README Document for the Earth Surface and Atmosphere Reflectivity Since 1979 from Multiple Satellites project

Multi-Satellite Lambertian Equivalent Reflectivity
Level-3 Daily Zonal Mean Products:

MSLERNNL3zm (noon normalized)
MSLERLSTL3zm (local satellite time)

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Revision History

Revision Date	*Changes*	*Author*
03/07/2013	Original	James E. Johnson
03/18/2013	Added PI section 6, NOAA 18 failed in section 1.1.3, and a few minor edits.	James E. Johnson
07/22/2013	Describes changes regarding v1.02 data files: new LER340_SBUV_Average data field added, removed NOAA-19, end date now 2012, mention TOMS, OMI and SeaWiFS are not included in common calibration.	James E. Johnson

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1. Introduction

This document provides basic information for using the zonal mean data products from the Earth Surface and Atmosphere Reflectivity Since 1979 from Multiple Satellites project. The corresponding gridded mean data products are described in a separate README document.

1.1 Data Product Description

The Multi-Satellite Lambertian Equivalent Reflectivity (LER) daily 5-deg zonal mean products are derived from multi-satellite observations from 1978 to 2012 (Herman et al., 2012).

There are two product types: Local Satellite Time (LST) and Noon Normalized (NN). The LST data are uncorrected for the drift of the spacecraft local equator crossing time. The NN data have been corrected to local noon equator crossing time (see Labow et al., 2011). The NN correction could only be done satisfactorily at latitudes less extreme than 60 degrees due to insufficient diurnal data at higher latitudes.

1.1.1 SBUV in General

The primary purpose of the SBUV (Solar Backscatter UltraViolet) instruments is to monitor changes in Earth's atmospheric ozone, but several other interesting geophysical quantities are also measured, including various Earth reflectivities.

Each SBUV instrument is a double monochromator designed to make well calibrated nadir-view observations of Earth from space at twelve discrete wavelength bands between 250 and 340 nm with a spectral bandpass of approximately 1.1 nm. All of the LER calculations use 340 nm to avoid ozone absorption effects.

1.1.2 Nimbus-7 SBUV

The Nimbus 7 (N7) spacecraft, which included an SBUV instrument, was launched on October 4, 1978 into a sun-synchronous polar orbit with an initial local equator-crossing time of 11:45 a.m. The satellite drifted to slightly earlier times after the maneuvering fuel ran out in 1984.

The N7 SBUV instrument achieved full global coverage each week from approximately 81 degrees South to 81 degrees North latitude.

The instrument was operational from October 30, 1978 until June 26, 1990 when increasing chopper errors made the data unusable. The purpose of the chopper was to subtract noise contamination that occurred from high energy particles, particularly when the satellite passed through the South Atlantic Anomaly.

The Lambertian Equivalent Reflectivity at 340 nm based on N7 SBUV observations has been included in the LER daily 5-deg zonal mean products.

1.1.3 NOAA SBUV/2 Series 9, 11, 14, 16, 17 and 18

The second generation Solar Backscatter UltraViolet (SBUV/2) instruments are an improved design over the Nimbus-7 SBUV instrument, and have been flown on the NOAA Polar-orbiting Operational Environment Satellites (POES).

The NOAA series of satellites were launched into near sun-synchronous polar orbits, mostly with an initial equator-crossing time of approximately 2:00 p.m., except for NOAA-17, which was launched into a morning orbit. These satellites drift towards later equator-crossing times (or to earlier times for NOAA-17) during their mission, leading to higher solar zenith angles at all latitudes. This orbital drift affects the availability of the SBUV/2 measurements, since the data are less accurate when the orbit is near- terminator (i.e., local equator crossing times outside of the 8:00 a.m. to 4:00 p.m. range). The orbital drift problem was especially bad for the NOAA-9 and -11 satellites.

Each SBUV/2 instrument provided global coverage from 80 degrees South latitude to 80 degrees North latitude every 7 to 10 days.

The NOAA-9 satellite was launched on December 12, 1984, and the others were subsequently launched every two to six years to result in continuous coverage to present. Only the SBUV/2 instruments aboard the NOAA-16, -17 and -19 satellites remained in operation at the end of 2012. The SBUV/2 instrument aboard NOAA-18 failed on December 12, 2012. Observations from the SBUV/2 instrument aboard NOAA-19 have not been included in the LER daily 5-deg zonal mean products.

