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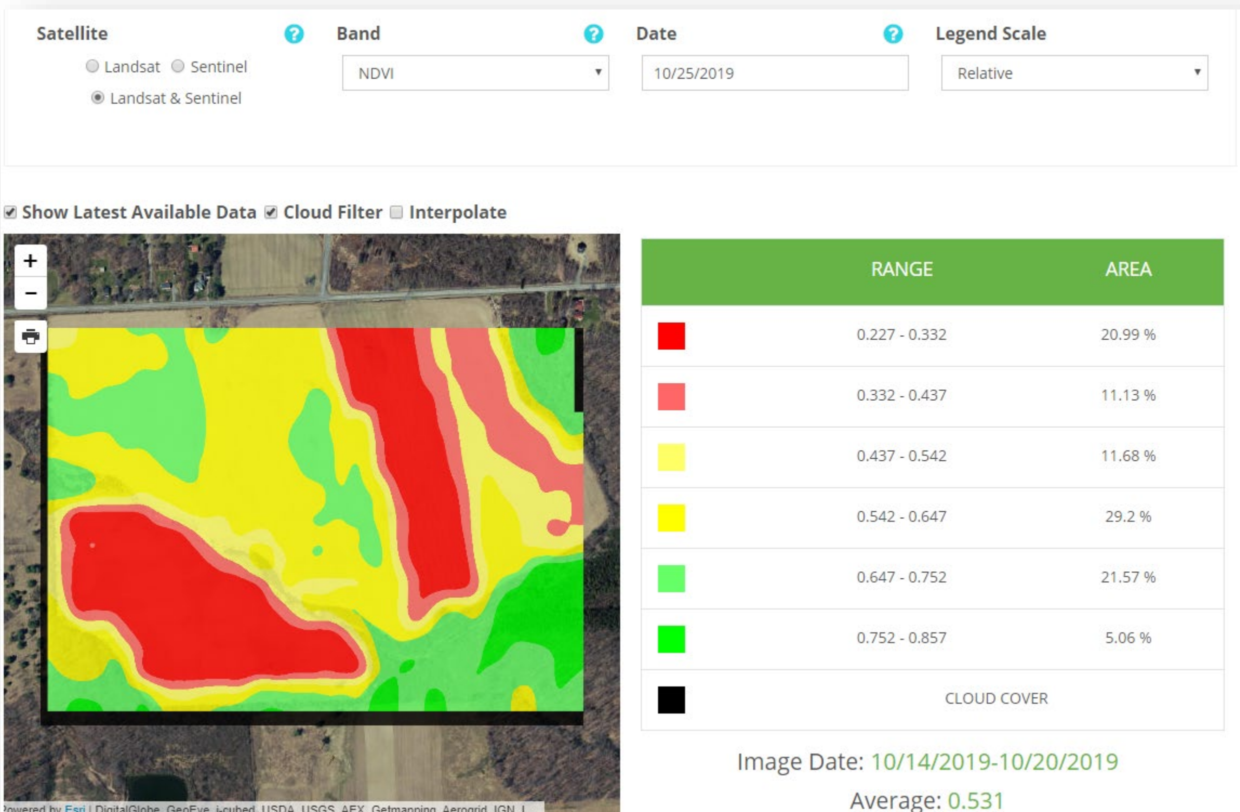
HARMONIZED LANDSAT-SENTINEL SERVICE

API Documentation
2019

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.



Harmonized Landsat-Sentinel Service used in FARMSCOPE® at analytics.ag, viewing NDVI data.

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

Indexes Formulas and Explanation

Normalized Difference Vegetation Index (NDVI)

NDVI is derived from readily available satellite imagery which is positively correlated with green vegetation cover.

Formula: NDVI = (NIR - Red) / (NIR + Red)

Normalized Difference Tillage Index (NDTI)

Similarly, NDTI is also derived from satellite imagery but calculated with different bands. It is positively correlated with crop residue cover.

Formula: NDTI= (SWIR1 - SWIR2) / (SWIR1 + SWIR2)

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.

    > ***When the interpolation option is chosen, the AOI will be a larger area (determined by the interpolation parameters) of the given field boundary. Otherwise, the AOI will be a rectangle polygon around the given AOI.*

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.

