Scope	Description	Granule Size
Harmonized Landsat-8 Sentinel-2A/B v2.0	Near Global	The input HLS products to OPERA system	3660 x 3660 (x, y)
Ocean mask	Global	Mask delineating the ocean with a 3 km coastal buffer	3660 x 3660 (x, y)

2.2 DIST Product Suite Overview

Each DIST-ALERT and DIST-ANN product is distributed as a set of Cloud-Optimized GeoTIFF (COG) files to enable download of only the particular layers of interest to a given user. All L3_DIST layers are stored within files following GeoTIFF format specifications [RD2]. A separate metadata file will be included.

The pixel spacing of the DIST products in East and North directions is consistent with the input HLS product with 30 m posting in Northing and 30 m posting in Easting.

The updated validated DIST-ALERT product (version 1) was released March 2024 and includes granules corresponding to all HLS granules from January 1, 2023 forward. The provisional DIST-ALERT product was produced from February 2023 to March 2024 is labeled as version 0 (v0). DIST-ANN is only produced in version 1, with 2023 as the first year of annual summary.

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3 PRODUCT ORGANIZATION

In this section, we describe the DIST-ALERT and DIST-ANN tile definition, file format, naming convention, and spatial organization.

3.1 Collection names

The long name of the updated validated collection is **OPERA Land Surface Disturbance Alert from Harmonized Landsat Sentinel-2 product (Version 1)**. The long name of the provisional collection of the DIST-ALERT product is **OPERA Land Surface Disturbance Alert from Harmonized Landsat Sentinel-2 provisional product (Version 0)**. The name has the following characteristics:

- Land Surface Disturbance: geophysical parameter being mapped
- Harmonized Landsat Sentinel-2: derived from HLS imagery
- Alert: distributed at the temporal cadence of the source HLS data
- Version 1: Collection version

The provisional and validated collections have the following short names, respectively:

OPERA_L3_DIST-ALERT-HLS_PROVISIONAL_V0, **OPERA_L3_DIST-ALERT-HLS_V1**.

The collection of DIST-ANN products has the long name **OPERA Land Surface Disturbance Annual from Harmonized Landsat Sentinel-2 product (Version 1)**. This collection has the same characteristics as the DIST-ALERT except that the temporal cadence is Annual instead of the near daily cadence of HLS. The validated collection has the following short name: **OPERA_L3_DIST-ANN-HLS_V1**, where L3 indicates the processing level.

3.2 Spatial Organization

OPERA DIST-ALERT and DIST-ANN products are aligned with the source HLS products, sharing the same projection, resolution, and tiling scheme. All the DIST-ALERT and DIST-ANN data are provided over projected map coordinates in tiles aligned with the Military Grid Reference System (MGRS) [RD5]. Each tile has a ground footprint of 109.8 km x 109.8 km. All rasters in the DIST product suite have 3660 rows and 3660 columns with 30 m of pixel spacing in both directions. The data for each layer is arranged on a standard uniformly spaced, North-up and West-left grid – i.e., the first row of pixels represent the northern-most pixels, and the first column of pixels represent the western-most pixels.

The MGRS is a geographic grid reference system defined over the Universal Transverse Mercator (UTM) and Universal Polar Stereographic (UPS) coordinate systems. The MGRS grid *The technical data in this document is controlled under the U.S. Export Regulations, release to foreign persons may require an export authorization.*

reference defines a hierarchical tiling scheme with different sizes starting from 1 m x 1 m and reaching up to 6 degrees in longitude and 8 degrees in latitude. Figure 3-1 shows the 6° x 8° grid zone designators in the MGRS grid.

