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Landsat 4-7 Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) Calibration and Validation (Cal/Val) Algorithm Description Document (ADD)

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Executive Summary

This Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) Calibration and Validation (Cal/Val) Algorithm Description Document (ADD) details the Top-of-Atmosphere (TOA), Brightness Temperature (BT), and Surface Reflectance (SR) processing algorithms for the data processing of the Landsat 4 (L4), Landsat 5 (L5), and Landsat 7 (L7) sensors. The processing algorithms for the Landsat 8 (L8) and Landsat 9 (L9) are addressed in the Landsat 9 Calibration and Validation (Cal/Val) Algorithm Description Document (ADD).

Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data. More than four decades of imagery provide a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Landsat images are also invaluable for emergency response and disaster relief.

This document is under the Land Satellites Data System (LSDS) Configuration Control Board (CCB) control. Please submit changes to this document, as well as supportive material justifying the proposed changes, via Change Request (CR) to the Process and Change Management Tool.

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Section 1 Introduction

The Landsat mission is a joint mission formulated, implemented, and operated by the National Aeronautics and Space Administration (NASA) and the Department of the Interior (DOI) U.S. Geological Survey (USGS). Landsat is a remote sensing satellite mission providing coverage of the Earth's land surfaces. The Landsat series of satellites continue the 40+ years of global data collection and distribution.

1.1 Background

The goal of Landsat is to continue the collection, archiving, and distribution of multispectral imagery affording global, synoptic, and repetitive coverage of the Earth's land surfaces at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time. The Landsat programmatic goals are stated in the United States Code, Title 15 Chapter 82 "Land Remote Sensing Policy" (derived from the Land Remote Sensing Policy Act of 1992). This policy requires that the Landsat Project provide data into the future that are sufficiently consistent with previous Landsat data to allow the detection and quantitative characterization of changes in or on the surface of the Earth. The highly successful Landsat series of missions have provided satellite coverage of the Earth's continental surfaces since 1972. The data from these missions constitute the longest continuous record of Earth's surface as seen from space.

Landsat 4 (L4), launched on July 16, 1982, Landsat 5 (L5), launched on March 1, 1984, and Landsat 7 (L7), launched on April 15, 1999. Out of scope of this document, but relevant for data comparison, Landsat 8 (L8), launched on February 11, 2013, and Landsat 9 (L9), to be launched in 2021, are the latest satellites in the 40-year history of the Landsat Program.

1.2 Purpose and Scope

The primary purpose of this document is to explain the methods for the Top-of-Atmosphere (TOA), Brightness Temperature (BT), and Surface Reflectance (SR) corrections for the Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) instruments implemented at the United States Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center. These data will be used in conjunction with the L8 and L9 products, which are generated from the Land Surface Reflectance Code (LaSRC) algorithm.

Section 2 Algorithms

2.1 Level 2 Algorithms

2.1.1 Level 2 Auxiliary Preprocessing Algorithm

2.1.1.1 Background/Introduction

The Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) surface reflectance algorithm requires auxiliary inputs for ozone and climate variables. Those auxiliary inputs are described below.

2.1.1.2 Inputs

2.1.1.2.1 Level 2 Auxiliary Inputs

Description	Source
NCEP REANALYSIS Data	Pulled from the ftp site
OMI/TOMS Ozone Data	Pulled from the NASA http site

Table 2-1. Level 2 Auxiliary Inputs

The National Centers for Environmental Prediction (NCEP) REANALYSIS products are annual Network Common Data Form (netCDF) files that contain the daily values for each of *surface pressure, precipitable water,* and *air temperature.* The NCEP data are pulled from ftp://ftp.cdc.noaa.gov/Datasets/ncep.reanalysis/surface.

