



# Status of Harmonized Landsat/Sentinel-2 Data

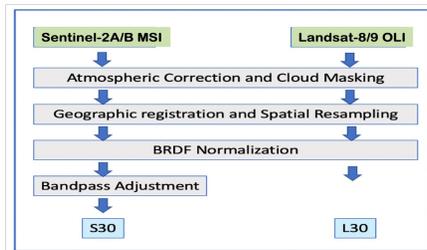
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## Introduction

The Harmonized Landsat/Sentinel-2 (HLS) project, a NASA-USGS collaboration, is operationally producing surface reflectance data for all non-Antarctic land at least once every 3 days with a 30m pixel size. The high temporal frequency is made possible by the availability of spectrally and spatially similar data from ESA's Sentinel-2A/2B sensors, NASA's Landsat-8 and recently launched Landsat-9 sensors. To make the data comparable as if they came from the same sensor, the harmonization uses the same atmospheric correction code LaSRC developed by GSFC and USGS, the same cloud/shadow masking code Fmask, a view angle effect correction by a BRDF model, the subtle adjustment of the Sentinel-2 bandpasses to the Landsat ones, and the gridding of the HLS surface reflectance and quality assessment data to a common spatial reference system. HLS data products are processed from L1T and L1C TOA input data in a cloud computing environment by the NASA IMPACT team, and distributed from the LP DAAC. The 30m HLS product from Landsat-8/9 is named L30, and the product from Sentinel-2A/B is named S30.



## Harmonization Procedures

**Atmospheric correction** Vermote et al [1] developed the Land Surface Reflectance Code (LaSRC) and the USGS EROS modified the spatial sampling density in aerosol retrieval for speedup; the radiative transfer core remains the same. Landsat surface reflectance is gridded into the Military Grid Reference System, and Sentinel-2 bands are resampled to 30m.

**Cloud masking** Cloud, cloud shadow, water, snow/ice masking by Fmask [2]; cloud and shadow are dilated up to 150 meters and labeled as cloud edge.

**Registration and resampling** Geolocation quality for HLS v2.0 input has been substantially improved by ESA and USGS with the use of ESA's Global Reference Images. Previously HLS v1.4 had internally selected geolocation images to improve the geolocation of both earlier Sentinel-2 and all Collection-1 Landsat-8 images; this operation had become obsolete.

**BRDF Normalization** View angle is set to nadir, and the daily solar zenith angle is set to the value at the average overpass time of Sentinel-2 and Landsat when the sensors overpass the latitude of the tile center [3].

**Bandpass Adjustment** A simple linear regression per band applied globally [4].

## Product Status

HLS data are operationally generated by the NASA IMPACT team at the Marshall Space Flight Center and available from LP DAAC.

With Landsat-9 included, even the equator area gets one observation every 2.9 days on average; the coverage is more frequent at higher latitude.

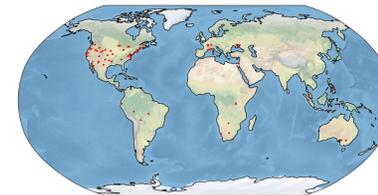
The data latency for forward processing is 1.7 days in general (between sensor overpass and product ingestion into LP DAAC); further delay can be caused by the latency of the Level-1 input and the MODIS ancillary atmospheric data needed by LaSRC.

The complete L30 time series are available for 2013 to present.

The S30 time series are available currently only for September 2020 to present, and the complete time series are expected to be available by the Fall of 2023 as ESA is starting to provide pre-September 2020 Sentinel-2 data that are reprocessed to the current processing baseline.

