

# HARMONIZED LANDSAT-SENTINEL SERVICE

API Documentation 2020

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## Service Overview

The Ag-Analytics® Harmonized Landsat-Sentinel Service (HLS) API provides the service in which a user can provide an area-of-interest (AOI) with additional customized options to retrieve the dynamics of their land at various times from the Landsat-8 (L30 Product) and Sentinel-2 (S30 Product) satellites. This service provides information on cloud cover, statistics, and Normalized Difference Vegetation Index in addition to MSI bands information.

The Harmonized Landsat-Sentinel (HLS) Project is a NASA initiative to produce a Virtual Constellation (VC) of surface reflectance (SR) data from the Operational Land Imager (OLI) and Multispectral Instrument (MSI) onboard the Landsat-8 and Sentinel-2 remote sensing satellites, respectively. The data from these satellites creates unprecedented opportunities for timely and accurate observation of Earth status and dynamics at moderate (<30 m) spatial resolution every 2-3 days.



HLS used in [FarmScope](#)

## Service Information

Specifications for the HLS products used in the Ag-Analytics® Harmonized Landsat- Sentinel Service API are provided below (information from <https://hls.gsfc.nasa.gov>)

Product Name	S30	L30
<b>Input sensor</b>	Sentinel-2A/B MSI	Landsat-8 OLI/TIRS
<b>Spatial Resolution</b>	30 m	30 m
<b>BRDF-Adjusted</b>	Yes (except for bands 01, 05, 06, 07, 09, 10)	Yes
<b>Bandpass-adjusted</b>	Adjusted to OLI-like but no adjustment for Red Edge or water vapor	No
<b>Projection</b>	UTM	UTM
<b>Tiling System</b>	MGRS (110*110)	MGRS (110*110)

## HLS Spectral Bands Nomenclature

HLS spectral band nomenclatures from the [HLS User's guide](#).

Band Name	OLI band MSI number	MSI band number	HLS band code name Landsat8	HLS band code name Sentinel 2	L30** Subdataset number **	S30 **Subdataset number**	Wavelength (micrometers)
<b>Coastal Aerosol</b>	1	1	band01	B01	01	01	0.43 – 0.45*
<b>Blue</b>	2	2	band02	B02	02	02	0.45 – 0.51*
<b>Green</b>	3	3	band03	B03	03	03	0.53 – 0.59*
<b>Red</b>	4	4	band04	B04	04	04	0.64 – 0.67*
<b>Red-Edge 1</b>		5		B05		05	0.69 – 0.71**
<b>Red-Edge 2</b>		6		B06		06	0.73 – 0.75**
<b>Red-Edge 3</b>		7		B07		07	0.77 – 0.79**
<b>NIR Broad</b>		8		B08		08	0.78 – 0.88**
<b>NIR Narrow</b>	5	8A	band05	B8A	05	09	0.85 – 0.88*
<b>SWIR 1</b>	6	11	band06	B11	06	10	1.57 – 1.65*
<b>SWIR 2</b>	7	12	band07	B12	07	11	2.11 – 2.29*
<b>Water vapor</b>		9		B09		12	0.93 – 0.95**



<b>Cirrus</b>	9	10	band09	B10	08	13	1.36 – 1.38*
<b>Thermal Infrared 1</b>	10		band10		09		10.60 – 11.19*
<b>Thermal Infrared 2</b>	11		band11		10		11.50 – 12.51*
<b>QA</b>					11	14	

## General Flow of Service

When a user passes an area-of-interest (AOI) in the form of a shapefile, json, raster .tif, or geojson, the service finds the correct satellite imagery and clips each image to the AOI given. The service has the options to interpolate the result and to specify the imagery weeks that are returned.

### General Algorithm Flow

1. Determine the AOI polygon given
2. Identify the corresponding satellite imageries based on the AOI, acquisition date, interpolation parameters, and other options passed by users.
3. The satellite imageries will then be clipped to the AOI. If the imageries from the same date overlay with each other on the AOI, the **mean** of the overlay area will be returned and **merged** with the area without overlay from each imagery.
4. The imageries of the AOI will then be mosaiced to get weekly average imageries.
5. If the interpolation option is chosen, the selected interpolation method and parameters will be applied to each weekly imagery where has cloud cover.

