Harmonized Landsat-8 Sentinel-2 (HLS)
Product User's Guide

Web site:

http://hls.gsfc.nasa.gov/

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1   Introduction

The combination of Landsat and Sentinel-2 data offers a unique opportunity to observe globally the land every 2-3 days at medium (<30m) spatial resolution. The Harmonized Landsat-Sentinel-2 (HLS) project is a NASA initiative to produce a consistent, harmonized surface reflectance product from Landsat and Sentinel-2 data.

In this context a "harmonized" reflectance product means that necessary radiometric, spectral, geometric, and spatial corrections have been applied to create a seamless time series, such that it is transparent to the user which sensor contributed any particular observation. It is also desirable that the harmonized products share a common gridding & tiling system, such that they are "stackable".

Note: current HLS products (as of June 2016) are _preliminary and unvalidated_.

2   Products overview

2.1   HLS processing flowchart

The processing (Figure 1) starts with orthorectified TOA reflectance data from Sentinel-2 (L1C) and Landsat-8 (L1T) and yields to three products: S10, S30 and L30.
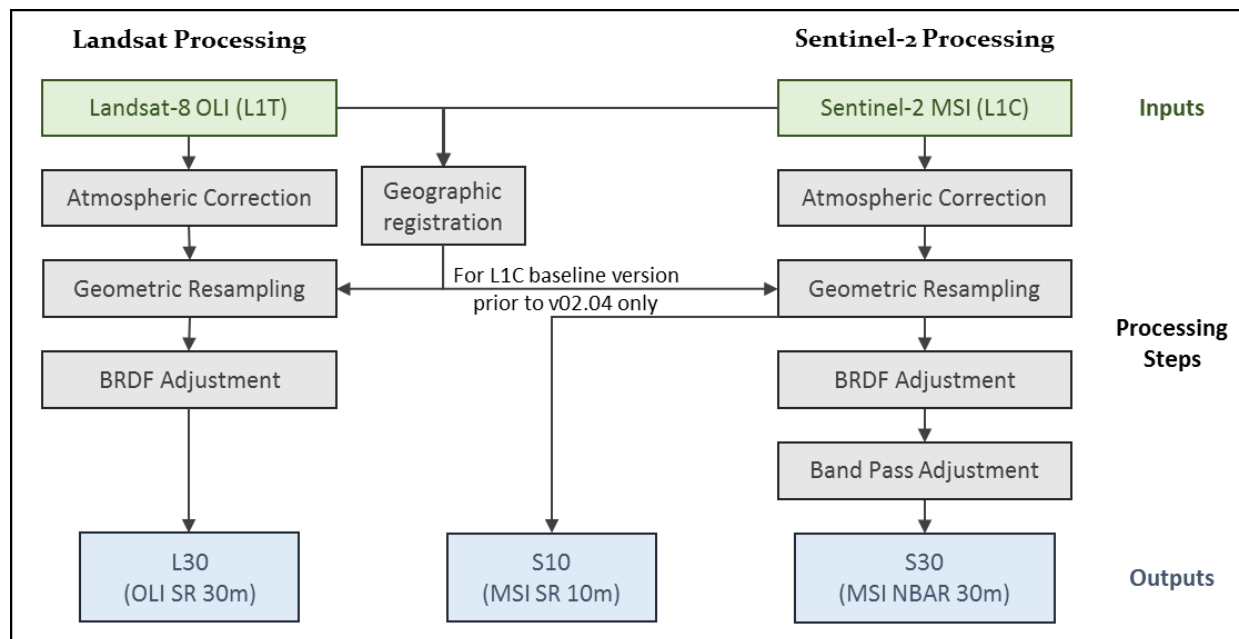

Figure 1: HLS science algorithm processing flow

2.2   Products specifications

The HLS suite contains three products:

- S10: MSI surface reflectance at full (native) resolutions (i.e. 10m, 20m and 60m).
- S30: MSI harmonized surface reflectance resampled to 30m using the Sentinel-2 MGRS tiling system.

    − L30: OLI harmonized surface reflectance and TOA brightness temperature resampled to 30m using the Sentinel-2 MGRS tiling system.

Note that the S30 and L30 products are gridded to the same resolution and tiling system, and thus are "stackable" for time series analysis.

Standard specifications are given in the Table 1.

Table 1: Products specifications

Product Name	S10	S30	L30
Input sensor	Sentinel-2A/B MSI	Sentinel-2A/B MSI	Landsat-8 OLI/TIRS
Spatial resolution	10-20-60m	30m	30m
BRDF-adjusted	No	Yes (except for bands 01, 05, 06, 07, 09, 10)	Yes
Bandpass-adjusted	No	OLI-like	No
Projection	UTM	UTM	UTM
Tiling system	MGRS (110*110)	MGRS (110*110)	MGRS (110*110)

2.3 Spectral bands

All Landsat-8 OLI and Sentinel-2 MSI reflective spectral bands are retained in the HLS products. Band 10 of Landsat-8 TIRS is reported in the L30, while band 11 is not because it is highly affected by a known stray light issue. HLS band numbers and code names are given in the Table 2.