The Lambertian Equivalent Reflectivity at 340 nm based on NOAA SBUV/2 observations has been included in the LER daily 5-deg zonal mean products.

1.1.4 Nimbus-7 TOMS

The Nimbus 7 (N7) spacecraft also carried a Total Ozone Mapping Spectrometer (TOMS) instrument, the primary purpose of which was to provide daily global observations of Earth's ozone layer. Reflectivity values at six wavelengths were also measured. The Lambertian Equivalent Reflectivity based on N7-TOMS observations has been estimated from December 2, 1978 to May 6, 1993, and is included in the LER daily 5-deg zonal means products, but are not a part of the common calibration.

1.1.5 Earth Probe TOMS

The Earth Probe (EP) spacecraft was launched into Earth orbit on August 17, 1996, and carried a Total Ozone Mapping Spectrometer (TOMS) instrument, the primary purpose of which was to provide daily global observations of Earth's ozone layer, which was achieved once the orbit was boosted high enough. Reflectivity values at six wavelengths were also measured. The Lambertian Equivalent Reflectivity at 331 nm based on EP-TOMS observations has been estimated from August 24, 1996 to July 23, 2004, and is included in the LER daily 5-deg zonal mean products, but are not a part of the common calibration.

1.1.6 Aura OMI

The Aura spacecraft carrying the Ozone Monitoring Instrument (OMI) was launched into Earth orbit on July 15, 2004. The primary purpose of OMI is to provide daily global observations of Earth's ozone layer. Reflectivity values at all wavelengths from 330 nm to 500 nm are available. An instrument anomaly appeared in 2007 and became increasingly worse such that data from January 2009 onwards have been excluded from this study. The Lambertian Equivalent Reflectivity at 340 nm based on OMI observations has been estimated from January 1, 2005 to December 31, 2008, and is included in the LER daily 5-deg zonal mean products, but are not a part of the common calibration.

1.1.7 SeaStar SeaWiFS

The SeaStar spacecraft carrying the SeaWiFS instrument was launched into Earth orbit on August 1, 1997. The primary purpose of the SeaWiFS instrument was to observe ocean color, but it could also be used to measure Earth's reflectivity. The shortest wavelength band of the SeaWiFS instrument is centered at 412 nm and has a spectral bandpass of 10 nm. The Lambertian Equivalent Reflectivity at 412 nm based on SeaWiFS observations has been estimated from January 1, 1998 to December 31, 2008, and is included in the LER daily 5-deg zonal mean products, but are not a part of the common calibration.

1.2 Algorithm Background

A mathematical description of the algorithm is given in Herman et al. (2012). It is based on a numerical solution of the radiative transfer equation applied to a formal solution in terms of the radiation at the top of the atmosphere and a single free parameter representing the LER. The LER value is adjusted in the range from 0.0 to 1.0 until the calculated radiance at the top of the atmosphere matches the measured radiance.

1.3 Data Disclaimer

These data were produced under the NASA MEaSUREs program with the goal being to apply a consistent instrument-to-instrument calibration so that the data could be used for long term trend analysis. The quality of the LER data varied depending on the instrument. In particular, the SBUV/2 data from NOAA-9, -11 and 14 are of somewhat lower quality due to various issues (Herman et al., 2012). The Nimbus-7 TOMS, Earth Probe TOMS, Aura OMI and SeaStar SeaWiFS data are not a part of the common calibration.

2. Data Organization

The Multi-Satellite Lambertian Equivalent Reflectivity Zonal Mean Products contain latitude versus time reflectivity values for the entire time period from 1978 to 2012 from the Nimbus-7 SBUV, and NOAA 9, 11, 14, 16, 17 and 18 SBUV/2 instruments, Nimbus-7 TOMS, Earth Probe TOMS, OMI and SeaWiFS. The data files are written in the HDF-EOS5 format.