### Interpolation Function

Due to cloud cover, the original satellite images may have many gaps and cannot fully cover the area-of-interest (AOI). The interest to solve this problem arose in 2003, and there have been many papers and methods developed for this problem since then. After comparing and testing multiple methods and algorithms that have been used in dealing with the missing data on remote sensing satellite images, we adopted a customized “inpainting” method - which means filling gaps in an image by extrapolating the existing parts of the image in our API service.

To take the spatial and temporal correlation of the images into consideration, our customized inpainting algorithm “inpaints” a sequence of images with cloud covered for the given AOI. Each missing part (multiple pixels) at a certain location is inpainted by linear transformation of the intensity of pixels at the same location of other images where the data of these pixels are available.





## Header Parameters

**content-type:** "application/x-www-form-urlencoded"

## Request Parameters

Parameter	Data Type	Required?	Default	Options	Description
<b>AOI</b>	Geometry, file/text	Yes	-	JSON, GEOJSON, Shapefile, Raster	See Fig. 2 for further explanation.
<b>Band</b>	List	Yes	-	See Request Parameters - "Band" Options on page 7	Provide the list of HLS Spectral band names to retrieve for given AOI. See supplementary info tables.
<b>Startdate</b>	Date, mm / dd / yyyy	No	-	-	Landsat – data starts from <b>2013</b> , Sentinel – data starts from <b>2015</b>
<b>Enddate</b>	Date, mm / dd / yyyy	No	-	-	In the absence of startdate or enddate, or both, the service retrieves the latest information available on the land.
<b>byweek</b>	Int, boolean	No	1	1, 0	If set to 1, result raster will be the mosaic of all the tiles in a particular week for a given satellite
<b>satellite</b>	text	No	Landsat	Landsat, Sentinel	If set to both Landsat, Sentinel then the result raster will be the mosaic of both satellites for the given dates
<b>showlatest</b>	Int, boolean	No	1	-	If startdate or enddate is not given, shows the latest available tile.



<b>filter</b>	Int, boolean	No	0	0, 1	If set to 1, returns the response which is cloud-free after mosaic.
<b>qafilter</b>	Int, boolean	No	0	0, 1	If set to 1, continues to filter tiles until the invalid pixels are < <b>qacloudperc</b>
<b>qacloudperc</b>	float	No	100	0-100	This parameter comes to action with <b>qafilter</b> . If <b>qafilter</b> parameter is 1, then filters the tiles until the invalid pixels in those are < <b>qacloudperc</b>
<b>displaynorm alvalues</b>	float	No	2000	-	This parameter is used to normalize the band values for display purposes. Used for bands like RGB, AGR, etc.
<b>legendtype</b>	text	No	Relative	Relative, Absolute	Legend type of display ranges of resulting response.
<b>resolution</b>	float	No	0.0001	-	Cellsize in meters.
<b>flatten_data</b>	Int, boolean	No	0	0, 1	Flatten data which has a list of Xcoord, Ycoord and Values for each band in the output. If 1, flatten_data is returned.
<b>statistics</b>	Int, boolean	No	1	0, 1	Returns statistical features of the output .tif file.
<b>return_tif</b>	int	No	1	0, 1	Returns the downloadable link to output raster. If 0, link will not be returned.
<b>projection</b>	text	No	Projection of AOI Given	<b>See projection example.</b>	Enter the desired projection for the result raster. See <b>projection example</b> for details.