*(**when interpolation is chosen)*

Interpolation Function

Due to cloud cover, the original satellite images may have many gaps and can not 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.

Interpolation Algorithm Flow

1. Identify the missing parts of the image and find the contours of each gap.
2. Find the best candidates from similar sequences of images which have non-missing pixels to fill the largest part of a given gap.
3. Define an outline – a thin curve around each gap, then used for obtaining the linear transformation of the pixel intensity between the two images for each of the best candidates. The candidate image with the best linear fit of the outline is chosen.
4. To better-fit the area close to the outline, an intensity correction mask is then created by blurring the patch-intensity difference image.
5. The mask is applied to the gap area on the best candidate and generates an inpainted patch.
6. Finally, this inpainted patch is used to fill the gap in the image.

API Specifications

API: Here

Header Parameters

Execute Type: POST

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

Request Parameters

Parameter	Data Type	Required?	Default	Options	Description
AOI	Geometry, file/text	Yes	-	JSON, GEOJSON, Shapefile, Raster	See Fig. 2 for further explanation.
Band	List	Yes	-	Red, Green, Blue, Coastal Aerosol, NIR, SWIR1, SWIR2, QA, NDVI, RGB, NDWI, NDBI, NDTI, UI, CIR, UE, LW, AP, AGR, FFBS, BE, VW	Provide the list of HLS Spectral band names to retrieve for given AOI. See Figures 3-4.
Startdate	Date, mm/dd/yyyy	No	-	-	• Landsat – data starts from **2013** •Sentinel – data starts from **2015**
Enddate	Date, mm/dd/yyyy	No	-	-	In the absence of startdate or enddate, or both, the service retrieves the latest information available on the land.
byweek	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
satellite	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
showlatest	Int, boolean	No	1	-	If startdate or enddate is not given, shows the latest available tile.

filter	Int, boolean	No	0	0, 1	If set to 1, returns the response which is cloud-free after mosaic.
qafilter	Int, boolean	No	0	0, 1	If set to 1, continues to filter tiles until the invalid pixels are < **qacloudperc**
qacloudperc	float	No	100	0-100	This parameter comes to action with **qafilter**. If **qafilter** parameter is 1, then filters the tiles until the invalid pixels in those are < **qacloudperc**
displaynormalvalues	float	No	2000	-	This parameter is used to normalize the band values for display purposes. Used for bands like RGB, AGR, etc.
legendtype	text	No	Relative	Relative, Absolute	Legend type of display ranges of resulting response.
resolution	float	No	0.0001	-	Cellsize in meters.
flatten_data	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.
statistics	Int, boolean	No	1	0, 1	Returns statistical features of the output .tif file.
return_tif	int	No	1	0, 1	Returns the downloadable link to output raster. If 0, link will not be returned.
projection	text	No	Projection of AOI Given	**See Figure 5.**	Enter the desired projection for the result raster. See **Figure 5** for details.

Response Parameters

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

Figure 1.

Acronyms and Definitions

MSI Multi-Spectral Instrument	Multi-Spectral Instrument
HLS	Harmonized Landsat and Sentinel-2
HDF	Hierarchical Data Format
NIR	Near-Infrared
GLS	Global Land Survey
BRDF	Bidirectional Reflectance Distribution Function
NBAR	Nadir BRDF-normalized Reflectance
OLI	Operational Land Imager
QA	Quality assessment
SWIR	Short-wave Infrared
SDS	Scientific Data Sets
SR	Surface reflectance
SZA	Sun zenith angle
NDVI	Normalized Difference Vegetation Index
UTM	Universal Transverse Mercator
WRS	Worldwide Reference System

Figure 2.