2.1 File Naming Convention

The data product files are named according to the following convention:

<Product>_<Version>.<Suffix>

where:
o Product =   product short name in format <Variable><Type><Level> where
    1. Variable = Multi-Satellite Lambertian Equivalent Reflectivity (MSLER)
    2. Type = either noon normalized (NN) or local satellite time (LST)
    3. Level = Level-3 5° lat zones (L3zm)
o Version =   product collection version in format <Major>-<Minor> where
    4. Major = 2 digit major version (e.g. 01)
    5. Minor = 2 digit minor version (e.g. 00)
    6. Created = file creation time in format YYYYmMMDDtHHMMSS
       (e.g. 2012m0925t175415)
o Suffix = the file format (always he5)

```
File name example: MSLERNNL3zm_v01-00-2012m0925t175415.he5
```

2.2 File Format and Structure

The data files are written in the HDF-EOS5 format, which is an extension of the Hierarchical Data Format Version 5 (HDF-5), developed by the HDF Group, formerly the National Center for Supercomputing Applications (http://www.hdfgroup.org/). HDF-EOS5 employs standard HDF5 objects: data arrays, attributes, and groups. Using these HDF5 objects it defines four data structures for Earth Observing System data: grid, point, swath, and zonal average. These data structures allow the file contents to be referenced to Earth coordinates, such as latitude and longitude, and to time. The HDF-EOS5 files are self-describing, portable, and platform independent. The files can be read with applications which understand HDF5, HDF-EOS5 and even the netCDF4 format.

The Multi-Satellite Lambertian Equivalent Reflectivity daily zonal mean products use the HDF-EOS Zonal Average (ZA) data structure. All data fields are represented in a table like structure with latitude versus time. In the HDF-EOS5 format, the location of a data field array within a file is given by its **path** (similar to a Unix directory) and takes the form:

/HDFEOS/ZAS/<grid_name>/Data Fields/<field_name>.

The grid_name for the LER data is always "Lambertian Equivalent Reflectivity". For example the location of the data field named "LER340_Aura_OMI" is given by:

/HDFEOS/ZAS/Lambertian Equivalent Reflectivity/Data Fields/LER340_Aura_OMI

Within each file there is a set of global attributes which define the metadata for that data product. Section 3.0 (below) describes the dimensions, global attributes, and data fields in more detail.

2.3 Key Science Data Fields

The primary science data field for these data products is the Lambertian Equivalent Reflectivity values for each of the individual sensors. The data field names begin with LER (e.g. LER340_Nimbus7_SBUV)
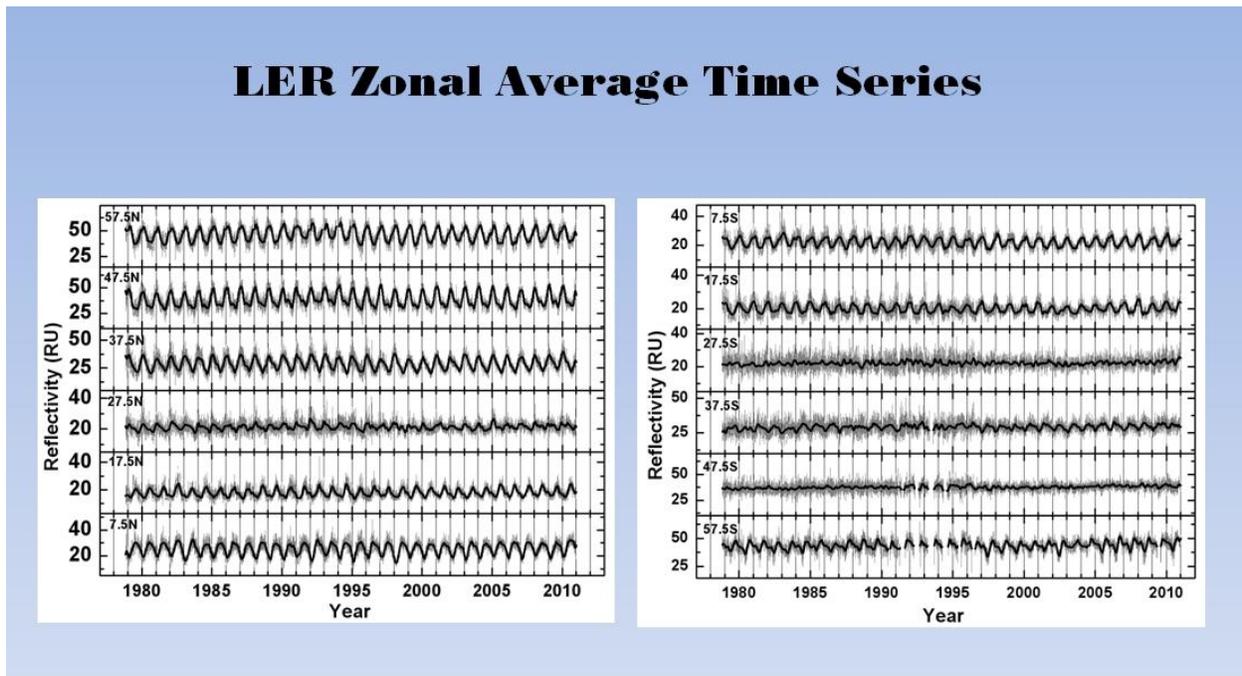
Figure 1. The LER time series is formed from the common calibrated overlapping N7-SBUV and SBUV-2 series of instruments. Where the LER time series overlap, the values are averaged to form a 33-year continuous data set. The light grey color corresponds to daily LER, while the black solid lines are a 30-day low-pass filter of the daily data.