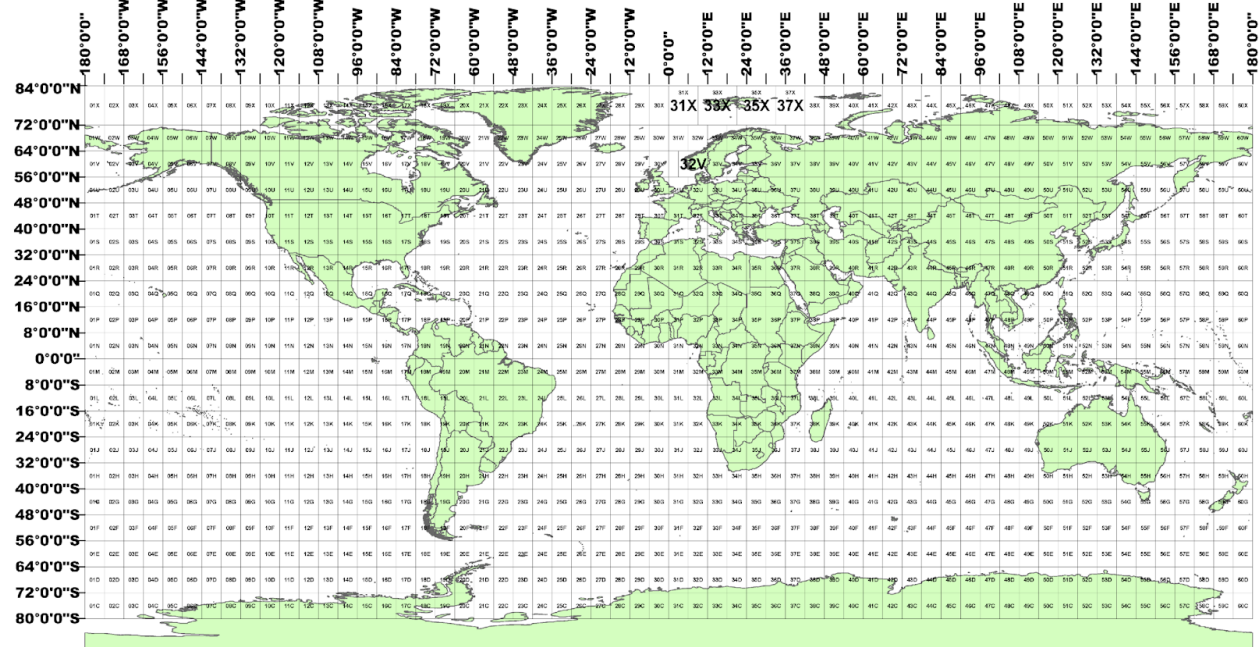


Figure 3-1 The global map of the grid zone designators for the HLS products (same as original Sentinel-2 tiling system [RD5]).

The MGRS tiling scheme used by HLS and L3_DIST products is defined over 100 km x 100 km. At this precision level, MGRS tiles are labeled using the grid zone designation followed by the 100 -km square identification. This identification consists of a column letter “A” to “Z” followed by a row letter from “A” to “V”. Similar to latitude bands, column and row letters also omit letters “I” and “O”.

Therefore, the MGRS tiling scheme used by HLS and DIST-ALERT and DIST-ANN has the following format:

<UTM_ZONE_NUMBER><LATITUDE_BAND><COLUMN_LETTER><ROW_LETTER>.

For example, the tile 21LYG is centered at 54°39'26.14"W, 12°14'45.54”S in Mato Grosso, Brazil.

The 109.8 km x 109.8 km dimension of HLS and DIST products include an overlap of 4,900 m in each direction over the MGRS 100,000-meter square tiling scheme to facilitate mosaicking of contiguous DIST product tiles without gaps.

3.3 File Format - GeoTIFF

The DIST-ALERT product is distributed as set of 19 Georeferenced Tagged Image File Format (GeoTIFF) [RD2] files corresponding to each of the output layers (defined in Table 4-1) as well as an additional metadata file contained in a folder associated with each input HLS image tile.

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The DIST-ANN product will also be distributed as a set of 21 GeoTIFF files corresponding to each of the output layers (defined in Table 4-2) as well as an additional metadata file.

The GeoTIFF files are Cloud Optimized GeoTIFFs (COGs) providing more efficient data retrieval from Web Object Storages [RD3]. The GeoTIFF is a format to store georeferenced raster images that is widely used by remote sensing communities. The GeoTIFF format is defined over the public domain Tagged Image File Format (TIFF) [RD4]. 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).