Table 2: HLS spectral bands

Band name	OLI band number	MSI band number	HLS band code name	Wavelength (micrometers)
Coastal Aerosol	1	1	CA	0.43 - 0.45*
Blue	2	2	BLUE	0.45 - 0.51*
Green	3	3	GREEN	0.53 - 0.59*
Red	4	4	RED	0.64 - 0.67*
Red-Edge 1	-	5	RE1	0.69-0.71**
Red-Edge 2	-	6	RE2	0.73-0.75**
Red-Edge 3	-	7	RE3	0.77-0.79**
NIR Narrow	5	8A	NIR1	0.85 - 0.88*
NIR Broad	-	8	NIR2	0.78-0.88**
SWIR 1	6	11	SWIR1	1.57 - 1.65*
SWIR 2	7	12	SWIR2	2.11 - 2.29*
Water vapor	-	9	WV	0.93-0.95**
Cirrus	9	10	CIRRUS	1.36 - 1.38*
Thermal Infrared 1	10	-	TIRS1	10.60 - 11.19*

* from OLI specifications (may vary for S10 product which follow MSI specifications);
** from MSI specifications

2.4 Output Projection and Gridding

The HLS tiling system is identical to the one used for Sentinel-2. Tiles use the UTM projection, and are 109,800m on a side. There is an overlap of 4,900m on each side for adjacent tiles of the same UTM zone. The tiling system is aligned with the Military Grid Reference System (MGRS) and its naming

convention derived from the UTM (Universal Transverse Mercator) system. The UTM system divides the Earth's surface into 60 vertical zones. Each UTM zone has a horizontal width of 6° of longitude and vertical width of 8° of latitude, as shown in the map below. Each UTM zone is subdivided in 100x100km tiles. The first 2 digits in a tile name correspond to the UTM zone, the following 1 letter corresponds a 8° latitude band, and the two last letters to the tile location in the longitudinal and latitudinal directions respectively.

The kml edited by ESA with all tiles ID can be downloaded here. A text file with geographic coordinates of all tiles ID can be downloaded here.

3   Algorithms description

3.1   Spatial co-registration of input data

Landsat-8 and Sentinel-2 data have been found to not be accurately co-registered, due to small errors in the Landsat-8 ground reference system. Sentinel-2 L1C data with baseline processing version prior to v02.04 (v02.00, v02.01, v02.02) have also been found to not be accurately co-registered, affecting mostly cross-orbit temporal registration.

The Automated Registration and Orthorectification Package (AROP) for Landsat (Gao et al. 2009) was adapted for Sentinel-2 data processing, and is used to warp and co-register an image to a base image. Based on a large number of control points derived from cross-correlation of small areas, the package yields to the fit of a 1 degree polynomial equations system (eq. 1). This system is then used when applying the spatial resampling (section 3.6).

$$\begin{cases} x' = a_1 + a_2x + a_3y \\ y' = b_1 + b_2x + b_3y \end{cases}$$

(1)

Where (x,y) and (x',y') correspond to the coordinates of the original and the warped image, respectively, and $a_{1,2,3}$ and $b_{1,2,3}$ the AROP coefficients.

The NIR band (B5 for OLI and B8A for MSI) is used for the cross-correlation analysis. The base (reference) image is defined by the less cloudy Sentinel-2 data selected among the data with baseline processing version v02.04 and a spatial coverage higher than 70% of the tile. A unique image is selected per tile using data acquired prior December 31st, 2016.

The warped image corresponds to all Landsat-8 data and Sentinel-2 tiles with baseline processing version prior to v02.04.

3.2   Atmospheric correction

The atmospheric correction method is based on continuous ratio map algorithm developed by Eric Vermote (NASA GSFC). A full description of the algorithm and the evaluation and validation of Landsat-8 OLI surface reflectance product is presented in (Vermote et al. 2016).

3.3   Cloud mask related masks

Landsat-8 cloud, cloud-shadow, snow and water masks are derived from the atmospheric tool introduced in 3.2.

Sentinel-2 cloud, cloud-shadow, snow and water mask relies on the Fmask algorithm which has been adapted from (Zhu et al. 2015). Fmask is run on 20m-aggregated TOA reflectance.

3.4 View and illumination angles adjustment

The S30 and L30 reflectance products are adjusted for the view and illumination angles. A view angle is set to nadir and the illumination is set constant per tile depending on the latitude.

The c-factor global 12 month fixed BRDF technique, introduced by Roy et al. (2016), is used to perform the BRDF normalization. It consists of a unique set of BRDF coefficients, i.e., a constant BRDF shape, derived from a large number of pixels in the MODIS 500m BRDF product (MCD43) that are globally and temporally distributed (more than 15 billion pixels). The technique has been evaluated using ETM+ data off-nadir (i.e. on the overlap areas of adjacent swaths). The technique is applied on OLI and MSI bands equivalent to MODIS ones. Note that the nadir-adjustment with this technique and over these sensors has not been published yet. Only ETM+ equivalent bands are adjusted. BRDF coefficients for the three kernels (isotropic, volumetric and geometric) are shown in the Table 3. The kernels definition is described in the ATBD of MOD43 product (Strahler et al. 1999).