AOI Structure Examples

JSON Example:

{"geometryType":"esriGeometryPolygon","features":[{"geometry":{"rings":[[[-92.678953,41.741707],[-92.678966,41.740563],[-92.678972,41.739963],[-92.67896,41.738874],[-92.686062,41.738873],[92.688546,41.738868],[-92.688544,41.739223],[-92.688555,41.743961],[-92.688124,41.743969],[-92.686658,41.744045],[-92.685481,41.74411],[-92.68513,41.744086],[-92.684627,41.743993],[92.684352,41.743833],[-92.683972,41.743603],[-92.683789,41.743476],[-92.683333,41.742983],[92.682923,41.742627],[-92.682497,41.742283],[-92.68213,41.742294],[-92.681444,41.742131],[92.680101,41.741842],[-92.679444,41.741817],[-92.679094,41.741713],[-92.678953,41.741707]]],"spatialReference":{"wkid":4326}}}]}

GEOJSON Example:

{"type":"Feature","geometry":{"type":"Polygon","coordinates":[[[-93.998809,41.993243],[-93.99873,41.988358],[94.001444,41.98838],[-94.00144,41.989089],[-94.003556,41.989116],[-94.003571,41.991767],[94.002054,41.991735],[-94.002086,41.993278],[-93.998809,41.993243]]]},"properties":{"OBJECTID":2038888,"CALCACRES":44.63000107,"CALCACRES2":null},"id":2038888}

Shapefile Example:

A Zip folder with following files [example.shp, example.prj, example.dbf, example.shx]

Raster Example:

A GeoTiff file of '.tif' extension

Figures 3-4.

Bands Information and Request Syntax

Figure 3.

HLS spectral bands nomenclature

Band name	OLI band number	MSI band number	HLS band code name L8	HLS band code name S2	L30 Subdataset number	S30 Subdataset number	Wavelength (micrometers)
Coastal Aerosol	1	1	band01	B01	01	01	0.43 – 0.45*
Blue	2	2	band02	B02	02	02	0.45 – 0.51*
Green	3	3	band03	B03	03	03	0.53 – 0.59*
Red	4	4	band04	B04	04	04	0.64 – 0.67*
Red-Edge 1		5		B05		05	0.69 – 0.71**
Red-Edge 2		6		B06		06	0.73 – 0.75**
Red-Edge 3		7		B07		07	0.77 – 0.79**
NIR Broad		8		B08		08	0.78 –0.88**
NIR Narrow	5	8A	band05	B8A	05	09	0.85 – 0.88*
SWIR 1	6	11	band06	B11	06	10	1.57 – 1.65*
SWIR 2	7	12	band07	B12	07	11	2.11 – 2.29*
Water vapor		9		B09		12	0.93 – 0.95**
Cirrus	9	10	band09	B10	08	13	1.36 – 1.38*
Thermal Infrared 1	10		band10		09		10.60 – 11.19*
Thermal Infrared 2	11		band11		10		11.50 – 12.51*
QA					11	14	

Figure 4.

The table below shows 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
CA	1	1	0.9959	-0.0002	0.9959	-0.0002
Blue	2	2	0.9778	-0.004	0.9778	-0.004
Green	3	3	1.0053	-0.0009	1.0075	-0.0008
Red	4	4	0.9765	0.0009	0.9761	0.001
NIR	5	8A	0.9983	-0.0001	0.9966	0.000
SWIR 1	6	11	0.9987	-0.0011	1.000	-0.0003
SWIR 2	7	12	1.003	-0.0012	0.9867	0.0004

Figure 5

Projection Syntax and 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
6. well known name, such as NAD27, NAD83, WGS84 or WGS72
7. "IGNF:xxxx", "ESRI:xxxx", etc. definitions from the   PROJ database
```

Projection Example:

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

Figure 6

Request Examples – form-data and urlencoded

form-data

application/json

```
{
Band: "['NDVI']"
Enddate: "3/8/2019"
Startdate: "3/2/2019"
aoi: "{"type":"Feature","geometry":{"type":"Polygon","coordinates":[[[-93.511545,42.0
71053],[93.511565,42.074566],[-93.50667,42.074588],[-93.501908,42.074559],[-93.501936
,42.071045],[-
93.511545,42.071053]]]},"properties":{"OBJECTID":3350330,"CALCACRES":77.09999847,"CAL
CACRES2":n
ull},"id":3350330}"
legendtype: "Relative"
satellite: "Landsat"
}
```

application/x-www-form-urlencoded