## Request Parameters - “Band” Options

The following bands, indices, and RGB insertions can be used for the “Band” parameter in the API request

### Band Explanations

API Variable	Band Definition	Description
<b>Red</b>	Red (0.64-0.67µm)	Reflects reds, such as tropical soils or rust-like soils.
<b>Green</b>	Green (0.53-0.59µm)	Reflects greens, particularly leaf surfaces.
<b>Blue</b>	Blue (0.45-0.51µm)	Reflects blues, particularly helpful for deep waters.
<b>NIR</b>	Near Infrared (0.76-0.90µm)	Reflects healthy vegetation.
<b>NIR_Broad</b>	Near Infrared (.842 µm central)	Good for mapping shorelines and biomass content, as well as at detecting and analyzing vegetation.
<b>Red_Edge_1</b>	Red Edge (.69 - .71µm)	Can gauge foliage chlorophyll, canopy area, and water content. Applications include growth studies, precision ag, and vegetation productivity modeling.
<b>Red_Edge_2</b>	Red Edge (0.73 – 0.75 µm)	Can gauge foliage chlorophyll, canopy area, and water content
<b>Red_edge_3</b>	Red Edge (0.77 – 0.79 µm)	Can gauge foliage chlorophyll, canopy area, and water content
<b>SWIR1</b>	Short-wave Infrared (1.57-1.65µm)	Sensitive to moisture content. Assists in distinguishing between dry and wet soils and vegetation.
<b>SWIR2</b>	Short-wave Infrared 2 (2.08-2.35µm)	Used in imaging soil types, geological features, and minerals. Sensitive to vegetation and soil moisture variations.
<b>Coastal Aerosol</b>	Coastal Aerosol (0.43-0.45µm)	Reflects blues and violets.



<b>QA</b>	<a href="#">Quality Assessment</a>	Provides useful information for optimizing the value of pixels, identifying which pixels may be affected by surface conditions, clouds, or sensor conditions.
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## Index Information

Index Name	API Variable	Formula	Description
<b>Normalized Difference Vegetation Index (NDVI)</b>	NDVI	$NDVI = (NIR - Red) / (NIR + Red)$	NDVI is derived from readily available satellite imagery which is positively correlated with green vegetation cover
<b>Red-Green-Blue (RGB)</b>	RGB	Composite of red, green, and blue bands.	Color imagery, how the human eye would view something.
<b>Normalized Difference Water Index (NDWI)</b>	NDWI	$NDWI = (NIR - SWIR) / (NIR + SWIR)$	NDWI uses the NIR and SWIR bands to determine changes in water content
<b>Normalized Difference Buildup Index (NDBI)</b>	NDBI	$NDBI = (SWIR1 - NIR) / (SWIR1 + NIR)$	NDBI uses SWIR1 and NIR bands to determine urban areas
<b>Normalized difference Tillage Index (NDTI)</b>	NDTI	$NDTI = (SWIR1 - SWIR2) / (SWIR1 + SWIR2)$	Similarly, NDTI is also derived from satellite imagery but calculated with different bands. It is positively correlated with crop residue cover
<b>Urban Index (UI)</b>	UI	$UI = (SWIR2 - NIR) / (SWIR2 + NIR)$	UI uses SWIR2 and NIR bands to determine urban density
<b>Green Chlorophyll Vegetation Index (GCVI)</b>	GCVI	$GCVI = (NIR / GREEN) - 1$	Used to estimate the content of leaf chlorophyll in various species of plants
<b>MERIS-based Terrestrial Chlorophyll Index (MTCI)</b>	MTCI	$MTCI = (NIR_{Broad} - Red_{Edge_1}) / (NIR_{Broad} + Red)$	MTCI can be used to gauge chlorophyll content.





<b>Normalized Difference Red Edge (NDRE)</b>	NDRE	$\text{NDRE} = (\text{NIR} - \text{Red\_Edge\_1}) / (\text{NIR} + \text{Red\_Edge\_1})$	NDRE uses NIR and red edge bands to gauge late season plant health. Calculated using Red_Edge_1 based on wavelength used for NDRE calculation in <a href="#">this paper</a> (Carisse et al 2010).
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## Band Insertion Into RGB

Features can be isolated to stand out by loading different combinations of bands into the red, green, and blue channels. [Read more here.](#)