3.4 File Naming Convention

3.4.1 DIST-ALERT Naming Convention

DIST-ALERT granule names are designed to ensure unique names for each input HLS image tile. The granule will be of the format:

Project_Level_ProductType_TileID_AcquisitionDateTime_ProductionDateTime_Sensor_Resolution_ProductVersion, where:

Project: OPERA

Level: L3

ProductType: DIST-ALERT-HLS

TileID: Specific tile id of the product which is also the tile id of the input HLS product in the Military Grid Reference System (MGRS)

AcquisitionDateTime: The acquisition date and time of the input satellite imagery for this product in the following format (<YYYYMMDD>T<HHMMSS>)

ProductionDateTime: The production date and time of the granule (<YYYYMMDD>T<HHMMSS>)

Sensor: L8,L9, S2A, or S2B

Resolution: 30

ProductVersion: DIST product version number of the format “v<VERSION>”

For example, the DIST-ALERT product folder for a Sentinel-2A acquisition on 10/20/2021 over the tile 21LYG could be: OPERA_L3_DIST-ALERT-HLS_T21LYG_20211020T135121_20220810T155131_30_S2A_v1.

Each output layer (defined in Table 4-1) within a granule will be distributed as a single GeoTIFF and named by the granule name followed by a “_” and the variable name (e.g.

OPERA_L3_DIST-ALERT-HLS_T21LYG_20211020T135121_20220810T155131_30_S2A_v1_VEG-IND.tif).

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3.4.2 DIST-ANN Naming Convention

As the DIST-ANN product is not associated with individual HLS inputs, but rather the whole year for a given MGRS tile, the layers will all be contained in a single granule corresponding to the year (e.g. 2023). Granules will be named according to:

Project_Level_ProductType_TileID_Year_ProductionDateTime_Resolution_ProductVersion, where all fields are defined as in the DIST-ALERT product except:

ProductType: DIST-ANN-HLS

Year: The corresponding year of DIST-ALERT products that were input to the annual product

For example, for the tile 21LYG, the granule could be entitled OPERA_L3_DIST-ANN-HLS_T21LYG_2023_20240105T120202_30_v1. Each output layer (defined in Table 4-2) will be distributed as an individual GeoTIFF. Additional metadata files will be included.

4 PRODUCT SPECIFICATION

In this section, we describe the DIST-ALERT and DIST-ANN product layers and associated metadata.

4.1 Product Raster Layers

Each DIST-ALERT product contains 19 layers (raster files), each with 3660 rows and 3660 columns and are posted at 30m. Each DIST-ANN product contains 21 layers (raster files), each with 3660 rows and 3660 columns and are posted at 30m. Specifics regarding file names and content for v1 are shown in Table 4-1 for DIST-ALERT and in Table 4-2 for DIST-ANN.

Table 4-1. DIST-ALERT raster layers for v1

DIST-ALERT Raster Layer	Description	Layer name	Data type	Layer values
Vegetation disturbance status*	Indication of vegetation cover loss (vegetation disturbance). The status label is based on the maximum anomaly value, confidence level, and whether it is ongoing or finished. “First” means the pixel has had an anomaly detection but no subsequent observations whether anomalous or not. “Provisional” means there have been two consecutive disturbance detections but not yet high confidence. “Confirmed” means that vegetation disturbance is detected with high confidence (≥ 400). The label “finished” is applied to confirmed disturbances that have had two consecutive no-anomaly observations or one 15 days or more after the last anomaly detection. If a new disturbance is detected, it will overwrite those in a “finished” state. These labels are reported for both above and below the 50% disturbance threshold based on the maximum anomaly value.	VEG-DIST-STATUS	UInt8	0: No disturbance 1: first <50% 2: provisional <50% 3: confirmed <50% 4: first $\geq 50\%$ 5: provisional $\geq 50\%$ 6: confirmed $\geq 50\%$ 7: confirmed <50%, finished 8: confirmed $\geq 50\%$, finished 255: No data
Current vegetation cover indicator	The percent vegetation cover estimated for the current HLS scene for all land and water pixels.	VEG-IND	UInt8	0-100: Estimated percent vegetation 255: No data
Current vegetation anomaly value	Difference between historical baseline and observed vegetation cover at the current date (vegetation loss of 0-100%). When >0 , the sum of this anomaly value and the current vegetation cover indicator will be the historical vegetation cover estimate.	VEG-ANOM	UInt8	0-100: Estimated loss of percent vegetation 255: No data
Historical vegetation cover indicator	Historical percent baseline value at the time of the maximum anomaly for disturbance pixels. A fill value is used for all non-disturbance pixels. Historical vegetation is calculated from all HLS scenes within a synchronous temporal window (± 15 days) from previous three calendar years to capture intra-annual/seasonal variation.	VEG-HIST	UInt8	0-100: Vegetation percent 200: No disturbance 255: No data

