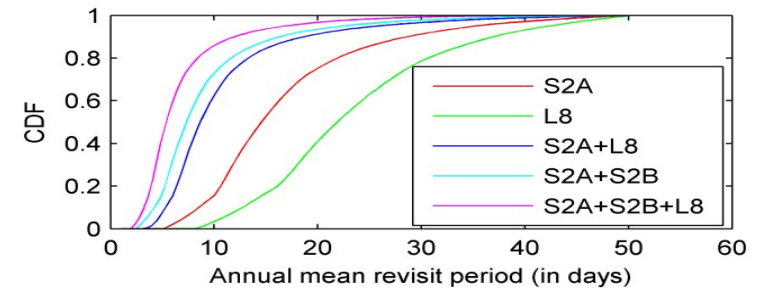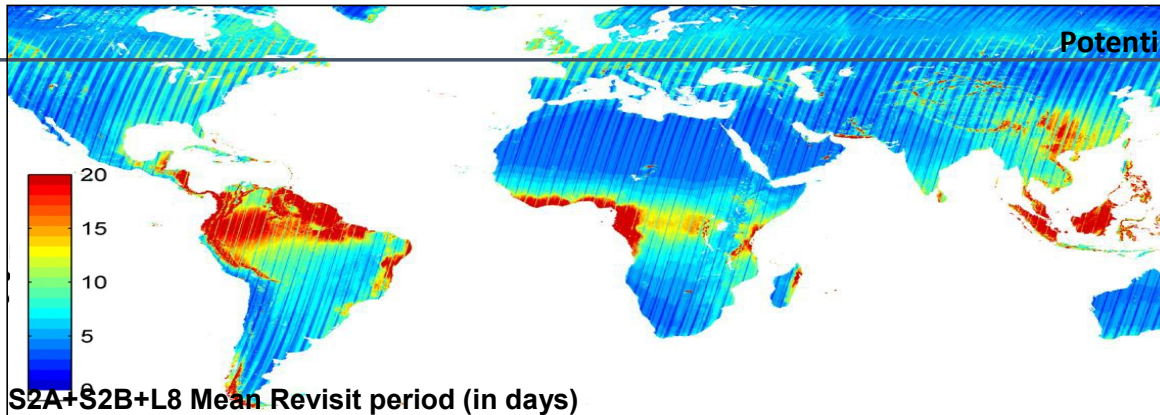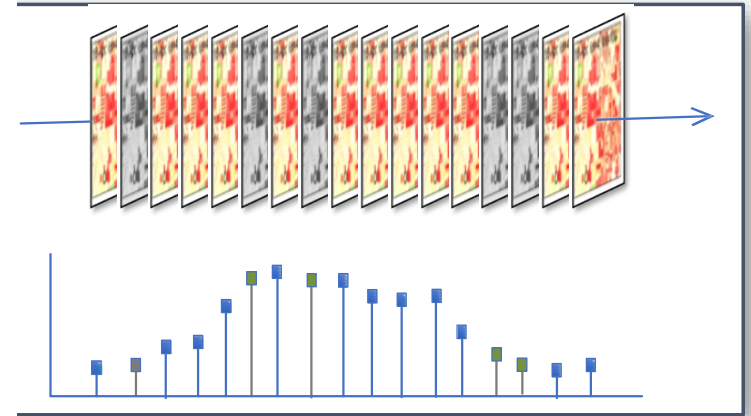# NASA MuSLI Program

- NASA Multi-Source Land Imaging (MuSLI) Team is a research program designed to advance use of multi-source remote sensing data for land monitoring
  - Solicited 2014 through NASA Land Cover/Land Use Change Program
  - Three-year projects (2015-17)
  - Re-competed in 2017 for second three year cycle

- Objectives:
  - **Develop algorithms and prototype products** that make use of multiple satellite sources & time series approaches
    - *Focus on Landsat and Sentinel-1 & 2*
    - *Focus on evolving continental-scale products analogous to what is available from MODIS, but at moderate resolution (<100m)*
  - Understand challenges associated with algorithms & processing streams that incorporate multiple satellite systems
  - Develop stronger community of practice among US and international (especially EU) researchers

Harmonized Landsat Sentinel-2 (HLS) Project

- Merging Sentinel-2 and Landsat data streams can provide **2- 3 day global coverage**

- Goal is "seamless" near-daily 30m surface reflectance record including atmospheric corrections, spectral and BRDF adjustments, regridding