NCEP Products	Grid (lat/lon)	Daily Values (Z)	Type
Surface pressure (slp.{year}.nc)	2.5º x 2.5º 90° S to 90° N and 0º E to 357.5º E	0, 6, 12, 18	Float
Precipitable water (pr_wtr.eatm.{year}.nc)	2.5º x 2.5º 90° S to 90° N and 0º E to 357.5º E	0, 6, 12, 18	Float
Air temperature (air.sig995.{year}.nc)	2.5º x 2.5º 90° S to 90° N and 0º E to 357.5º E	0, 6, 12, 18	Float

Table 2-2. NCEP Product Specifications

The Total Ozone Mapping Spectrometer (TOMS) ozone products are daily gridded ASCII files which contain global *ozone* values. These data are pulled from https://acd-ext.gsfc.nasa.gov/anonftp/toms and the following directories are used for each instrument:

```
NIMBUS = '/nimbus7/data/ozone/Y{year}'
METEOR3 = '/meteor3/data/ozone/Y{year}'
EARTHPROBE = '/eptoms/data/ozone/Y{year}'
OMI = '/omi/data/ozone/Y{year}'
```

The filenames are of the form *L3_ozone_XXX_YYYMMDD.txt*, where XXX is ‘n7t’ for Nimbus, ‘m3t’ for Meteor3, ‘epc’ for Earth Probe, and ‘omi’ for OMI.

TOMS Instrument	Date of Operation	Grid (lat/lon)
Nimbus 7	Oct. 1978 – May 1993	1.25° x 1° 90° S to 90° N and 180° W to 180° E
Meteor 3	Aug. 1991 – Dec. 1994	1.25° x 1° 90° S to 90° N and 180° W to 180° E
Earth Probe	Aug. 1996 – Dec. 2005	1.25° x 1° 90° S to 90° N and 180° W to 180° E
OMI	2006 - Present	1° x 1 90° S to 90° N and 180° W to 180° E

Table 2-3. TOMS Product Specifications

2.1.1.3 Outputs

2.1.1.3.1 Level 2 Auxiliary Outputs

Description	Data
HDF file	Surface pressure, precipitable water, air temperature SDSs
HDF file	Ozone SDS

Table 2-4. Level 2 Auxiliary Outputs

2.1.1.4 Procedure

2.1.1.4.1 LEDAPS Auxiliary Preprocessing

2.1.1.4.1.1 Processing NCEP Reanalysis Datasets

The updatencep.py script handles the processing of the NCEP REANALYSIS datasets. It supports daily and quarterly processing of data products.

1. Daily processing – processing products for the current year
    a. If (current month <= 30 days of start of year), then process data from the previous year as well
2. Quarterly processing – processing products all years from the current year back to 1978
    a. This processing is meant to basically reprocess the entire NCEP archive in the event the data products are changed, as has happened in the past

NCEP annual products for the desired date range are temporarily downloaded to /tmp/ncep for processing. The annual products are parsed for daily values and repackaged into daily products. Then the annual products are removed. The output daily Hierarchical Data Format (HDF) files are written to $LEDAPS_AUX_DIR/REANALYSIS/RE_{year}.

The ncep_repackage executable handles the end-to-end repackaging of the annual NCEP products that have been downloaded, and repackages them into output daily

HDF files containing the multiple NCEP variables (surface pressure, precipitable water, air temperature), which are stored as floating points variables.

2.1.1.4.1.2 Processing TOMS Datasets

The updatetoms.py script handles the processing of the TOMS ozone datasets. It supports daily and quarterly processing of data products. The daily ASCII products are parsed for daily values and repackaged into daily HDF products. Then the ASCII products are removed. The output daily HDF files are written to $LEDAPS_AUX_DIR/EP_TOMS/ozone_{year}.

1. Daily processing – processing products for the current year; temporarily downloaded to /tmp/ep_toms
    a. If (current month <= 30 days of start of year), then process data from the previous year as well
2. Quarterly processing – processing products all years from the current year back to 1978
    a. This processing is meant to basically reprocess the entire TOMS archive in the event the data products are changed, as has happened in the past

The convert_ozone executable handles the repackaging of the daily ozone data that have been downloaded, and repackages them into output daily HDF files containing the ozone data, which are stored as 16-bit integers.

Please note that the original ozone data has data gaps in 1978 (actual data starts on Nov. 1, 1978), 1979 (partial), 1993 (partial), 1994 (partial), 1995 (complete gap), 1996 (partial), 1997 (partial), 1998 (missing DOY 347+), 2008 (missing Sept. 28/29), ... The updatetoms.py script should be run on the baseline set of TOMS ozone data. The NASA LEDAPS group has filled some of these larger data gaps by interpolating the missing data. If the ozone data is missing from the NASA ftp site, then the updatetoms.py script will not try to update/overwrite that auxiliary file.