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DIST-ALERT Raster Layer	Description	Layer name	Data type	Layer values
Max vegetation anomaly value	Difference between historical and current year observed vegetation cover at the date of maximum decrease (vegetation loss of 0-100%). This layer can be used to threshold vegetation disturbance per a given sensitivity (e.g. disturbance of $\geq 20\%$ vegetation cover loss). The sum of the historical percent vegetation and the anomaly value will be the vegetation cover estimate for the current year	VEG-ANOM-MAX	UInt8	0-100: Maximum loss of percent vegetation 255: No data
Vegetation Disturbance Confidence Layer	Mean anomaly value since initial anomaly detection multiplied by the number of loss anomalies squared. Confidence is calculated until the anniversary date is reached, or a fixed number of consecutive non-anomalies are observed causing the status (VEG-DIST-STATUS) to change to "finished".	VEG-DIST-CONF	Int16	-1: No data 0: No disturbance >0: Disturbance confidence
Date of initial vegetation disturbance	Day of first loss anomaly detection of the most recent disturbance event. Day denoted as the number of days since December 31, 2020.	VEG-DIST-DATE	Int16	-1: No data 0: No vegetation anomalies in the last year >0: Day of initial anomaly detection in the last year
Number of detected vegetation loss anomalies	Total number of observations with anomalous low vegetation since initial anomaly detection (inclusive). Maximum of 254.	VEG-DIST-COUNT	UInt8	0: No disturbance 1-254: Count of loss anomalies 255: No data
Vegetation disturbance duration	Number of days of ongoing loss anomalies since initial anomaly detection (inclusive). Maximum duration is one year.	VEG-DIST-DUR	Int16	-1: No data 0: No disturbance 1-366: number of days from first anomaly to most recent anomaly detection
Date of last observation assessed for vegetation disturbance	Day of last quality assessed HLS observation flagged as land or water that also had sufficient observations for baseline calculation for vegetation disturbance algorithm. Day denoted as the number of days since December 31, 2020.	VEG-LAST-DATE	Int16	-1: No data ≥ 1 : Last day assessed
Generic disturbance status*	Indication of generic spectral difference. The status label is based on the maximum anomaly value, confidence level, and whether it is ongoing or finished. "First" means the pixel has had an anomaly detection but no subsequent observations whether anomalous or not. "Provisional" means there have been two consecutive disturbance detections but not yet high	GEN-DIST-STATUS	UInt8	0: No disturbance 1: first low 2: provisional low 3: confirmed low 4: first high 5: provisional high 6: confirmed high