Combo Name	API Variable	Formula (R-G-B)	Description
<b>Traditional Color Infrared Image (CIR)</b>	CIR	NIR - Red - Green	Combination of colors within the visible spectrum with addition of NIR light; useful for determining pigments in vegetation.
<b>Urban Environment (UE)</b>	UE	SWIR2 - SWIR1 - Red	False Color useful for visualizing urban environments.
<b>Land and Water (LW)</b>	LW	NIR - SWIR1 - Red	False Color good for picking out land from water.
<b>Atmospheric Penetration (AP)</b>	AP	SWIR2 - NIR - Green	False color image with good atmospheric penetration.
<b>Agriculture (AGR)</b>	AGR	SWIR1 - NIR - Blue	False color for visualizing agricultural activity.
<b>Forest Fire Burn Scars (FFBS)</b>	FFBS	SWIR2 - NIR - Blue	False color often used for visualizing forest fire burn scars
<b>Bare Earth (BE)</b>	BE	SWIR1 - Green - Blue	False color for distinguishing differences in bare earth.



<b>Vegetation and Water (VW)</b>	VW	NIR - SWIR2 - Coastal Aerosol	False color for visualizing vegetation and water.
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## POST Response

*POST Response Example – application/json*

```
[{
  "tiledate": "09/23/2019-09/29/2019",
  "band": "NDVI",
  "download_url": "raster_bandNDVI_date2019266-2019272_20200611_141827_6340.tif",
  "features": [{
    "attributes": {
      "OID": 0,
      "Extent": "-101.03596423533554, 38.591014376083464, -101.02686423533554, 38.598114376083466",
      "Mean": 0.3157017763301112,
      "Max": 0.4369778211533957,
      "Min": 0.22988474901936115,
      "Std": 0.02079966053531458,
      "Percentile5": 0.2891595012773403,
      "Percentile95": 0.35072763128969403,
      "pngb64": "",
      "Legend": [{
        "color": "#ffaa00",
        "Min": 0.2759054317158133,
        "Max": 0.2989157730640393,
        "Mean": 0.28741060238992633,
        "Area": "24.09 %",
        "Count": 852,
        "CountAllPixels": 6436},
        {"color": "#ffff00",
        "Min": 0.2989157730640393,
        "Max": 0.3219261144122654,
        "Mean": 0.3104209437381523,
        "Area": "54.1 %",
        "Count": 3482,
        "CountAllPixels": 6436},
        {"color": "#ccff00",
        "Min": 0.3219261144122654,
        "Max": 0.3449364557604915,
        "Mean": 0.3334312850863784,
        "Area": "21.81 %",
        "Count": 1404,
        "CountAllPixels": 6436}],
      "CoordinateSystem": "GEOGCS[\"WGS 84\", DATUM[\"WGS_1984\", SPHEROID[\"WGS 84\", 6378137, 298.257223563, AUTHORITY[\"EPSG\", \"7030\"]], AUTHORITY[\"EPSG\", \"6326\"]], PRIMEM[\"Greenwich\", 0, AUTHORITY[\"EPSG\", \"8901\"]], UNIT[\"degree\", 0.0174532925199433, AUTHORITY[\"EPSG\", \"9122\"]], AUTHORITY[\"EPSG\", \"4326\"]], \"CellSize\": [0.00010000000000004023, -0.00010000000000001714], \"Matrix\": [71, 91]]],
      "Xcoordinates": "",
      "Ycoordinates": "",
      "Values": "",
      "error": "",
      "nodata_raster": false,
      "dayoftiles": "2019266-2019272",
      "week": "38"
    }
  ]
}]
```



## Response Parameters

Parameter	Data Type	Description
<b>download_url</b>	URL	URL to download result raster (.tif) file
<b>flattendtext</b>	-	An array of Xcoords, Ycoords values from the .tif files.
<b>tiledate</b>	Date (mm/dd/yyyy)	The tile dates from where the band values are retrieved.
<b>tilenames</b>	-	List of the Blob names from the Azure Storage Container.
<b>features</b>	-	An array of features from the database.
<b>features.attributes</b>		
<b>CellSize</b>	Resolution	Resolution of result Geotiff file in meters.
<b>CoordinateSystem</b>	-	Coordinate system of the result raster.
<b>Extent</b>	-	Extents of the result raster.
<b>Legend</b>	List	Legend gives ranges of values for: <b>Area:</b> Area covered in % <b>Count:</b> # of pixels from the result raster in range <b>CountAllPixels:</b> Total # of pixels in result <b>Max:</b> Maximum value in range <b>Min:</b> Minimum value in range <b>Mean:</b> Mean value in range <b>Color:</b> Hex color used for value ranges
<b>Matrix</b>	List	Rows and Columns.
<b>Max</b>	Number	Maximum value from the result raster
<b>Min</b>	Number	Minimum value from the result raster
<b>Mean</b>	Number	Average value from the result raster
<b>Percentile5</b>	Number	5th percentile value from result raster
<b>Percentile95</b>	Number	95th percentile value from result raster
<b>pngb64</b>	URL	base64png image of the result raster with legend entries