- Project initiated in 2012 as collaboration among NASA GSFC, UMD, NASA Ames

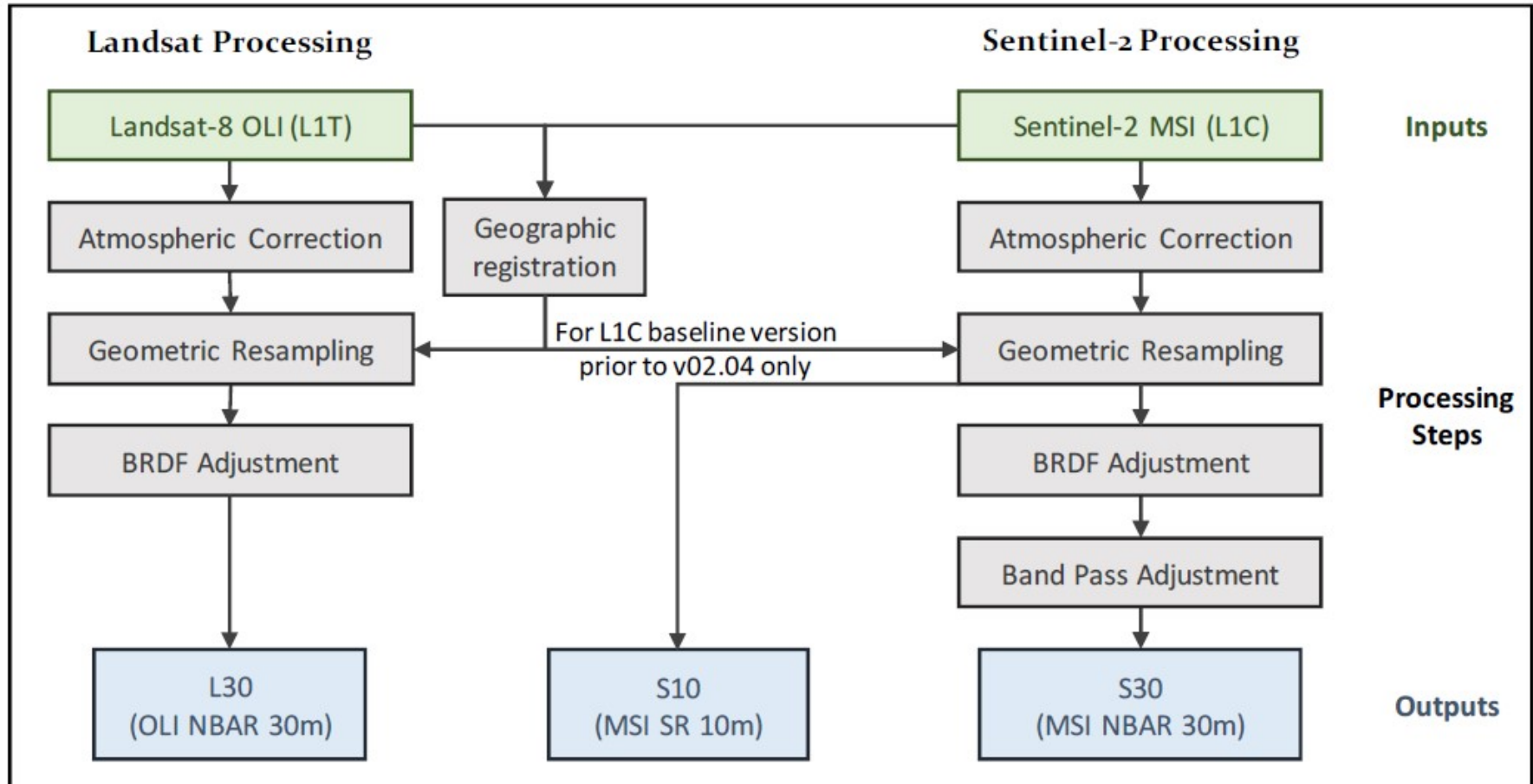- Prototype for a multi-sensor Analysis Ready Data product

Potential Revisit using different Virtual Constellations

S2A+S2B+L8 Mean Revisit period (in days)

Masek et al. 2019

HLS spectral bands

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

HLS processing

Landsat Processing   **Sentinel-2 Processing**

| | | | Inputs |
| Landsat-8 OLI (L1T) | | Sentinel-2 MSI (L1C) | |

Atmospheric Correction   Geographic registration   Atmospheric Correction

Geometric Resampling   For L1C baseline version prior to v02.04 only   Geometric Resampling   **Processing Steps**