Table 3: BRDF coefficients used for the c-factor approach (Roy et al. 2016)

MODIS band	f_{iso}	f_{geo}	f_{vol}	Equivalent HLS code name
1 (red)	0.169	0.0227	0.0574	RED
2 (NIR)	0.3093	0.033	0.1535	NIR1, NIR2
3 (blue)	0.0774	0.0079	0.0372	BLUE
4 (green)	0.1306	0.0178	0.058	GREEN
6 (1.6µm)	0.343	0.0453	0.1154	SWIR1
7 (2.1µm)	0.2658	0.0387	0.0639	SWIR2

$$\rho(\lambda, \theta^{Norm}) = c(\lambda) \times \rho(\lambda, \theta^{sensor}) \tag{2}$$

$$c(\lambda) = \frac{f_{iso}(\lambda) + f_{geo}(\lambda) \times K_{geo}(\theta^{Norm}) + f_{vol}(\lambda) \times K_{vol}(\theta^{Norm})}{f_{iso}(\lambda) + f_{geo}(\lambda) \times K_{geo}(\theta^{sensor}) + f_{vol}(\lambda) \times K_{vol}(\theta^{sensor})} \tag{3}$$

Where: $\quad \theta^{Norm} \Leftrightarrow (\theta_v = 0, \theta_s = \theta_s^{out}, \Delta\varphi = 0)$

$\quad\quad\quad\quad \theta_{sensor} \Leftrightarrow (\theta^{sensor} = \theta_v^{sensor}, \theta_s = \theta_s^{sensor}, \Delta\varphi = \Delta\varphi^{sensor})$

OLI and MSI equator crossing time are close, respectively, 10:00AM and 10:30AM. Following findings of Zhang et al. (2016), a constant sun zenith angle (SZA) per location, named θ_s^{out}, was derived. The SZA follow a 6th degree polynomial as a function of the latitude. The polynomial was calibrated using Landsat-8 archive (Figure 2). A single θ_s^{out} value per tile is defined based on the tile central latitude and eq. 4 (where k_i values are given in Table 4). Consequently, the output SZA for S30 and L30 products varies spatially but not temporally.

$$\theta_s^{out} = \sum_{i=0}^{6} k_i \times Lat^i \tag{4}$$

Table 4: Polynomial coefficient to retrieve the mean sun zenith angle (SZA) as a function of the central latitude (eq. 4)

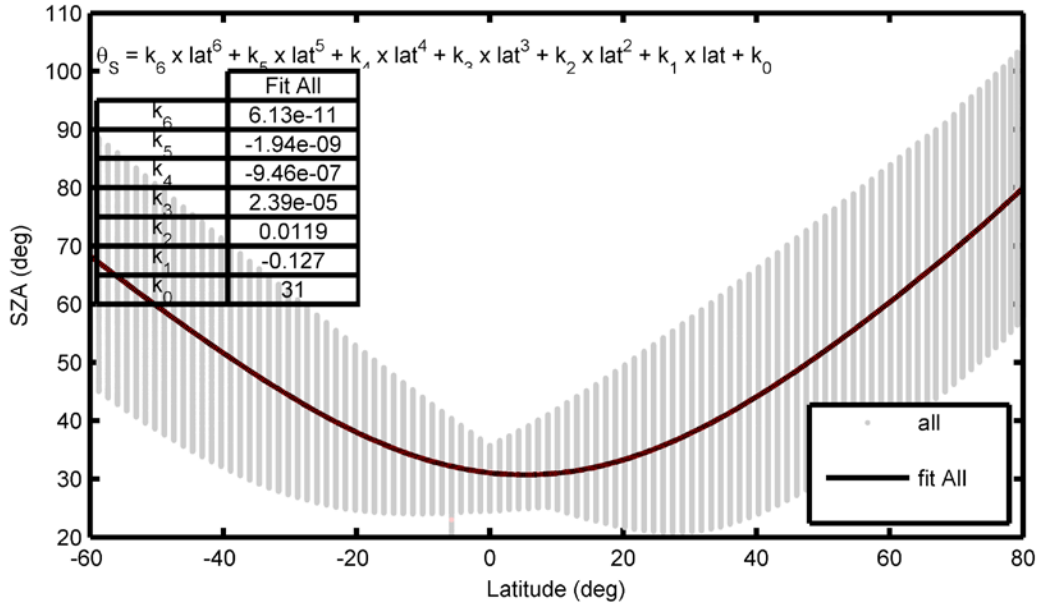| k0	k1	k2	k3	k4	k5	k6
31.0076	-0.1272	0.01187	2.40E-05	-9.48E-07	-1.95E-09	6.15E-11

Figure 2: sun zenith angle (SZA) and central latitude of all the scenes of the Landsat-8 archive. The line corresponds to the overall fit using a 6th degree polynomial.