3. Data Contents

3.1 Dimensions

The dimension information is located under the following HDF5 group path:

"/HDFEOS/ZAS/Lambertian Equivalent Reflectivity"

Table 3-1: List of dimensions associated with data fields.

Name	Size	Description
nLats	24 or 32	The dimension representing the 5° latitude zones (24 for the noon-normalized product, and 32 for the local satellite time product)
nTimes	12784	The dimension representing the observation times in the granule.

3.2 Global Attributes

The global (file) attributes are located under the following HDF5 group path:

"/HDFEOS/ADDITIONAL/FILE_ATTRIBUTES"

Table 3-2: Global metadata attributes associated with the file.

Name	Type	Size	Description
AuthorAffiliation	STRING	Scalar	The affiliation of the author of the product.
AuthorName	STRING	Scalar	The name of the author of the product.
Conventions	STRING	Scalar	The metadata conventions used.
DayNightFlag	STRING	Scalar	The flag that indicates whether the product includes day-side observations, night-side observations, or both.
EastBoundingCoordinate	32-BIT FLOAT	1	The terrestrial longitude (in degrees) of the easternmost data in the granule.
HDFVersion	STRING	Scalar	The version of HDF used to create the product.
LocalGranuleID	STRING	Scalar	The actual name of the product file.
LocalityValue	STRING	Scalar	The geographic locality of the product.

LongName	STRING	Scalar	The ESDT Long Name of the product.
NorthBoundingCoordinate	32-BIT FLOAT	1	The terrestrial latitude (in degrees) of the northernmost data in the granule.
NumLats	32-BIT SIGNED INTEGER	1	The number of latitudes in the granule, which is also the size of the nLats dimension.
NumTimes	32-BIT SIGNED INTEGER	1	The number of times in the granule, which is also the size of the nTimes dimension.
PGEVersion	STRING	Scalar	The version of the PGE or App that was used to create the product file.
ParameterName	STRING	Scalar	The measured science parameter expressed in the product.
ProcessLevel	STRING	Scalar	The process level of the product.
ProcessingCenter	STRING	Scalar	The processing center where the product was created.
ProductionDateTimeASCII	STRING	Scalar	The date and time of the processing that produced the ASCII data files.
ProductionDateTimeHDF	STRING	Scalar	The date and time of the ASCII to HDF-EOS5 conversion processing.
RangeBeginningDate	STRING	Scalar	The UTC year, month and day when the granule began.
RangeBeginningTime	STRING	Scalar	The UTC hour, minute and second when the granule began.
RangeEndingDate	STRING	Scalar	The UTC year, month and day when the granule ended.
RangeEndingTime	STRING	Scalar	The UTC hour, minute and second when the granule ended.
ShortName	STRING	Scalar	The ESDT Short Name of the product.
SouthBoundingCoordinate	32-BIT FLOAT	1	The terrestrial latitude (in degrees) of the southernmost data in the granule.
TimeSpacing	32-BIT FLOAT	1	The increment of spacing in time.
TimeSpacingUnit	STRING	Scalar	The units of the spacing in time.
VersionID	STRING	Scalar	The Collection Version of the product.
WestBoundingCoordinate	32-BIT FLOAT	1	The terrestrial longitude (in degrees) of the westernmost data in the granule.
identifier_product_doi	STRING	Scalar	The Digital Object Identifier (DOI) value.
identifier_product_doi_authority	STRING	Scalar	The authoritative service for use with DOI values in resolving to the URL.

3.3 Zonal Attributes

The zonal attributes are located under the following HDF5 group path:

"/HDFEOS/ZAS/Lambertian Equivalent Reflectivity"

Table 3-3: Attributes associated with the zonal averages.