## GET Request

### Request Example

The GET request to retrieve the tif image using the file name from the POST response.

```
https://ag-analytics.azure-api.net/harmonized-landsat-sentinel-service/?filename=raster_bandNDVI_date2019203-2019209_20190807_174457_1233.tif
```

### Request Parameters

Parameter	Data Type	Required?	Default	Options	Description
<b>filename</b>	text	Yes	--	.tif file	file name returned by POST request

### Response Parameters

Parameter	Data Type	Description
<b>file</b>	.tif	Tiff file will be download to the computer of the caller with the name that was used to call the API.

## Supplementary Information

### Acronym Definitions

Parameter	Description
<b>MSI</b>	URL to download result raster (.tif) file
<b>HLS</b>	An array of Xcoords, Ycoords values from the .tif files.
<b>HDF</b>	The tile dates from where the band values are retrieved.
<b>GLS</b>	An array of features from the database.
<b>BRDF</b>	Bidirectional Reflectance Distribution Function
<b>NBAR</b>	Nadir BRDF-normalized Reflectance
<b>OLI</b>	Operational Land Imager



<b>SDS</b>	Scientific Data Sets
<b>SR</b>	Surface reflectance
<b>SZA</b>	Sun zenith angle
<b>UTM</b>	Universal Transverse Mercator
<b>WRS</b>	Worldwide Reference System

## Coefficients of Linear Regression

*Coefficients of linear regression used to adjust from Sentinel-2A,B/MSI to Landsat 8/OLI*

			Sentinel-2A		Sentinel-2B	
HLS Band Name	OLI Band Name	MSI Band Name	Slope	Offset	Slope	Offset
<b>Coastal Aerosol</b>	1	1	0.9959	-0.0002	0.9959	-0.0002
<b>Blue</b>	2	2	0.9778	-0.004	0.9778	-0.004
<b>Green</b>	3	3	1.0053	-0.0009	1.0075	-0.0008
<b>Red</b>	4	4	0.9765	0.0009	0.9761	0.001
<b>NIR</b>	5	8A	0.9983	-0.0001	0.9966	0.000
<b>SWIR 1</b>	6	11	0.9987	-0.0011	1.000	-0.0003
<b>SWIR 2</b>	7	12	1.003	-0.0012	0.9867	0.0004



## Projection Syntax Example

### Projection Syntax:

**projection:** projection of a new resampled raster. It may take the following forms:

1. Well Known Text definition
2. "EPSG:n"
3. "EPSGA:n"
4. "AUTO:proj\_id,unit\_id,lon0,lat0" - WMS auto projections
5. "urn:ogc:def:crs:EPSG::n" - ogc urns
6. PROJ.4 definitions
7. well known name, such as NAD27, NAD83, WGS84 or WGS72
8. "IGNF:xxxx", "ESRI:xxxx", etc. definitions from the PROJ database

### Projection Example:

"urn:ogc:def:crs:EPSG::n"

## Citations:

- [NASA Landsat Information](#)
- [ESA Sentinel Information](#)
  - [Sentinel Band Descriptions](#)
- [NASA HLS Information](#)
  - [HLS User Guide](#)
  - [HLS Data Descriptions](#)
- [RGB Band Insertion Source](#)
- [Usage of Red edge 1 for NDRE calculation](#)
- Spatial Reference Information: Universal Transverse Mercator (UTM)



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