3.5 Bandpass adjustment

The small differences between MSI and OLI equivalent spectral bands need to be adjusted. The bandpass adjustment is a linear fit between equivalent spectral bands. The slope and offset coefficients were computed based on 500 hyperspectral spectra selected on 160 Hyperion scenes globally distributed processed at surface reflectance level (Figure 3). The coefficients are shown in the Table 5.
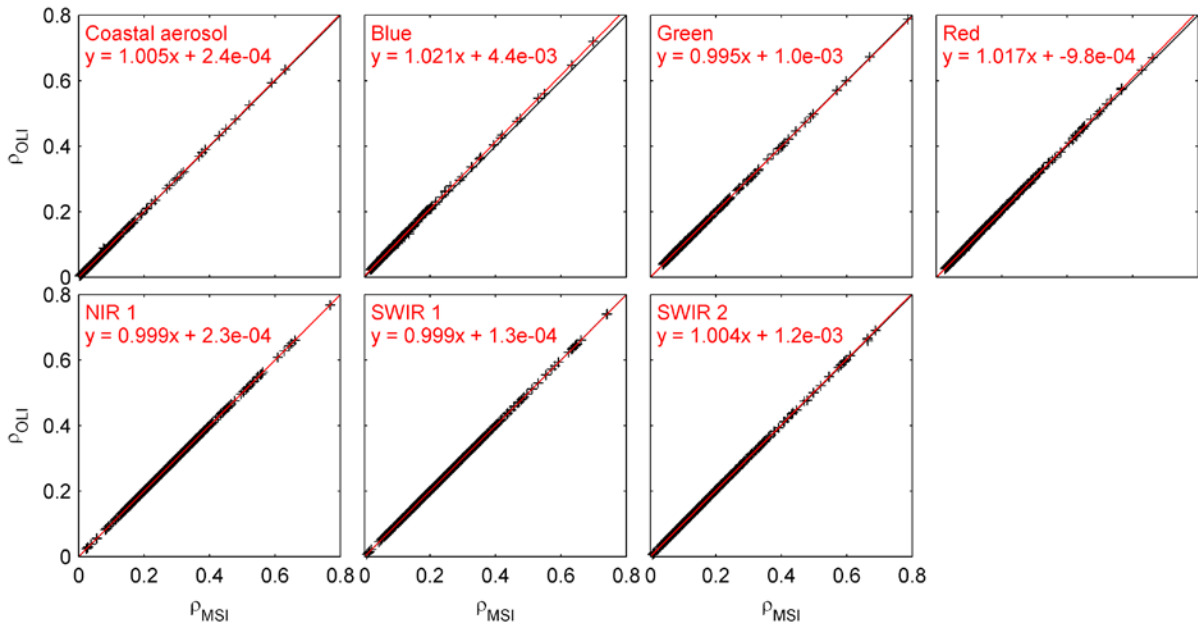

Figure 3: MSI vs OLI surface reflectance for the seven equivalent bands, using a synthetic dataset built with 500 surface reflectance spectra from Hyperion.

$$\rho_{OLI} = a \times \rho_{MSI} + b \tag{5}$$

Table 5: Bandpass adjustment coefficients

HLS Band name	OLI band number	MSI band number	Slope (a)	Intercept (b)
CA	1	1	1.005	2.09E-04
BLUE	2	2	1.020	4.47E-03
GREEN	3	3	0.994	1.09E-03
RED	4	4	1.017	-1.04E-03
NIR1	5	8A	0.999	2.50E-04
SWIR1	6	11	0.999	1.24E-04
SWIR2	7	12	1.003	1.19E-03

3.6   Spatial resampling

HLS products are resampled over the MGRS grid. Depending on the product, several resampling methods are utilized.

S10 - Sentinel-2 full resolution

S10 products are processed and delivered at full spatial resolution. No resampling is used.

S30 - Sentinel-2 at 30m

Following resampling methods are used depending on the spatial resolution of the S10 data:

- S10 10m bands are resampled to 30m using a boxcar method,
- S10 20m bands are resampled to 30m using an area weighted average method,
- S10 60m bands are resampled to 30m using a nearest neighbor method (i.e., split).

L30 - Landsat-8 gridded over the MGRS tiling system

Due to the spatial shift observed between Landsat-8 and Sentinel-2 data, AROP was used for registering L30 products to S30 products. Following resampling methods are used depending on the input L2A data (i.e. Landsat-8 surface reflectance in WRS grid):

- transform UTM coordinates of each pixel using AROP polynomial regression (eq. 1),
- If Landsat-8 and MGRS tile have different UTM zone, transformed Landsat-8 UTM coordinates of each pixel are converted to MGRS tile UTM coordinates.
- Retrieve the gridded value in the MGRS grid using a cubic convolution method.

Note on the QA layer resampling

QA layers are created during the atmospheric correction processing, performed at 20m over the MGRS grid for Sentinel-2 and at 30m over the WRS path-row grid for Landsat. The resample of the QA is performed per information (i.e. for each bit). Depending on the product type, different strategy is used:

- S10: A simple nearest neighbor method (i.e., split) from 20m to 10m is used.
- S30: 10m QA are resampled to 30m using a boxcar method. S30 pixel bit value is set to 0 if only all the nine S10 pixels bit values are set to 0.
- L30: using a 2x2 window (i.e., 4 closest pixels), the L30 pixel bit value is set to 0 if only at least 3 pixels bit values are set to 0. If 2 or more pixel bit value is set to 1, the L30 pixel bit value is set to 1.

4 Selected regions

Sixty-three regions (Figure 4) were selected, corresponding to a total of 747 MGRS tiles. These tiles overlap with a total of 630 Landsat WRS-2 path-row. The list of the regions and the corresponding MGRS tiles can be downloaded here.