BRDF Adjustment   BRDF Adjustment

Band Pass Adjustment

L30 (OLI NBAR 30m)   S10 (MSI SR 10m)   S30 (MSI NBAR 30m)   **Outputs**

HLS tiling

Selected HLS tiling system is identical as the one used for Sentinel-2. The tiles dimension is 109.8km and there is an overlap of 4,900m on each side.
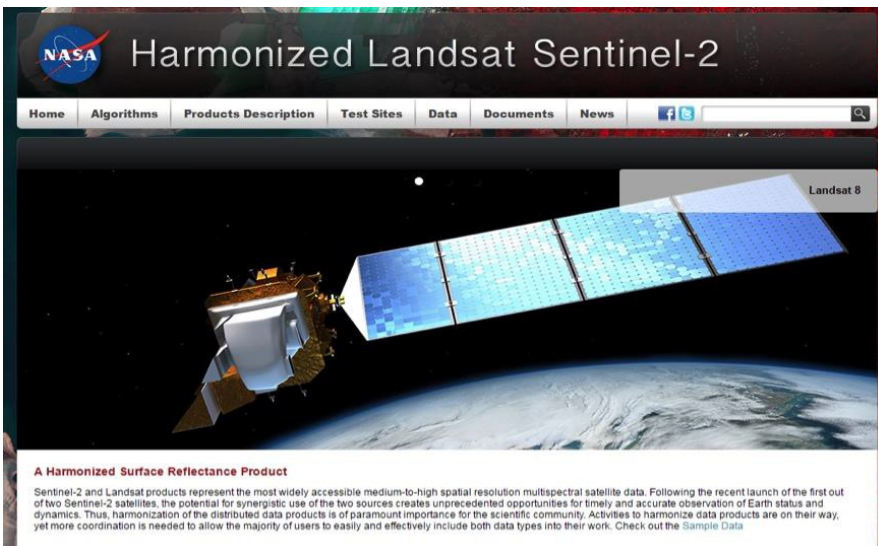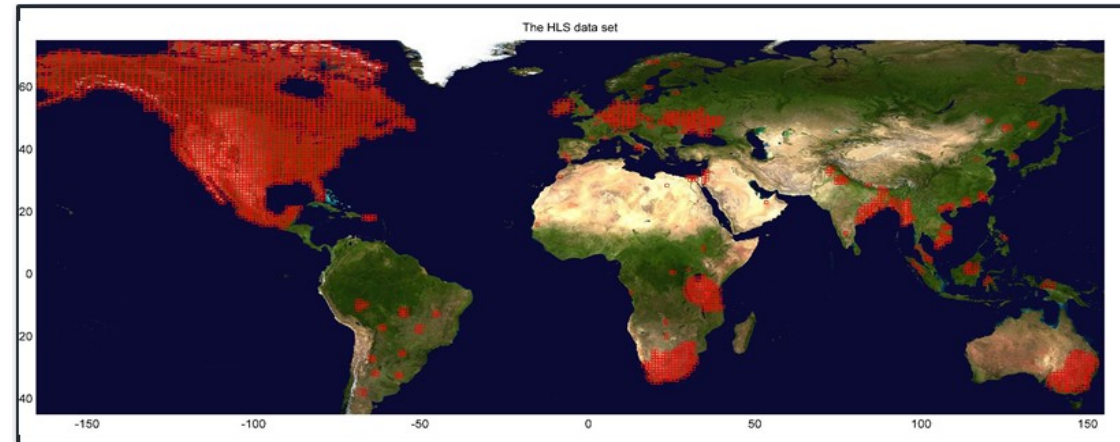The system is aligned with the Military Grid Reference System (MGRS) and its naming convention derived from the UTM (Universal