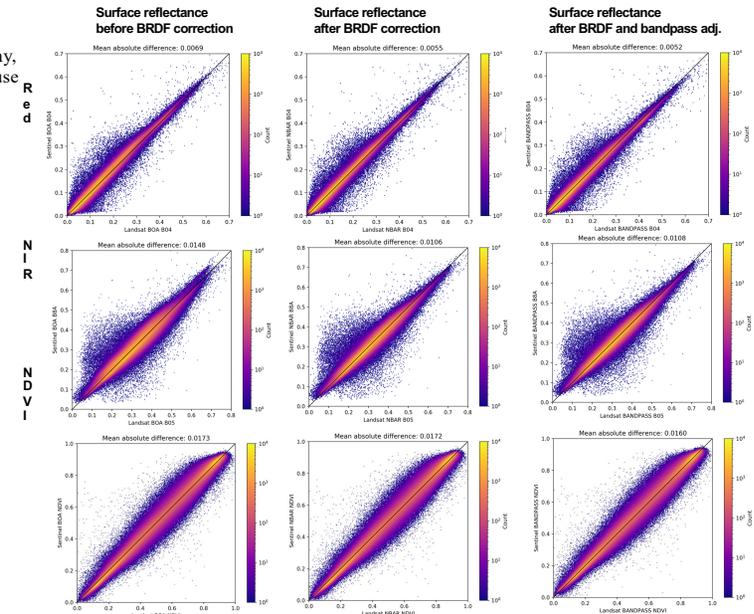
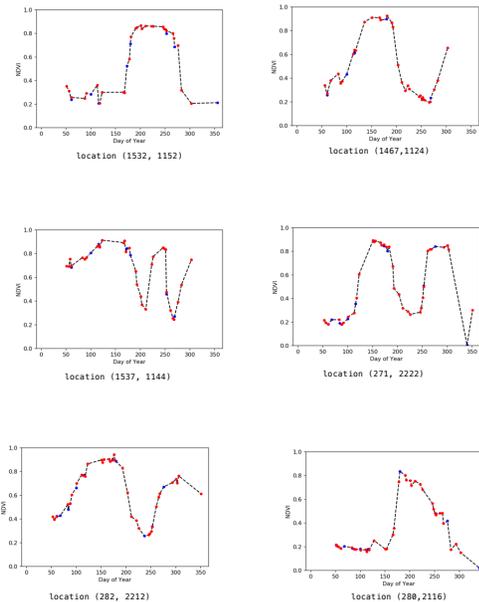
## Initial Quality Assessment

Landsat-8 and Sentinel-2A/B observations occurring on the same days in 2021 for tens of globally distributed sites are used to assess the efficacy of each of the HLS processing steps. The data consistency between the two sensors was evaluated.



## Example Time Series

Example cloud-free NDVI time series from the 2021 HLS data, without Landsat-9, for an MGRS Tile (32UQU) in southern Germany, showing the HLS data's capture of the diverse and distinctive land use practices within close proximity. (● L30, ● S30)



The reflectance difference between Landsat-8 and Sentinel-2A/B in the red band (1<sup>st</sup> row), NIR (2<sup>nd</sup> row), and NDVI (3<sup>rd</sup> row), after each of the processing steps: atmospheric correction (1<sup>st</sup> column), BRDF correction (2<sup>nd</sup> column), and bandpass adjustment (3<sup>rd</sup> column). The HLS processing has reduced the reflectance difference between the two sources.

## References

1. E. Vermote, J.C. Roger, B. Franch, Sergii Skakun. LaSRC (Land Surface Reflectance Code): Overview, application and validation using MODIS, VIIRS, LANDSAT and Sentinel 2.2 data. <https://trrs.nas.gov/applications/20190001670/downloads/20190001670.pdf>.
2. Qiu, Shi, Zhu, Zhe & He, Binbin. Fmask 4.0: Improved cloud and cloud shadow detection in Landsats 4-8 and Sentinel-2 imagery. *Remote Sensing of Environment*, vol. 231, p. 111205
3. Roy, David & Zhang, Hankui & Ju, Jeong-sun & Gomez-Dans, Jose & Lewis, Philip & Schaaf, C. & Sun, Qingsong & Li, J. & Huang, H. & Kovalskyy, V. (2016). A general method to normalize Landsat reflectance data to nadir BRDF adjusted reflectance. *Remote Sensing of Environment*, 176, 255-271. 10.1016/j.rse.2016.01.023.
4. 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.