Table 6: List of regions and associated codes

Code	Region Name	Code	Region Name	Code	Region Name
ABI	Abisko	HE2	Heilongjiang-2	REA	Rosemount Agri Exp [3]
ALB	Albuera Dehesa	HVF	Harvard Forest	RUS	Russel Sage
BAH	Bahia	IND	Odisha | West Bengal	SA	South Africa
BAR	Bartlett	ISP	Ispra	SC	South Carolina
BGD	Chittagong	KS	Kansas	SCR	Santa Cruz
BIT	Bitterroot Valley	LAH	Lahore	SEA	SE
CAA	Caagazú	LCW	Least Chub Wetland	SHA	Shandong
CAB	Cabauw	LET	Lethbridge	SKU	Skukuza
CEN	Central Plains Exp [1]	MAR	Marocco	SLT	Sevilleta Research site [4]
COL	Columbus	MAU	Maun	SOD	Sodankyla
COW	Coweeta	MBO	Monte Bondone	STA	Staffordshire
CRA	Carpentras-La Craux	MEZ	Mezaira	TOR	Toravere
DAH	Dahra field site	MMR	Myanmar [2]	TUC	Tucumán
DE	Germany	MON	Mongu	TZ	Tanzania
DEP	Delmarva Peninsula	NOR	Norunda	UIE	U of Ill. Energy Farm
EVE	Everglades	OSR	OSR	UMB	U of Mich. Biological Station
FAJ	Fajemyr	PAM	Pampas	VAI	Vaira Ranch
FTB	Fontainebleau	PAY	Paysandú	VMD	Mekong
GDS	Great Dismal Swamp	POK	Pokhara	VRR	Red River
HBB	Hubbard Brook	PPR	Prarie Pothole Region	WNU	Gangneung_WNU
HE1	Heilongjiang-1	PUN	Punjab	YAK	Yakutsk-Larch

[1] Central Plains Experimental Range

[2] Myanmar | Magway | Ayeyarwady | Bago | Yangon | Mandalay

[3] Rosemount Agricultural Experiment Station

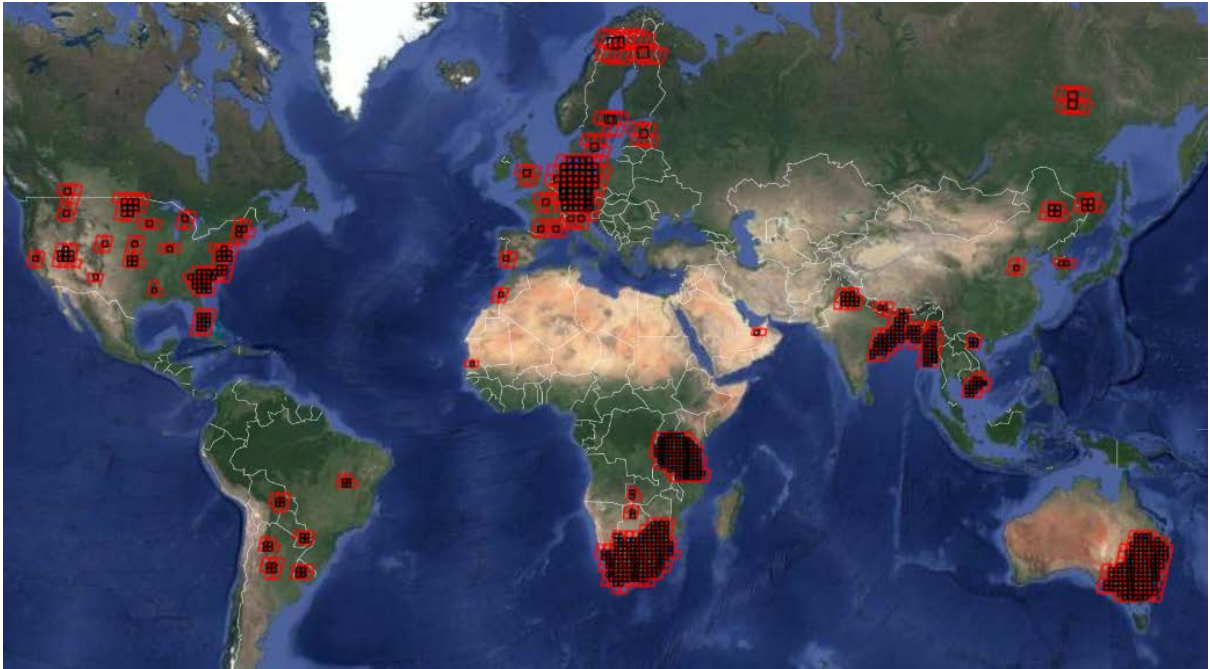[4] Sevilleta Long Term Ecological Research site

Figure 4: Map of the 63 regions with the 747 MGRS tiles footprint (black) and the 630 Landsat WRS-2 path-row (red). Get an interactive map [here](#).

5 Products formats

5.1 Files format

HLS products are stored in Hierarchical Data Format (HDF)-4 compressed format. Each HDF data file is associated with an ENVI header file containing georeference information.

5.2 S10

The product S10 contains MSI surface reflectance at full spatial resolution. Table 6 lists all the Scientific Data Sets (SDS) of the S10 product.

Table 7: list of the SDS of the S10 product (SR = Surface Reflectance, TOA Refl. = Top of Atmosphere Reflectance)

SDS layer Name	MSI band number	Data type	Scale	Unit	Spatial Resolution	Description
CA	1	int16	0.0001	unitless	60	SR
BLUE	2	int16	0.0001	unitless	10	
GREEN	3	int16	0.0001	unitless	10	
RED	4	int16	0.0001	unitless	10	
RE1	5	int16	0.0001	unitless	20	
RE2	6	int16	0.0001	unitless	20	
RE3	7	int16	0.0001	unitless	20	
NIR1	8A	int16	0.0001	unitless	20	
NIR2	8	int16	0.0001	unitless	10	
SWIR1	11	int16	0.0001	unitless	20	

SWIR2	12	int16	0.0001	unitless	20	
WV	9	int16	0.0001	unitless	60	TOA Refl.
CIRRUS	10	int16	0.0001	unitless	60	
QA		int8			10	QA

5.3 S30

The product S30 contains MSI surface reflectance at 30m spatial resolution. Table 7 lists all the SDS of the S30 product.