Transverse Mercator) system. The UTM system divides the Earth's surface into 60 vertical zones. Each UTM zone has a vertical width of 6° of longitude and horizontal width of 8° of latitude, as shown in the map below. Each UTM zone is subdivided in MGRS 100x100km zone. The first 2 digits and 1 letter correspond to the UTM zone, the two last letters to unique ID.
The kml edited by ESA with all tiles ID can be downloaded here.
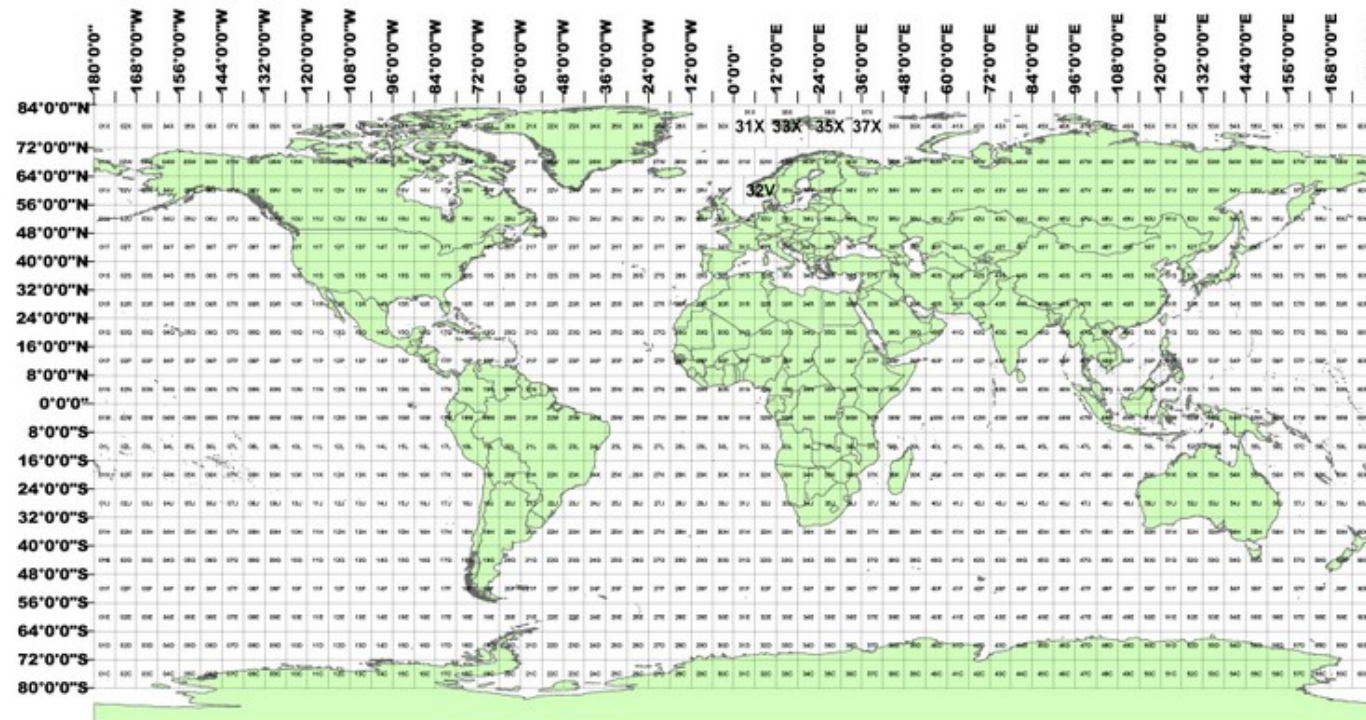
HLS (v1.4) Data Set (released Nov 2018)