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DIST-ALERT Raster Layer	Description	Layer name	Data type	Layer values
	confidence. "Confirmed" means that disturbance is detected with high confidence. The label "finished" is applied to confirmed disturbances that have had two consecutive no-anomaly observations or one 15 days or more after the last anomaly detection. If a new disturbance is detected, it will overwrite those in a "finished" state. These labels are reported for both above a low and high threshold based on the maximum spectral anomaly.			7: confirmed low, finished 8: confirmed high, finished 255: No data
Current generic disturbance anomaly value	Spectral distance between current HLS scene reflectance and the reflectance of the previous three calendar years within ±15 calendar days. Calculated by Mahalanobis distance.	GEN-ANOM	Int16	-1: No data 0: No disturbance >0: Spectral distance
Generic disturbance maximum anomaly value	Maximum spectral distance between a current year HLS scene reflectance and the composite reflectance of previous calendar years.	GEN-ANOM-MAX	Int16	-1: No data 0: No disturbance >0: Spectral distance
Generic Disturbance Confidence Layer	Mean spectral distance since initial spectral anomaly detection times the number of spectral anomalies above a threshold, until the anniversary date is reached, or a fixed number of consecutive non-anomalies are observed.	GEN-DIST-CONF	Int16	-1: No data 0: No disturbance >0: Disturbance confidence
Date of initial generic disturbance	Day of first spectral anomaly detection of the most recent disturbance event. Day denoted as the number of days since December 31, 2020.	GEN-DIST-DATE	Int16	-1: No data 0: No spectral anomalies in the last year >0: Day of initial anomaly detection in the last year
Number of detected spectral anomalies	Total number of observations with spectral reflectance anomalies (inclusive). Maximum of 254.	GEN-DIST-COUNT	UInt8	0: No disturbance 1-254: Count of loss anomalies 255: No data
Generic disturbance duration	Number of days of ongoing spectral reflectance anomalies since initial anomaly detection (inclusive). Maximum duration is one year.	GEN-DIST-DUR	Int16	-1: No data 0: No disturbance 1-366: number of days from first anomaly to most recent anomaly detection
Date of last observation assessed for generic disturbance	Day of last quality assessed HLS observation flagged as land that also had sufficient observations for baseline calculation for generic disturbance algorithm. Day denoted as the number of days since December 31, 2020.	GEN-LAST-DATE	Int16	-1: No data ≥1: Last day assessed

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DIST-ALERT Raster Layer	Description	Layer name	Data type	Layer values
Data mask*	Mask of pixels the algorithms are applied to in the current HLS scene. Based on the Fmask layer of the source HLS granule.	DATA-MASK	UInt8	0: Not land 1: Land 2: Water

Note: Layers with * have different layer values in v1 and v0. More details can be found in APPENDIX B.

Table 4-2. DIST-ANN raster layers for v1

DIST-ANN Raster Layer	Description	File name	Data type	Layer values
Vegetation disturbance status*	Status corresponding to the highest confidence vegetation disturbance confirmed within the year. Status classes identify confirmed ongoing disturbance, confirmed finished disturbance, and confirmed disturbance initially detected in previous year for both <50% and ≥50%, and no disturbance.	VEG-DIST-STATUS	UInt8	0: No disturbance 3: confirmed <50% ongoing 6: confirmed ≥50% ongoing 7: confirmed <50% finished 8: confirmed ≥50% finished 9: confirmed previous year <50% 10: confirmed previous year ≥50% 255: No data
Historical vegetation cover indicator	Historical percent vegetation from composite of HLS scenes during the same time period of the maximum anomaly for disturbance pixels. A fill value is used for all non-disturbance pixels. Historical vegetation is calculated from a synchronous temporal window from previous calendar years to capture intra-annual/seasonal variation.	VEG-HIST	UInt8	0-100: Vegetation percent 200: No disturbance 255: No data
Maximum vegetation cover indicator	For non-disturbance pixels, maximum annual vegetation fraction from the HLS time-series data will be reported. For disturbance pixels, the vegetation fraction from the date of maximum anomaly will be reported.	VEG-IND-MAX	UInt8	0-100: Estimated percent vegetation 255: No data
Maximum vegetation anomaly value	Difference between historical vegetation cover and vegetation cover at the date of maximum decrease (vegetation loss of 0-100%). This layer can be used to threshold vegetation disturbance per a given sensitivity (e.g. disturbance of ≥20% vegetation cover loss).	VEG-ANOM-MAX	UInt8	0-100: Maximum loss of percent vegetation 255: No data