Table 8: list of the SDS of the S30 product (SR = Surface Reflectance, NBAR = Nadir BRDF-Adjusted Reflectance, TOA Refl. = Top of Atmosphere Reflectance)

SDS layer Name	MSI band number	Data type	Scale	Unit	Spatial Resolution	Description
CA	1	int16	0.0001	unitless	30	SR
BLUE	2	int16	0.0001	unitless	30	
GREEN	3	int16	0.0001	unitless	30	NBAR
RED	4	int16	0.0001	unitless	30	
RE1	5	int16	0.0001	unitless	30	
RE2	6	int16	0.0001	unitless	30	SR
RE3	7	int16	0.0001	unitless	30	
NIR1	8A	int16	0.0001	unitless	30	
NIR2	8	int16	0.0001	unitless	30	NBAR
SWIR1	11	int16	0.0001	unitless	30	
SWIR2	12	int16	0.0001	unitless	30	
WV	9	int16	0.0001	unitless	30	TOA Refl.
CIRRUS	10	int16	0.0001	unitless	30	
QA		int8			30	QA

5.4 L30

The product L30 contains Landsat-8 OLI surface reflectance and TOA TIRS brightness temperature gridded at 30m spatial resolution over the MGRS tiling system. Table 8 lists all the SDS of the L30 product.

Table 9: list of the SDS of the L30 product (SR = Surface Reflectance, NBAR = Nadir BRDF-Adjusted Reflectance, TOA Refl. = Top of Atmosphere Reflectance, TOA BT = Top of Atmosphere Brightness temperature)

SDS layer Name	OLI band number	Data type	Scale	Unit	Spatial Resolution	Description
CA	1	int16	0.0001	unitless	30	NBAR
BLUE	2	int16	0.0001	unitless	30	
GREEN	3	int16	0.0001	unitless	30	
RED	4	int16	0.0001	unitless	30	
NIR1	5	int16	0.0001	unitless	30	
SWIR1	6	int16	0.0001	unitless	30	
SWIR2	7	int16	0.0001	unitless	30	
CIRRUS	9	int16	0.0001	unitless	30	TOA Refl.
TIRS1	10	int16	0.01	°C	30	TOA BT
QA		int8			30	QA

5.5 Quality Assessment layers

Quality assessment (QA) SDS of the 3 products follows the same bit structure described in Table 9.

Table 10: Bit ordering of the Quality Assessment layer for the 3 products. Bits are listed from the MSB (bit 7) to the LSB (bit 0)

Bit number	QA description	S10	S30	L30
7-6	Aerosol Quality 00 - climatology 01 - low 10 - average 11 - high	Not used	Not used	used
5	water	Used	Used	Used
4	snow/ice	Used	Used	Used
3	cloud shadow	Used	Used	Used
2	adjacent cloud	Not used	Not used	Used
1	cloud	Used	Used	Used
0	cirrus	Used	Used	Used

5.6 Metadata dictionary

Metadata are encapsulated in the HDF file and can be extracted using nchdfdump command line. The metadata fields are:

Input[1]

- SENSOR: Input Sensor [S10/L30]
- TILE_ID: Tile directory name in the SAFE file [S30/S10]
- DATASTRIP_ID: Datastrip name in the SAFE file [S30/S10]

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[1] For L30 products, some metadata field may have two values due to the use of two Landsat-8 scenes as inputs.

- <u>LANDSAT_SCENE_ID</u>: Landsat-8 scene ID name [L30]
- <u>HORIZONTAL_CS_NAME</u>: HLS Projection name [S30/S10/L30]
- <u>HORIZONTAL_CS_CODE</u>: HLS Projection code [S30/S10]
- <u>TIRS_SSM_MODEL</u>: TIRS SSM encoder position model (Preliminary, Final or Actual) see http://landsat.gsfc.nasa.gov/?p=12294 [L30]
- <u>TIRS_SSM_POSITION_STATUS</u> [L30]
- <u>L1C_IMAGE_QUALITY</u>: Sentinel-2 L1C product quality control, including the following quality controls: "SENSOR", "GEOMETRIC", "GENERAL", "FORMAT" and "RADIOMETRIC", related to the following value: "PASSED" or "FAILED". The "NONE" metadata value means all quality controls were set to PASSED [S30]
- <u>SENSING_TIME</u> [S30/S10/L30]
- <u>L1_PROCESSING_TIME</u>: L1C/L1T Processing date [S30/S10/L30]
- <u>PROCESSING_BASELINE = "02.04" ;</u>
- <u>USGS_SOFTWARE = "LPGS_2.6.2" ;</u>

Product_Info

- <u>NROWS</u>: Number of rows [S30/S10/L30]
- <u>NCOLS</u>: Number of columns [S30/S10/L30]
- <u>SPATIAL_RESOLUTION:</u> HLS spatial resolution in meter [S30/S10/L30]
- <u>ULX</u>: X-coordinate of the Upper-left corner of the Upper-left pixel [S30/S10/L30]
- <u>ULY</u>: Y-coordinate of the Upper-left corner of the Upper-left pixel [S30/S10/L30]
- <u>HLS_PROCESSING_TIME</u>: HLS Processing date and time [S30/S10/L30]
- <u>spatial_coverage</u>: Percentage of HLS tile with data [S30/S10]
- <u>cloud_coverage</u>: Percentage of HLS tile (excluding no-data) with cloud [S30/S10]