2.1.1.4.2 Time Lag in Data Availability

Both the NCEP and TOMS products have a 2-3 day time lag, as to when they are available on their specific ftp site. The updatencep.py and updatetoms.py scripts are appropriate to be run as nightly scripts using the --daily switch to designate daily processing. These scripts will essentially download the available NCEP and TOMS products from their specific ftp sites and package those into the output HDF files which are then used by LEDAPS for processing to Surface Reflectance.

2.1.2 LEDAPS TOA Reflectance Algorithm

2.1.2.1 Background/Introduction

The LEDAPS Top of Atmosphere (TOA) Reflectance Algorithm generates Landsat TOA reflectance band data using the LEDAPS processing system. Processing of Landsat 4-5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper (ETM+) data result in an estimated in-band product that is optionally either TOA radiance (W/m2-sr-mu) or

TOA reflectance (unitless). This conversion occurs after Level 1 Radiometric (L1R) calibrations are applied.

2.1.2.2 Inputs

Description	Level	Source	Type
Scene (bias corrected, linearized)	N_{band} x N_{pixel}	Level 1 input data	Float
Per-pixel solar zenith angle	N_{pixel}	Level 1 input data	Float
TOA reflectance gain	N_{band}	Metadata	Float
TOA reflectance bias	N_{band}	Metadata	Float
TOA radiance gain	N_{band}	Metadata	Float
TOA radiance bias	N_{band}	Metadata	Float
Esun	N_{band}	Metadata	Float
Dsun		Metadata	Float

Table 2-5. LEDAPS Inputs

2.1.2.3 Outputs

Description	Level	Type
Level 1 TOA Reflectance	N_{band} x N_{pixel}	Scaled Integer

Table 2-6. LEDAPS Outputs

2.1.2.4 Options

- Convert to TOA reflectance

2.1.2.5 Procedure

The first step in gain application is the decision of which method to use. Landsat data can be calibrated to either TOA radiance or TOA reflectance.

If TOA radiance is selected, the radiance is calculated using the radiance gain and bias from the metadata:

Rad(p) = (DN(p) * rad_gain) + rad_bias

where:
Rad(p) = Output radiance value for pixel ‘p’
DN(p) = Input DN value (linearized and bias corrected) for pixel ‘p’
rad_gain = Radiance gain, from metadata
rad_bias = Radiance bias, from metadata

If TOA reflectance is selected, the reflectance is calculated in two different ways. If the metadata contains a TOA reflectance gain and bias, then those parameters are used:

Ref(p) = (DN(p) * refl_gain + refl_bias) / cos_sun_zen

where: Ref(p) = Output reflectance value for pixel ‘p’
DN(p) = Input Digital Number (DN) value (linearized and bias corrected) for pixel ‘p’
Cos_sun_zen = Cosine of the solar zenith angle. If processing collection data, this value is calculated per-pixel from values in the metadata (scene solar zenith angle and viewing geometry). If processing non-collection data, this value is a scene-wide value equal to the cosine of the solar zenith angle of the scene center.

If the TOA reflectance gain/bias values are not available, then the radiance is calculated first, then converted to reflectance using the Solar Spectral Irradiance (Esun) method:

$$\mathrm{Ref(p)} = \mathrm{Rad(p)} * \frac{\pi * \mathrm{dsun}^2}{\mathrm{esun(b)} * \mathrm{cos\_sun\_zen}}$$

where: dsun = Earth-sun distance in AU
esun(b) = Solar spectral irradiance for band ‘b’

2.1.3 LEDAPS TOA Brightness Temperature Algorithm

2.1.3.1 Background/Introduction

The Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) Top of Atmosphere (TOA) Brightness Temperature (BT) Algorithm generates Landsat TOA-BT thermal band data using the LEDAPS processing system. Processing of Landsat 4-5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper (ETM+) thermal infrared data result in an estimated in-band product that is TOA BT, expressed in the kelvin (K) unit of temperature. This conversion occurs after Level 1 radiometric (L1R) calibrations are applied.