```
aoi=%7B%22type%22%3A%22Feature%22%2C%22geometry%22%3A%7B%22type%22%3A%22Polygon%22%2C
%22coordinates%22%3A%5B%5B%5B-101.02684%2C38.598114%5D%2C%5B-101.026842%2C38.597962%5
D%2C%5B-101.026956%2C38.59093%5D%2C%5B-101.028768%2C38.590943%5D%2C%5B-101.029234%2C3
8.590946%5D%2C%5B-101.035523%2C38.590991%5D%2C%5B-101.035526%2C38.590991%5D%2C%5B-101
.035564%2C38.590991%5D%2C%5B-101.035576%2C38.590991%5D%2C%5B-101.035595%2C38.590991%5
D%2C%5B-101.035956%2C38.590994%5D%2C%5B-101.035974%2C38.591099%5D%2C%5B-101.035957%2C
38.594349%5D%2C%5B-101.036017%2C38.598193%5D%2C%5B-101.035203%2C38.598193%5D%2C%5B-10
1.033665%2C38.598182%5D%2C%5B-101.031726%2C38.598158%5D%2C%5B-101.02684%2C38.598114%5
D%5D%5D%7D%2C%22properties%22%3A%7B%22OBJECTID%22%3A8091992%2C%22CALCACRES%22%3A156.1
000061%2C%22CALCACRES2%22%3Anull%7D%2C%22id%22%3A8091992%7D&satellite=Landsat%2CSenti
nel&Band=%5B'NDVI'%5D&filter=1&interpolate=1&showlatest=1&resolution=0.0001&statistic
s=1&Startdate=9%2F26%2F2019&Enddate=10%2F2%2F2019&legendtype=Relative
```

Figure 7

Response Examples – JSON and XML

JSON


```
[
    {
        "Values": "",
        "Xcoordinates": "",
        "Ycoordinates": "",
        "band": "NDVI",
        "dayoftiles": "2019280-2019286",
        "download_url": "downloads/raster_bandNDVI_date2019280-2019286_20191028_202045_9592.tif",
        "error": "",
        "features": [
            {
                "attributes": {
                    "CellSize": [
                        0.0003450919525318096,
                        -0.0003450919525320728
                    ],
                    "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\"]]",
                    "Extent": "-99.05607495139091, 44.071737897653954, -99.04675746867255, 44.076224093036
87",
                    "Legend": [
                        {
                            "Area": "5.13 %",
                            "Count": 18,
                            "CountAllPixels": 351,
                            "Max": 0.25481394966689086,
                            "Mean": 0.24510178002825062,
                            "Min": 0.2353896103896104,
                            "color": "#ff0000"
                        },
                        {
                            "Area": "58.69 %",
                            "Count": 206,
                            "CountAllPixels": 351,
                            "Max": 0.2742382889441713,
                            "Mean": 0.26452611930553105,
                            "Min": 0.25481394966689086,
                            "color": "#ff6666"
                        },
                        {
                            "Area": "28.21 %",
                            "Count": 99,
                            "CountAllPixels": 351,
                            "Max": 0.2936626282214518,
                            "Mean": 0.28395045858281154,
                            "Min": 0.2742382889441713,
                            "color": "#ffff66"
                        },
                        {
                            "Area": "4.27 %",
                            "Count": 15,
                            "CountAllPixels": 351,
                            "Max": 0.3130869674987322,
                            "Mean": 0.303374797860092,
```