Angles

- <u>MEAN_SUN_ZENITH_ANGLE</u>: Mean Sun Zenith Angle in degree of the input data [S30/S10/L30]
- <u>MEAN_SUN_AZIMUTH_ANGLE</u>: Mean Sun Azimuth Angle in degree of the input data [S30/S10/L30]
- <u>MEAN_VIEW_ZENITH_ANGLE</u>: Mean View Zenith Angle in degree of the input data [S30/S10]
- <u>MEAN_VIEW_AZIMUTH_ANGLE</u>: Mean View Azimuth Angle in degree of the input data [S30/S10]
- <u>NBAR_Solar_Zenith</u>: Mean Sun Zenith Angle in degree of the HLS product after BRDF-adjustment [S30/L30]
- AngleBand = '\0', '\1', '\2', '\3', '\4', '\5', '\6', '\7', '\10', '\11', '\12', '\13', '\14' ;

Geometric Coregistration

- <u>arop_s2_refimg</u>: S10 product name used as based image for AROP [L30/S30]
- <u>AROP_ncp</u>: Number of control point found by AROP [L30/S30]
- <u>arop_ave_xshift(meters)</u>: Average X-shift in meter computed over the HLS tile [L30/S30]
- <u>arop_ave_yshift(meters)</u>: Average Y-shift in meter computed over the HLS tile [L30/S30]

5.7   File naming

Each tile is stored in a single HDF file. File naming convention follows:

HLS.<HLS_Product>.T<Tile_ID>.<year><doy>.v<version_number>.hdf

Where,

- *<HLS_Product>* is the HLS product type (S10, S30 or L30) [3 digits]
- *<Tile_ID>* is the MGRS Tile ID [5 digits]
- *<Year>* is the sensing time year [4 digits]
- *<Doy>* is the sensing time day of year [3 digits]
- *<Version_number>* is the HLS version number (e.g., 1.2, major and minor changes reflected in the first and second digits respectively) [3 digits]

5.8   Products access and directories structure

S10, S30 and L30 files are stored in the NASA NEX facility in the following directory:

/nobackuppp6/jju/HLS_LOCAL_IO.v1.2/

S30 and L30 files are also stored in a public FTP:

ftp://hls.gsfc.nasa.gov/pub/data/v1.2/

In both storage location, files are stored in a hierarchical directory structure designed as follow:

./<Region>/<HLS_Product>/<year>/<Tile_ID>/

Where,

- *<Region>* is the Region code as defined in Table 6 [2 or 3 digits]
- *<HLS_Product>* is the HLS product type (S10, S30 or L30) [3 digits]
- *<Year>* is the sensing time year [4 digits]
- *<Tile_ID>* is the MGRS Tile ID [5 digits]