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DIST-ANN Raster Layer	Description	File name	Data type	Layer values
Vegetation disturbance confidence layer	Mean anomaly value since initial anomaly detection times the number of loss anomalies squared, until the anniversary date is reached, or a fixed number of consecutive non-anomalies are observed.	VEG-DIST-CONF	Int16	-1: No data 0: No disturbance >0: Disturbance confidence
Date of initial vegetation disturbance	Day of first loss anomaly. Day denoted as the number of days since December 31, 2020.	VEG-DIST-DATE	Int16	-1: No data 0: No disturbance >0: Day of first loss anomaly detection
Number of detected vegetation loss anomalies	Total number of observations with anomalous low vegetation since initial anomaly detection (inclusive). Maximum of 254.	VEG-DIST-COUNT	UInt8	0: No disturbance 1-254: Count of loss anomalies 255: No data
Vegetation disturbance duration	Number of days of ongoing loss anomalies since initial anomaly detection (inclusive). Maximum duration is one year.	VEG-DIST-DUR	Int16	-1: No data 0-366: number of days from first anomaly to most recent anomaly detection
Indicator of vegetation disturbance from previous year	Indicator of whether the highest confidence vegetation disturbance event confirmed within the year (corresponding to the above layers) was initially detected in the previous calendar year.	VEG-CONF-PREV	UInt8	0: no disturbance 1: confirmed low previous year, 2: confirmed high previous year, 255: no data
Count of confirmed vegetation disturbance events	Count of distinct confirmed vegetation disturbance events.	VEG-CONF-COUNT	UInt8	≥0: count of confirmed vegetation disturbance events 255: no data
Minimum three year vegetation cover indicator	The minimum vegetation cover of the current year and two previous years with stricter aerosol filtering. Becomes input to the following year's DIST-ALERT product.	VEG-IND-3YR-MIN	UInt8	0-100: Vegetation percent 255: No data
Date of last observation assessed for vegetation disturbance	Day of last quality assessed HLS observation flagged as land that also had sufficient observations for baseline calculation for vegetation disturbance algorithm. Day denoted as the number of days since December 31, 2020.	VEG-LAST-DATE	Int16	-1: No data 0: Never flagged as land >0: Day of last land observation

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DIST-ANN Raster Layer	Description	File name	Data type	Layer values
Generic disturbance status*	Status corresponding to the highest confidence generic spectral difference confirmed within the year. Status classes identify confirmed ongoing disturbance, confirmed finished disturbance, and confirmed disturbance initially detected in previous year for both above a low and high threshold and no disturbance.	GEN-DIST-STATUS	UInt8	0: No disturbance 3: confirmed low, ongoing 6: confirmed high, ongoing 7: confirmed low, finished 8: confirmed high, finished 9: confirmed low, previous year 10: confirmed high, previous year 255: No data
Generic maximum disturbance anomaly value	Maximum spectral distance between a current year HLS scene reflectance and the composite reflectance of previous calendar years.	GEN-ANOM-MAX	Int16	-1: No data 0: No disturbance >0: Spectral distance
Generic Disturbance Confidence Layer	Mean spectral distance since initial spectral anomaly detection times the number of spectral anomalies above a threshold, until the anniversary date is reached, or a fixed number of consecutive non-anomalies are observed.	GEN-DIST-CONF	Int16	-1: No data 0: No disturbance >0: Disturbance confidence
Date of generic initial disturbance anomaly	Day of first spectral anomaly. Day denoted as the number of days since December 31, 2020.	GEN-DIST-DATE	Int16	-1: No data 0: No disturbance >0: Day of first anomaly detection
Number of detected spectral anomalies	Total number of observations with a spectral anomaly since initial anomaly detection (inclusive). Maximum of 254.	GEN-DIST-COUNT	UInt8	0: No loss anomalies 1-254: Count of loss anomalies 255: No data
Generic disturbance duration	Number of days of ongoing spectral anomalies since initial anomaly detection (inclusive). Maximum duration is one year.	GEN-DIST-DUR	Int16	-1: No data 0-366: number of days from first anomaly to most recent anomaly detection
Indicator of generic disturbance from previous year	Indicator of whether the highest confidence generic disturbance event confirmed within the year (corresponding to the above GEN layers) was initially detected in the previous calendar year.	GEN-CONF-PREV	UInt8	0: no disturbance 1: confirmed low previous year, 2: confirmed high previous year, 255: no data
Count of confirmed generic disturbance events	Count of distinct confirmed generic disturbance events.	GEN-CONF-COUNT	UInt8	>0: count of confirmed generic disturbance alert 255: no data
Date of last observation assessed for generic disturbance	Day of last quality assessed HLS observation flagged as land that also had sufficient observations for baseline calculation for generic disturbance	GEN-LAST-DATE	Int16	-1: No data 0: Never flagged as land >0: Day of last land observation