- 105 Global Test Sites (3904 MGRS tiles)
- >37 million sq. km2 (~25% global land)
- < 7 day latency

The HLS data set

NASA Harmonized Landsat Sentinel-2

| Home | Algorithms | Products Description | Test Sites | Data | Documents | News |

Landsat 8

A Harmonized Surface Reflectance Product

Sentinel-2 and Landsat products represent the most widely accessible medium-to-high spatial resolution multispectral satellite data. Following the recent launch of the first out of two Sentinel-2 satellites, the potential for synergistic use of the two sources creates unprecedented opportunities for timely and accurate observation of Earth status and dynamics. Thus, harmonization of the distributed data products is of paramount importance for the scientific community. Activities to harmonize data products are on their way, yet more coordination is needed to allow the majority of users to easily and effectively include both data types into their work. Check out the Sample Data
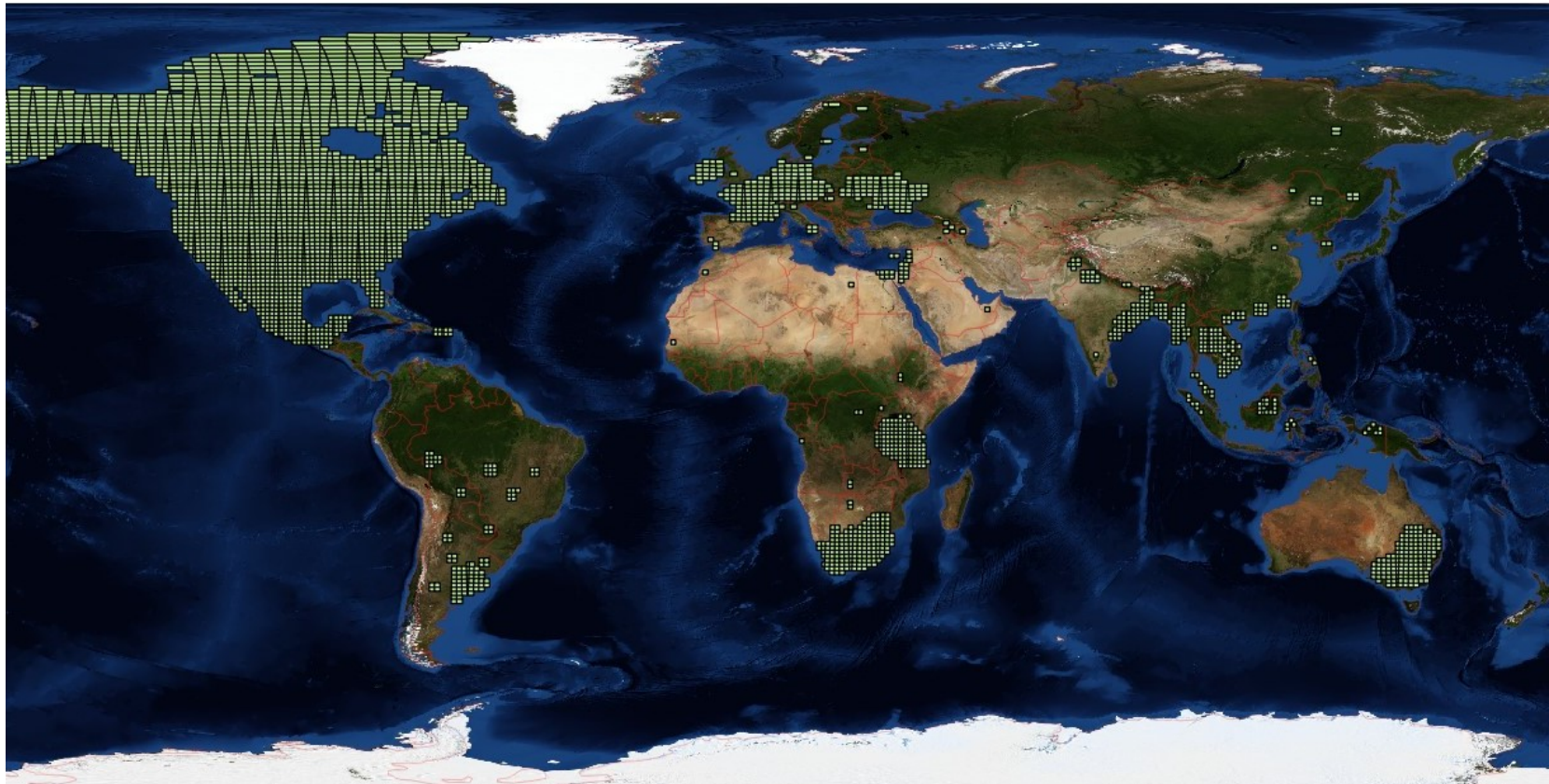
- https://hls.gsfc.nasa.gov
- Public access
- S30, L30 data available (via HTTPS)
- QA, Product documentation
- Products also available via S3 storage for AWS users

Masek et al. 2019

HLS sites/coverage

HLS - Next Steps

HLS team working on algorithm improvements for v1.5 (end-2019):

- Improved BRDF implementation
    - C-factor (Roy et al., 2016) with only view angle normalization (nadir looking)
    - Franch et al (2019) approach with view and SZA normalization
    - Inclusion of solar & view angles - possibly in separate file
- Improved S30 cloud mask
    - Bug fixes in LaSRC cloud algorithm
    - Substitution with Fmask for Sentinel (Zhu)

- NASA ESD & USGS to transition operational HLS processing to USGS EROS in 2020

HLS products

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

S10

Sentinel-2 MSI surface reflectance at full resolution (i.e. 10m, 20m and 60m).

S30

Sentinel-2 MSI harmonized surface reflectance resampled at 30m over the Sentinel-2 tiling system.

L30

Landsat-8 OLI harmonized surface reflectance resampled at 30m over the Sentinel-2 tiling system.

M30

5-day Landsat-8 OLI or Sentinel-2 MSI harmonized surface reflectance resampled at 30m over the Sentinel-2 tiling system.

https://hls.gsfc.nasa.gov/test-sites/

Product Name	S10	S30	L30	M30
Spatial	10-20-60m	30m	30m	30 m
Spectral	As input	OLI-like	OLI-like	Landsat-like
Temporal	As input	As input	As input	5-day (TBC)
BRDF-adj.	No	Yes	Yes	Yes
Projection	UTM	UTM	UTM	UTM
Tiling system	S2 (110*110)	S2 (110*110)	S2 (110*110)	S2 (110*110)

All products are gridded using the same tiling system.