Name	Type	Size	Description
ZonalSpacing	STRING	Scalar	The zonal spacing latitude value.
ZonalSpacingUnit	STRING	Scalar	The units of the zonal spacing value.

3.4 Data Fields

The data fields are located under the following HDF5 group path:

"/HDFEOS/ZAS/Lambertian Equivalent Reflectivity/Data Fields"

Tables 3-4: Data fields

Name	LER331_EarthProbe_TOMS			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats			
Description	The Lambertian Equivalent Reflectivity at 331 nm based on observations from the TOMS instrument aboard the Earth Probe spacecraft. The valid range of data dates is 1996-207 (6780) to 2004-173 (9668).			
Attributes				
Name	Type	Size	Value	
units	STRING	Scalar	%	
long_name	STRING	Scalar	LER at 331 nm from Earth Probe TOMS	
valid_min	32-BIT FLOAT	2	0.0, 100.0	
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)	

Name	LER331_Nimbus7_TOMS			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats			
Description	The Lambertian Equivalent Reflectivity at 331 nm based on observations from the TOMS instrument aboard the Nimbus-7 spacecraft. The valid range of data dates is 1978-306 (305) to 1993-126 (5604).			
Attributes				
Name	Type	Size	Value	
units	STRING	Scalar	%	
long_name	STRING	Scalar	LER at 331 nm from Nimbus-7 TOMS	

valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_Aura_OMI		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the OMI instrument aboard the EOS-Aura spacecraft. The valid range of data dates is 2005-001 (9862) to 2008-366 (11322).		
Attributes			

Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from EOS-Aura OMI
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA09_SBUV2a		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-9 spacecraft during the ascending phase of the mission. The valid range of data dates is 1985-033 (2589) to 1991-244 (4991 NN) and 1991-246 (4993 LST).		
Attributes			

Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-9 SBUV/2 Ascending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA09_SBUV2d		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-9 spacecraft during the descending phase of the mission. The valid range of data dates is 1990-115 (4497) to 1997-151 (7090).		
Attributes			

Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-9 SBUV/2 Descending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA11_SBUV2a		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2		

	instrument aboard the NOAA-11 spacecraft during the ascending phase of the mission. The valid range of data dates is 1988-336 (3987) to 1995-090 (6298).		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-11 SBUV/2 Ascending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA11_SBUV2d		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-11 spacecraft during the descending phase of the mission. The valid range of data dates is 1997-196 (7135) to 2001-085 (8485).		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-11 SBUV/2 Descending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA14_SBUV2a		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-14 spacecraft during the ascending phase of the mission. The valid range of data dates is 1995-036 (6244) to 2002-252 (9017 NN) and 2002-254 (9019 LST).		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-14 SBUV/2 Ascending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA14_SBUV2d		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-14 spacecraft during the descending phase of the mission. The valid range of data dates is 2002-099 (8864) to 2006-271 (10497).		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-14 SBUV/2 Descending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA16_SBUV2a
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-16 spacecraft during the ascending phase of the mission. The valid range of data dates is 2000-277 (8311) to 2009-257 (11579 NN) and 2009-258 (11580 LST).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-16 SBUV/2 Ascending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA16_SBUV2d
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-16 spacecraft during the descending phase of the mission. The valid range of data dates is 2008-119 (11075) to 2012-366 (12783).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-16 SBUV/2 Descending
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA17_SBUV2
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-17 spacecraft. The valid range of data dates is 2002-192 (8957) to 2012-366 (12783).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-17 SBUV/2
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_NOAA18_SBUV2
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV/2 instrument aboard the NOAA-18 spacecraft. The valid range of data dates is 2005-157 (10018)

			to 2012-347 (12764).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from NOAA-18 SBUV/2
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_Nimbus7_SBUV
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The Lambertian Equivalent Reflectivity at 340 nm based on observations from the SBUV instrument aboard the Nimbus-7 spacecraft. The valid range of data dates is 1978-306 (305) to 1990-172 (4554).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 340 nm from Nimbus-7 SBUV
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	LER340_SBUV_Average *
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The SBUV average of Lambertian Equivalent Reflectivity at 340 nm based on observations from all available SBUV and SBUV/2 instruments. The valid range of data dates is 1978-306 (305) to 2012-366 (12783).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	SBUV Average of LER at 340 nm
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

*NOTE: This field is only available in the Noon-Normalized product

Name	LER412_SeaStar_SeaWiFS
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	The Lambertian Equivalent Reflectivity at 412 nm based on observations from the SeaWifs instrument aboard the SeaStar spacecraft. The valid range of data dates is 1998-001 (7305) to 2008-365 (11321).