2.1.3.2 Inputs

Description	Level	Source	Type
Scene (bias corrected, linearized)	N_{band} x N_{pixel}	Level 1 input data	Float
TOA radiance gain	N_{band}	Metadata	Float
TOA radiance bias	N_{band}	Metadata	Float

Table 2-7. LEDAPS TOA Brightness Temperature Inputs

2.1.3.3 Outputs

Description	Level	Type
Level 1 TOA thermal band product	N_{band} x N_{pixel}	Scaled Integer

Table 2-8. LEDAPS TOA Brightness Temperature Outputs

2.1.3.4 Procedure

To calculate brightness temperature, the thermal band data must first be converted to TOA radiance (W/m2-sr-mu). This is done using the radiance gain and bias from the metadata:

$$\mathrm{Rad(p)} = (\mathrm{DN(p)} * \mathrm{rad\_gain}) + \mathrm{rad\_bias}$$

where:
Rad(p) = Output radiance value for pixel ‘p’
DN(p) = Input DN value (bias corrected) for pixel ‘p’
rad_gain = Radiance gain, from metadata.
rad_bias = Radiance bias, from metadata.

The brightness temperature is then calculated:

$$\mathrm{BT(p)} = \frac{\mathrm{K2}}{\log\left(1.0+\left(\frac{\mathrm{K1}}{\mathrm{Rad(p)}}\right)\right)}$$

where:
BT(p) = Output brightness temperature for pixel ‘p’
K2 = Thermal constant from metadata.
K1 = Thermal constant from metadata.

The constants K1 and K2 are dependent on the satellite instrument and the thermal spectral response of the band being processed. (Note that target emissivity is normally part of this equation, but for brightness temperature the emissivity is assumed to be 1.)

Brightness temperature for TM products is computed using band 6. Brightness temperature for ETM+ products is computed using both Band 6 – High Gain (6H) and Band 6 – Low Gain (6L). By default, 6H is used. However, if 6H is saturated (either high using a value of 255 or low using a value of 1), then 6L is used. If 6L is saturated on the high end (it will not saturate low), then the output is masked as saturated. The algorithm uses the appropriate 6H or 6L radiance gain and bias as well as the appropriate K1/K2 constants for 6H and 6L, as obtained from the metadata.

2.1.4 LEDAPS Surface Reflectance Algorithm

2.1.4.1 Background/Introduction

The LEDAPS Surface Reflectance Algorithm Description Document generates Landsat surface reflectance products in the LEDAPS ground system. Processing of Landsat 4-7 TM or ETM+ data results in an estimated in-band product that is TOA reflectance (unitless). After that, the atmosphere must be taken into account. Processing of TOA reflectance products with an atmospheric retrieval algorithm results in an estimated in-band product that is Surface Reflectance (unitless).

2.1.4.2 Inputs

Description	Level	Source	Type	Variable
Level 1 TOA Reflectance Scene	N_{band} x N_{pixel}	Level 1 input data	Scaled Integer	line_in
Level 1 TOA Brightness Temp	N_{band} x N_{pixel}	Level 1 input data	Scaled Integer	b6_line
Level 1 QA	N_{band} x N_{pixel}	Level 1 input data	Integer	qa_line
Solar Zenith Angle		Metadata	Float	sza
Relative Azimuth		Metadata	Float	phi
Water Vapor	N_{band} x N_{pixel}	Auxiliary Data (NCEP Reanalysis)	Float	uwv
Surface Air Pressure	N_{band} x N_{pixel}	DEM	Float	spres
Ozone	N_{band} x N_{pixel}	Auxiliary Data (TOMS)	Float	uoz
Spherical Albedo	N_{band} x N_{pixel}	Internal Model	Float	S_r

Table 2-9. LEDAPS Surface Reflectance Algorithm Inputs

2.1.4.2.1 Hardcoded Parameters

These parameters are ostensibly input variables, but are currently set in the code which set up the Second Simulation of a Satellite Signal in the Solar Spectrum (6S) tables and are therefore static:

Description	Level	Value	Type	Variable
Instrument Relative Spectral Response	N_{band} x Spectral Resolution	Hardcoded Lookup Table	Float	Etm_spectral_function_t
Month and Day		September 15th	Integer	month, day
View Zenith Angle		0.0	Float	vza
Target Altitude		0 km	Float	target_alt
Assumed TOA Reflectance		0.14	Float	srefl

Table 2-10. LEDAPS Surface Reflectance Hardcoded Parameters

2.1.4.3 Outputs

Description	Level	Type
Level 1 Surface Reflectance	N_{band} x N_{pixel}	Scaled Integer

Table 2-11. LEDAPS Surface Reflectance Algorithm Output

2.1.4.4 Procedure

The first step in surface reflectance calculation is to assemble the input parameters for the 6S atmospheric retrieval algorithm. 6S is FORTRAN code that runs an atmospheric retrieval model, and outputs the transmittance parameters necessary for estimating surface reflectance from TOA reflectance.

Note that 6S results are not valid for solar zenith angles greater than 76 degrees – generally high-latitude data – and thus surface reflectance is not implemented for those scenes.

The input parameters for 6S and their origin are:

- Solar Zenith Angle and Relative Azimuth Angle, which are calculated from values in the Level 1 metadata.
- Month, Day, Target Altitude, and View Zenith Angle, which are currently hardcoded as default values in LEDAPS.
- Surface Air Pressure, which is calculated from the Digital Elevation Model (DEM) altitude of the pixel being processed.
- Water Vapor, which is read from auxiliary data. This data may be interpolated if it is coarser than the scene pixel resolution.
- Ozone, which is either read from auxiliary data or calculated from an internal model if no ozone auxiliary file exists. This data may be interpolated if it is coarser than the scene pixel resolution.
- Spherical Albedo, which is obtained from an external program named CSALBR.f. This program is part of the 6S software package, and it calculates spherical albedo from its own internal model based on the average transmittance of the atmosphere at the scene or pixel in question.

6S takes these inputs and returns atmospheric coefficients that are updated later by the AOT and are used in the surface reflectance correction. The relevant output variables are:

Description	**Level**	**Value**	**Type**	**Variable (6S and LEDAPS)**
Combined Rayleigh and Aerosol upwelling transmittance	N_{band} x N_{pixel}	output from 6S	Float	T_ra_up Tu_ra
Combined Rayleigh and Aerosol downwelling transmittance	N_{band} x N_{pixel}	output from 6S	Float	T_ra_down Td_ra
Combined Rayleigh and Aerosol spherical albedo	N_{band} x N_{pixel}	output from 6S	Float	S_ra
Combined Rayleigh and Aerosol general transmittance	N_{band} x N_{pixel}	output from 6S	Float	rho_ra
Water Vapor transmittance	N_{band} x N_{pixel}	output from 6S	Float	tgH2O T_g_wv
Other Gases transmittance	N_{band} x N_{pixel}	output from 6S	Float	tgOG T_g_og

Table 2-12. Outputs derived from 6S processing

The aerosol-dependent auxiliary inputs are computed for static-sized aerosol grid cells (40x40) using the center of each grid cell. The input values (solar zenith, view zenith, relative azimuth, water vapor, ozone, surface pressure) are interpolated for these grid locations.

Cloud diagnostics are computed for cloud grids (160x160). Input auxiliary air temp is interpolated for the scene center. An initial pass for clouds and water are masked based on interpolated atmospheric coefficients for each pixel. TM-referenced Bands 1, 3, 4, 5, and 7, along with the thermal band and interpolated air temp, are used to compute cloud coefficients for non-fill and non-saturated (Band 3) pixels. If the pixel is not identified as water (see equation below), then the temperature and cloud coefficients are used to determine whether the pixel is clear. The average and standard deviation of clear thermal and Band 7 values are computed from the clear pixels.

> Water = (ndvi < 0) OR ((((ndvi > 0) AND (ndvi < 0.1)) OR (rho4 < 0.05)) AND (rho5 < 0.02))

A second pass is used to mask the clouds, shadows, adjacent to cloud, and snow by using the air temperature for the current grid, the average and standard deviation of the thermal band, and TM Band 4 values. This mask is made based on the aerosol grids.