6   Quality Assessment

An evaluation of the S30 and L30 products has been applied. It follow the methodology of the cross-comparison of surface reflectance with MODIS MOD09CMG products involving BRDF and spectral adjustment (Claverie et al. 2015). The results are gathered in a table located here and individual QA graphics are linked in the table (Figure 5). Quick-look figures are also produced for each L30 and S30 products at 30m spatial resolution and at 120m spatial resolution (Figure 6).
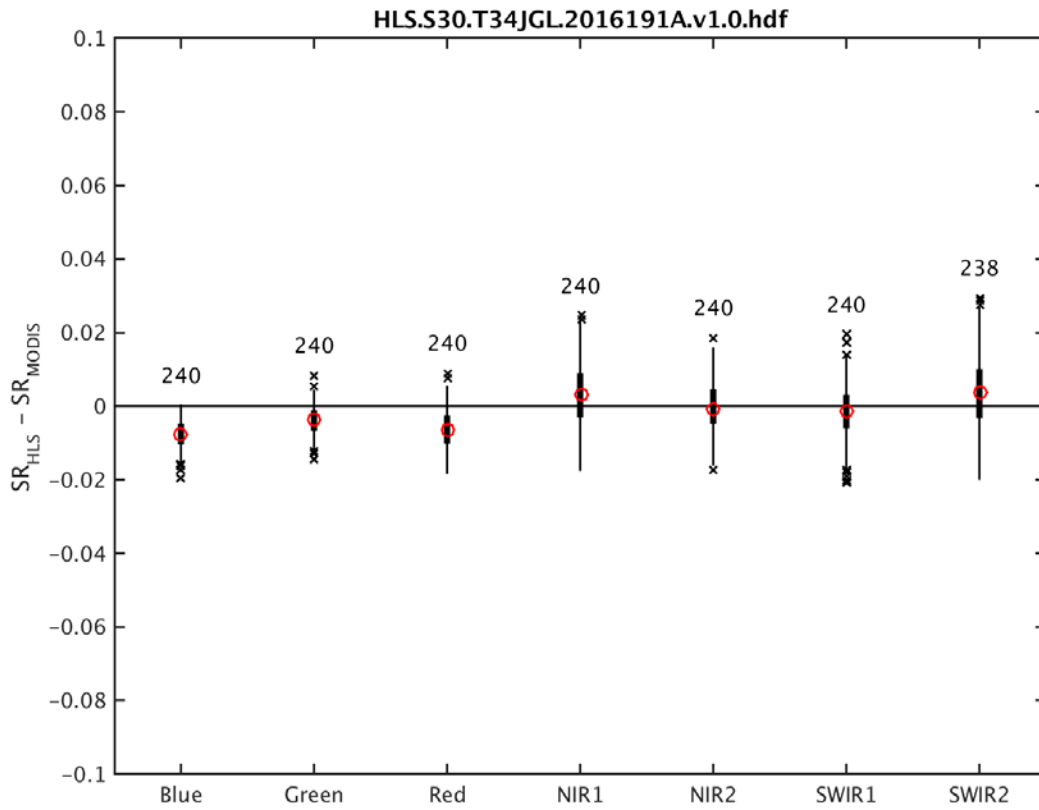
Figure 5: QA of a sample S30 product. Boxplots show for each spectral band, the deviation between HLS and MODIS surface reflectance. The number at the top of the bar corresponds to the number of used CMG pixels.
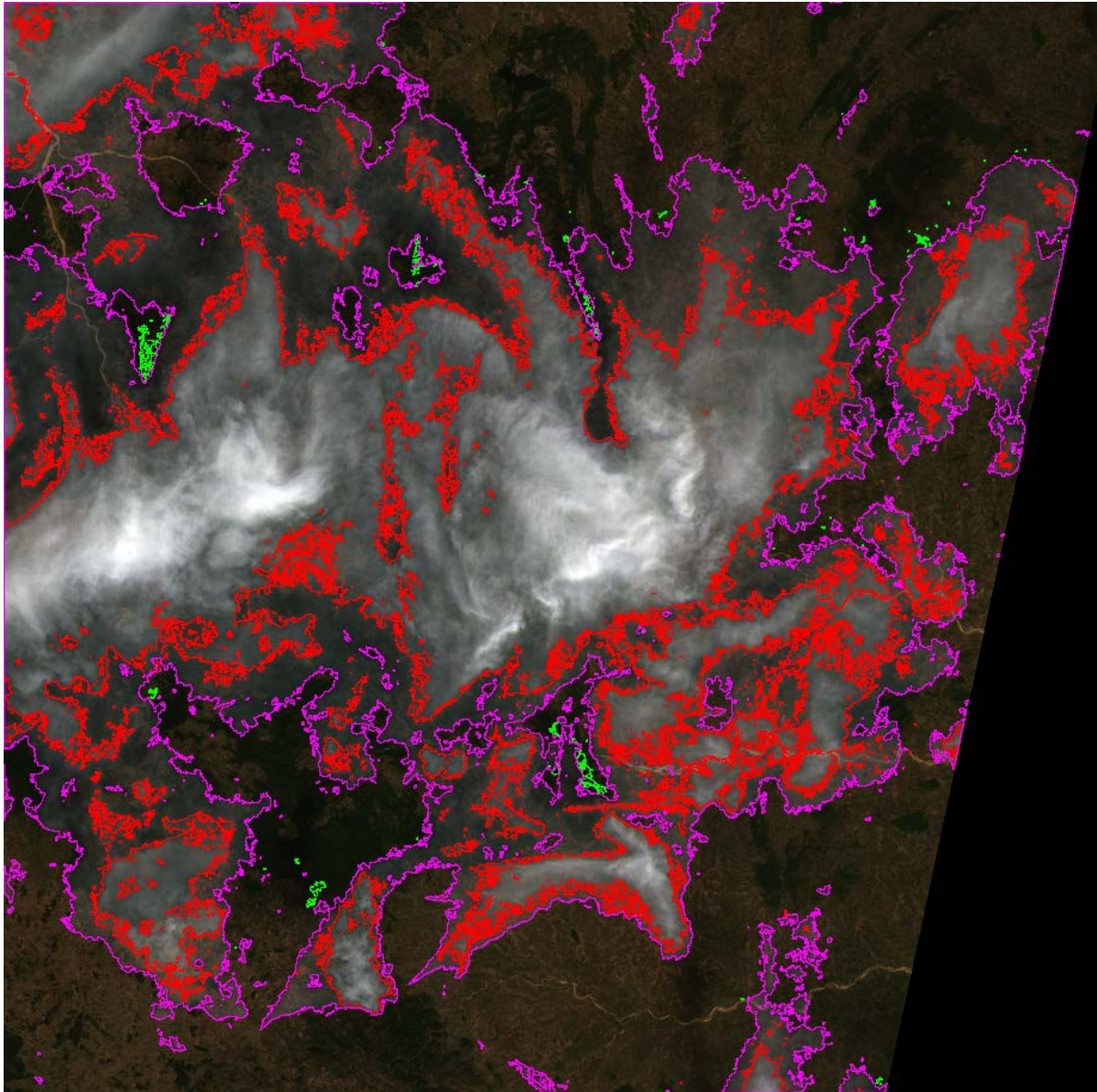
Figure 6: Quick-look of a sample S30 product. Water bodies are delineated with blue lines, snow with yellow, cloud with red, cirrus clouds with magenta, and shadow with green.

7 Known issues

−　　　Sentinel-2 atmospheric correction, although improved, has not yet implemented the operational Landsat-8 aerosol interpolation scheme. As a result, some blockiness and "pinholes" may occur in SR images;

−　　　Fmask for Sentinel-2 can generate erroneous results, particularly for hazy conditions, think clouds, cloud edges, and bright urban areas. Distinction between snow and cloud pixels can be unaccurate due to the lack of thermal data.

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