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	LER at 412 nm from SeaStar SeaWiFS
valid_min	32-BIT FLOAT	2	0.0, 100.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	Latitude		
Type	32-BIT FLOAT		
Dimensions	nLats		
Description	The terrestrial latitudes at the centers of the zones. The values are in degrees north of the equator.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	degrees_north
long_name	STRING	Scalar	Zonal Latitude
valid_range	32-BIT FLOAT	2	-90.0, 90.0
_FillValue	32-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	Time		
Type	64-BIT FLOAT		
Dimensions	nTimes		
Description	The TAI93 time (in continuous seconds since 12 a.m. UTC on January 1, 1993) of the start times of the observations.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	seconds since 1993-01-01
long_name	STRING	Scalar	Time of Observation (TAI93)
valid_range	64-BIT FLOAT	2	-1.0e+10, 1.0e+10
_FillValue	64-BIT FLOAT	1	-1×2.0^{100} (-1.2676506e+30)

Name	UTCDayNumber		
Type	32-BIT SIGNED INTEGER		
Dimensions	nTimes		
Description	The UTC day number of the observations. The values are in days since 1978-01-01.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	days since 1978-01-01
long_name	STRING	Scalar	Days Since 1978-01-01
valid_range	32-BIT SIGNED INTEGER	2	0, 12783
_FillValue	32-BIT SIGNED INTEGER	1	-2147483647

Name	UTCDayOfYear		
Type	32-BIT SIGNED INTEGER		
Dimensions	nTimes		
Description	The UTC day of year of the observations.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	1
long_name	STRING	Scalar	Day of Year
valid_range	32-BIT SIGNED INTEGER	2	1, 366
_FillValue	32-BIT SIGNED INTEGER	1	-2147483647

Name	UTCYear		
Type	32-BIT SIGNED INTEGER		
Dimensions	nTimes		
Description	The (four-digit) UTC year of the observations.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	1
long_name	STRING	Scalar	Year
valid_min	32-BIT SIGNED INTEGER	2	1978, 2012
_FillValue	32-BIT SIGNED INTEGER	1	-2147483647

4. Options for Reading the Data

There are many tools and visualization packages (free and commercial) for viewing and dumping the contents of HDF5 files. Libraries are available in several programming languages for writing software to read HDF5 files. A few simple to use command-line and visualization tools, as well as programming languages for reading the L2 HDF5 data files are listed in the sections below. For a comprehensive list of HDF5 tools and software, please see the HDF Group's web page at http://www.hdfgroup.org/products/hdf5_tools/.

4.1 Command Line Utilities

4.1.1 h5dump (free)

The h5dump tool, developed by the HDFGroup, enables users to examine the contents of an HDF5 file and dump those contents, in human readable form, to an ASCII file, or alternatively to an XML file or binary output. It can display the contents of the entire HDF5 file or selected objects, which can be groups, datasets, a subset of a dataset, links, attributes, or datatypes. The h5dump tool is included as part of the HDF5 library, or separately as a stand-alone binary tool at:

http://www.hdfgroup.org/HDF5/release/obtain5.html

4.1.2 ncdump (free)

The ncdump tool, developed by Unidata, will print the contents of a netCDF or compatible file to standard out as CDL text (ASCII) format. The tool may also be used as a simple browser, to display the dimension names and lengths; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables. To view HDF5 data files, version 4.1 or higher is required. The ncdump tool is included with the netCDF library. **NOTE: you must include HDF5 support during build.**

http://www.unidata.ucar.edu/downloads/netcdf/

4.1.3 H5_PARSE (IDL/commercial)

The H5_PARSE function recursively descends through an HDF5 file or group and creates an IDL structure containing object information and data values. You must purchase an IDL package, version 8 or higher, to read the L2 HDF5 data files.