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DIST-ANN Raster Layer	Description	File name	Data type	Layer values
	algorithm. Day denoted as the number of days since December 31, 2020.			

4.2 DIST-ALERT Metadata

DIST-ALERT metadata can be found in the cmr.json file in the package of DIST-ALERT product. It includes product identification and processing information, and HLS metadata. The details can be found in table 4-3.

Table 4-3. DIST-ALERT metadata for v1

Attribute	Description
GranuleUR	The granule ID for each DIST-ALERT. Format: OPERA_L3_DIST-ALERT-HLS_Tile_YYYYMMDDTHMMSSZ_YYYYMMDDTHMMSSZ_S2A_30_v1
TemporalExtent: RangeDateTime	Temporal extent of the HLS data, flagged as BeginningDateTime and EndingDateTime. Format: YYYY-MM-DDTHH:MM:SS.SSSSSSZ
ProviderDates	The date of DIST-ALERT product be provided
CollectionReference:ShortName	The short name of the collection, OPERA_L3_DSIT-ALERT-HLS_V1
CollectionReference:Version	The DIST-ALERT product version
DataGranule: DayNightFlag	Flag if the image is during the day or night
DataGranule: ProductionDateTime	DIST-ALERT product processing date. Format: YYYY-MM-DDTHH:MM:SS.SSSSSSZ.
Platforms	Name of the sensor platform (e.g. Landsat-8/9 or Sentinel-2 A/B)
Instruments	Name of the sensor instrument (e.g. OLI or MSI)
SpatialExtent	The longitude and latitude boundary of the image
CloudCover	The percentage of cloud and cloud shadow in the DIST-ALERT product (copied from HLS)
Input_DIST-ALERT_granule	The input DIST-ALERT granule ID
BaselineCalendarWindow	Number of days before and after the calendar date used to create the baseline
BaselineYearWindow	Number of previous years used to create the baseline
Baselinemagelds	List of the input HLS granules used to create the baseline
ValidationLevel	The validation level of the product

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HLSGranuleUR	Name of the input HLS granule used to generate the DIST-ALERT product
SENSOR_PRODUCT_ID	The source Landsat or Sentinel-2 data ID
SPATIAL_COVERAGE	The area percentage of the tile with data (copied from HLS)
MGRS_TILE_ID	The tile ID
HLS_PROCESSING_TIME	The input HLS granule processing date. Format: YYYY-MM-DDTHH:MM:SS.SSSSSSZ.
SENSING_TIME	The sensing time provided with the source Landsat or Sentinel-2 image. Format: YYYY-MM-DDTHH:MM:SSZ.
HORIZONTAL_CS_CODE	The code for the coordinate system, eg: "EPSG:32655"
HORIZONTAL_CS_NAME	The name of the coordinate system, eg: "UTM, WGS84, UTM ZONE 55"
ULX	The E-W coordinate of the upper left within the given coordinate system
ULY	The N-S coordinate of the upper left within the given coordinate system

4.3 DIST-ANN metadata

DIST-ANN metadata can be found in the cmr.json file in the package of DIST-ANN product. The details can be found in table 4-4. There will also be a comma delimited file (CSV) listing all DIST-ALERT input files, HLS source files and image metadata.