```
                            "Min": 0.2936626282214518,
                            "color": "#ffff00"
                        },
                        {
                            "Area": "2.85 %",
                            "Count": 10,
                            "CountAllPixels": 351,
                            "Max": 0.3325113067760127,
                            "Mean": 0.32279913713737246,
                            "Min": 0.3130869674987322,
                            "color": "#66ff66"
                        },
                        {
                            "Area": "0.85 %",
                            "Count": 3,
                            "CountAllPixels": 351,
                            "Max": 0.35193564605329314,
                            "Mean": 0.3422234764146529,
                            "Min": 0.3325113067760127,
                            "color": "#00ff00"
                        }
                    ],
                    "Matrix": [
                        13,
                        27
                    ],
                    "Max": 0.35193564605329314,
                    "Mean": 0.27345243008865155,
                    "Min": 0.2353896103896104,
                    "OID": 0,
                    "Percentile5": 0.25480265232819305,
                    "Percentile95": 0.30446011009413093,
                    "Std": 0.015612864034601916,
                    "pngb64": "data:image/png;base64, iVBORw0KGgoAAAANSUhEUgAAABsAAAANCAYAAABYWxXTAAAAx0lE
QVR4nK2Uaw6EIAyEPwxnLWeil+3+EFDAouvuJCZOC52+NGCYIRxQqDzxHJn5Tu6PbNIJ/QH5wlYS2BppGTniY5CroJNPy1PEtJLz5U68z8
7lK5TYextXWb6B06UIQFCQm9ldLcDom7h25qONv8BpaUJISPMHM4wwnBqrHOe5QldlLWSPt6Xa11Ubv1mGablqZVpWv9kdQdU5yN1SpSLU
qBDz25k9qfZ0JgMRxP2OyU5Qz159VWioPoiJ5Serfwfv35iO9w9NyTh+0mirfQAAAABJRU5ErkJggg=="
                }
            }
        ],
        "nodata_raster": false,
        "tiledate": "10/07/2019-10/13/2019",
        "week": "40"
    }
]
```

XML

[{"Values":"","Xcoordinates":"","Ycoordinates":"","band":"NDVI","dayoftiles":"2019280-2019286","download_url":"downloads/raster_bandNDVI_date2019280-2019286_20191028_202045_9592.tif","error":"","features":[{"attributes":{"CellSize":[0.0003450919525318096,-0.0003450919525320728],"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\"]]","Extent":"-99.05607495139091, 44.071737897653954, -99.04675746867255, 44.07622409303687","Legend":[{"Area":"5.13 %","Count":18,"CountAllPixels":351,"Max":0.25481394966689086,"Mean":0.24510178002825062,"Min":0.2353896103896104,"color":"#ff0000"},{"Area":"58.69 %","Count":206,"CountAllPixels":351,"Max":0.2742382889441713,"Mean":0.2645261

1930553105,"Min":0.25481394966689086,"color":"#ff6666"},{"Area":"28.21 %","Count":99,"CountAllPixels":351,"Max":0.2936626282214518,"Mean":0.28395045858281154,"Min":0.2742382889441713,"color":"#ffff66"},{"Area":"4.27 %","Count":15,"CountAllPixels":351,"Max":0.3130869674987322,"Mean":0.303374797860092,"Min":0.2936626282214518,"color":"#ffff00"},{"Area":"2.85 %","Count":10,"CountAllPixels":351,"Max":0.3325113067760127,"Mean":0.32279913713737246,"Min":0.3130869674987322,"color":"#66ff66"},{"Area":"0.85 %","Count":3,"CountAllPixels":351,"Max":0.35193564605329314,"Mean":0.3422234764146529,"Min":0.3325113067760127,"color":"#00ff00"}],"Matrix":[13,27],"Max":0.35193564605329314,"Mean":0.27345243008865155,"Min":0.2353896103896104,"OID":0,"Percentile5":0.2548026523281930 5,"Percentile95":0.30446011009413093,"Std":0.015612864034601916,"pngb64":"data:image/png;base64, iVBORw0KGgoAAAANSUhEUgAAABsAAAANCAYAAABYWxXTAAAAx0lEQVR4nK2Uaw6EIAyEPwxnLWeil+3+EFDAouvuJCZOC52+NGCYIRxQqDzxHJn5Tu6PbNIJ/QH5wlYS2BppGTniY5CroJNPy1PEtJLz5U68z87lK5TYextXWb6B06UIQFCQm9ldLcDom7h25qONv8BpaUJISPMHM4wwnBqrHOe5QldlLWSPt6Xa11Ubv1mGablqZVpWv9kdQdU5yN1SpSLUqBDz25k9qfZ0JgMRxP2OyU5Qz159VWioPoiJ5Serfwfv35iO9w9NyTh+0mirfQAAAABJRU5ErkJggg=="}}],"nodata_raster":false,"tiledate":"10/07/2019-10/13/2019","week":"40"}]

References

Claverie, M., Ju, J., Masek, J. G., Dungan, J. L., Vermote, E. F., Roger, J.-C., Skakun, S. V., & Justice, C. (2018). The Harmonized Landsat and Sentinel-2 surface reflectance data set. Remote Sensing of Environment, 219, 145-161. (https://doi.org/10.1016/j.rse.2018.09.002).

Citation

Spatial Reference Information:

Universal Transverse Mercator (UTM) Dominant Zone, North American Datum 1983

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