The clouds identified in these cloud passes are dilated by 5 pixels. Next the cloud shadows are approximated using the pixel temperature to determine the cloud height and using the solar and view angles to cast the shadows for each cloud pixel. The shadows are also dilated by 5 pixels.

Next the aerosols are computed for each of the aerosol grids using the Dense Dark Vegetation (DDV) method, which involves interpolated auxiliary inputs, the cloud diagnostics, 6S tables, and the input TOA reflectance. Any aerosol grid pixels that are fill, water, cloud, shadow, or snow are excluded in aerosol computation. Fractional statistics of water, clouds, shadows, and snow are collected while processing the aerosols. If the average and standard deviation of the TM Band 7 TOA reflectance meet their thresholds and number of snow pixels, fraction of water, and fraction of cloud meet their thresholds for this course resolution grid pixel, then the grid pixel is determined to be DDV, and so the AOT of the blue band is computed. The AOT computation uses the solar zenith, view zenith, relative azimuth, water vapor, ozone, and surface pressure for the current pixel along with the 6S table. The atmospheric coefficients are updated for the current aerosol grid cell, and the red band is then tested with the computed AOT. If more than 10% of the surrounding pixels are negative in the red band with this AOT, then it is rejected and set to fill. After attempting to compute the aerosols for all course resolution grids, any grids that were not successful in computing the aerosol are filled using spatial interpolation of at least three neighboring grid values.

The atmospheric coefficients are updated using the computed aerosols, then the surface reflectance is computed for each pixel using the following equations. Fill pixels are saved as fill and saturated pixels are saved as saturated.

$$\rho_{i,b} = \frac{\frac{Ref_{i,b}}{tgOG} - rho\_ra}{tgH2O * td\_ra * tu\_ra}$$

where: $\rho_{i,b}$ = Intermediate reflectance product of pixel i in band b
$Ref_{i,b}$ = TOA reflectance of pixel *i* in band *b*

$$SR_{i,b} = \frac{\rho_{i,b}}{1 + S\_ra * \rho_{i,b}}$$

where: $SR_{i,b}$ = Surface Reflectance of pixel *i* in band *b*

The surface reflectance Quality Assessment (QA) band is written based on the cloud information determined prior to the aerosol computation.

Appendix A Acronyms

6H	Band 6 – High Gain
6L	Band 6 – Low Gain
6S	Second Simulation of Satellite Signal in the Solar Spectrum
ADD	Algorithm Description Document
ASCII	American Standard Code for Information Interchange
ATBD	Algorithm Theoretical Basis Document
AU	Astronomical Units
BT	Brightness Temperature
Cal/Val	Calibration and Validation
CCB	Configuration and Control Board
CR	Change Request
DDV	Dense Dark Vegetation
DEM	Digital Elevation Model
DFCB	Data Format Control Book
DN	Digital Number
DOI	Department of the Interior
DPAS	Data Processing and Archive System
EROS	Earth Resources Observation and Science
ESPA	EROS Science Processing Architecture
ESUN	Solar Spectral Irradiance
ETM+	Enhanced Thematic Mapper Plus
FTP	File Transfer Protocol
HDF	Hierarchical Data Format
IAS	Image Assessment System
K	Kelvin
L0Ra	Level 0 Reformatted Archive
L1R	Level 1 Radiometric
L4	Landsat 4
L5	Landsat 5
L7	Landsat 7
L8	Landsat 8
L9	Landsat 9
LaSRC	Land Surface Reflectance Code
LEDAPS	Landsat Ecosystem Disturbance Adaptive Processing System
NARR	North American Regional Reanalysis
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NDVI	Normalized Difference Vegetation Index
NetCDF	Network Common Data Form
OMI	Ozone Monitoring Instrument
QA	Quality Assessment
SDS	Scientific Dataset

SR	Surface Reflectance
SZA	Solar Zenith Angle
TM	Thematic Mapper
TOA	Top of Atmosphere
TOMS	Total Ozone Mapping Spectrometer
USGS	U.S. Geological Survey

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Please see https://www.usgs.gov/land-resources/nli/landsat/glossary-and-acronyms for a list of acronyms.

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