http://www.exelisvis.com/language/en-US/ProductsServices/IDL.aspx

4.2 Visualization Tools

4.2.1 HDFView (free)

HDFView, developed by the HDFGroup, is a Java-based graphic utility designed for viewing and editing the contents of HDF4 and HDF5 files. It allows users to browse through any HDF file, starting with a tree view of all top-level objects in an HDF file's hierarchy. HDFView allows a user to descend through the hierarchy and navigate among the file's data objects. Editing features allow a user to create, delete, and modify the value of HDF objects and attributes. For more info see:

http://www.hdfgroup.org/hdf-java-html/hdfview/

For the EOS perspective you can add the HDF-EOS5 plugin which is available at:

http://newsroom.gsfc.nasa.gov/sdptoolkit/HDFView/HDFView_hdfeos_plugin.html

4.2.2 Panoply (free)

Panoply, developed at the Goddard Institute for Space Studies (GISS), is a cross-platform application which plots geo-gridded arrays from netCDF, HDF and GRIB dataset required. The tool allows one to slice and plot latitude-longitude, latitude-vertical, longitude-vertical, or time-latitude arrays from larger multidimensional variables, combine two arrays in one plot by differencing, summing or averaging, and change map projections. One may also access files remotely into the Panoply application.

http://www.giss.nasa.gov/tools/panoply/

4.2.3 H5_BROWSER (IDL/commercial)

The H5_BROWSER function presents a graphical user interface for viewing and reading HDF5 files. The browser provides a tree view of the HDF5 file or files, a data preview window, and an information window for the selected objects. The browser may be created as either a selection dialog with Open/Cancel buttons, or as a standalone browser that can import data to the IDL main program. You must purchase an IDL package, version 8 or higher to view the L2 HDF5 data files.

http://www.exelisvis.com/language/en-US/ProductsServices/IDL.aspx

4.3 Programming Languages

Advanced users may wish to write their own software to read HDF5 data files. The following is a list of available HDF5 programming languages:

Free:

        C/C++ (http://www.hdfgroup.org/HDF5/release/obtain5.html)
        Fortran (http://www.hdfgroup.org/HDF5/release/obtain5.html)
        Java (http://www.hdfgroup.org/hdf-java-html/)
        Python (http://alfven.org/wp/hdf5-for-python/)
        GrADS (http://www.iges.org/grads/)

Commercial:

        IDL (http://www.exelisvis.com/language/en-US/ProductsServices/IDL.aspx)
        Matlab (http://www.mathworks.com/products/matlab/)

For a list of available HDF-EOS5 libraries (requires HDF5 libraries) see:

        http://hdfeos.org/software/library.php

5. Data Services

5.1 Mirador

The GES DISC provides basic temporal and advanced (event) searches through its Mirador search and download engine:

http://mirador.gsfc.nasa.gov/

Mirador offers various download options that suit users with different preferences and different levels of technical skills. Users can start from a point where they don't know anything about these particular data, its location, size, format, etc., and quickly find what they need by just providing relevant keywords, such as a data product (e.g. "MSLERNNL3d10"), or a parameter such as "reflectivity".

5.2 OPeNDAP

The Open Source Project for a Network Data Access Protocol (OPeNDAP) provides remote access to individual variables within datasets in a form usable by many OPeNDAP enabled tools, such as Panoply, IDL, Matlab, GrADS, IDV, McIDAS-V, and Ferret. Data may be subsetted dimensionally and downloaded in an ASCII, netCDF3 or binary (DAP) format. The GES DISC offers the SBUV L2 data products through OPeNDAP:

http://measures.gsfc.nasa.gov/opendap/LER/contents.html

6. More Information

6.1 Web Resources

For other reflectivity and related data, please search NASA's Global Change Master Directory at http://gcmd.nasa.gov.

6.2 Point of Contact

Name: GES DISC Help Desk

URL: http://disc.gsfc.nasa.gov/

E-mail: gsfc-help-disc@lists.nasa.gov

Phone: 301-614-5224

Fax: 301-614-5228

Address: Goddard Earth Sciences Data and Information Services Center

Attn: Help Desk

Code 610.2

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7. Acknowledgements

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Herman, J.R., M.T. DeLand, L.-K. Huang, et al., "A net decrease in the Earth's cloud plus aerosol reflectivity during the past 33 yr (1979-2011) and increased solar heating at the surface" Atmospheric Chemistry and Physics Discussions, 2012, Volume 12, Pages 31991-32038 doi:10.5194/acpd-12-31991-2012

Labow, G.J., J.R. Herman, L.-K. Huang, et al., "Diurnal variation of 340 nm Lambertian Equivalent Reflectivity due to clouds and aerosol over land and oceans", Journal of Geophysical Research, 2011, Volume 116, D11202, doi:10.1029/2010JD014980