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Table 4-4 DIST-ANN metadata for v1

Attribute	Description
GranuleUR	The granule ID for each DIST-ANN. Format: OPERA_L3_DIST-ANN-HLS_Tile_YYYY_YYYYMMDDTHMMSSZ_30_v1
TemporalExtent: RangeDateTime	Temporal extent of the HLS data of the input year, flagged as BeginningDateTime and EndingDateTime. Format: YYYY-MM-DDTHH:MM:SS.SSSSSSZ
ProviderDates	The date-time of when the granule was sent to LP-DAAC. Format: YYYY-MM-DDTHH:MM:SS.SSSSSSZ
CollectionReference:ShortName	OPERA_L3_DIST-ANN-HLS_V1
CollectionReference:Version	The DIST-ANN product version
SpatialExtent	The longitude and latitude boundary of the image
CloudCover	The percentage of no-data in the DIST-ANN product
Platforms	Names of the input sensor platforms (e.g. Landsat 8/9 and Sentinel-2 A/B)
Instruments	Names of the input sensor instruments (e.g. OLI and Sentinel-2 MSI)
ValidationLevel	The validation level of the product
SPATIAL_COVERAGE	The area percentage of the tile with data
MGRS_TILE_ID	The tile ID
HORIZONTAL_CS_CODE	The code for the coordinate system, eg: "EPSG:32655"
HORIZONTAL_CS_NAME	The name of the coordinate system, eg : "UTM, WGS84, UTM ZONE 55"
ULX	The E-W coordinate of the upper left within the given coordinate system
ULY	The N-S coordinate of the upper left within the given coordinate system
PROCESSING_DATETIME	DIST-ANN product processing date. Format: YYYY-MM-DDTHH:MM:SSZ.

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APPENDIX A: ACRONYMS

COG	Cloud-Optimized GeoTIFF
DAAC	Distributed Active Archive Center
DEM	Digital Elevation Model
DIST	Disturbance
DOI	Digital Object Identifier
GLAD	Global Land Analysis and Discovery
QGIS	Quantum Geographic Information System
GDAL	Geospatial Data Abstraction Library
GeoTIFF	Georeferenced Tagged Image File Format
GIS	Geographic Information System
HLS	Harmonized Landsat and Sentinel-2
MGRS	Military Grid Reference System
MSI	Multi-Spectral Instrument
OLI	Operational Land Imager
OPERA	Observational Products for End-users from Remote-sensing Analysis
SR	Surface Reflectance
UMD	University of Maryland, College Park
UPS	Universal Polar Stereographic
UTM	Universal Transverse Mercator

APPENDIX B: TABLES FOR PROVISIONAL PRODUCT

Table 4-1. DIST-ALERT raster layers for v0

DIST-ALERT Raster Layer	Description	Layer name	Data type	Layer values
Vegetation disturbance status	Indication of vegetation cover loss (vegetation disturbance). The label “provisional” is used from the first detection until vegetation disturbance is detected for a consecutive number of HLS scenes when it is then labeled “confirmed”. If a “provisional” disturbance does not have repeated detections, it is removed. These labels are reported for both above and below the 50% disturbance threshold.	VEG-DIST-STATUS	UInt8	0: No disturbance 1: provisional <50% 2: confirmed <50% 3: provisional ≥50% 4: confirmed ≥50% 255: No data
Generic disturbance status	Indication of generic spectral difference. The label “provisional” is used from the first anomaly detection until the anomaly is detected for a consecutive number of HLS scenes when it is then labeled “confirmed”. If a “provisional” disturbance does not have repeated detections, it is removed. These labels are reported for both above a low and high threshold.	GEN-DIST-STATUS	UInt8	0: No disturbance 1: provisional <50% 2: confirmed <50% 3: provisional ≥50% 4: confirmed ≥50% 255: No data
Land mask	Mask of pixels the vegetation disturbance algorithm is applied to in the current HLS scene.	LAND-MASK	UInt8	0: Not land 1: Land

Note: These layers in v0 have different layer values as v1. All the other layers except for the listed layers have the same layer values with v1, please refer to table 4.1 DIST-ALERT raster layers for v1 for the details of other layers.

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