National Aeronautics and Space Administration
Goddard Earth Science Data Information and Services Center (GES DISC)

Data Product User Guide for Aqua AIRS Huang Spectral Outgoing Longwave Radiation (OLR) Level-3 Product

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Product Version 6.1

Goddard Earth Sciences Data and Information Services Center (GES DISC)
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Revision History

Revision Date	***Changes***	***Author***
2020-01-02	Initial Release	Xianglei Huang

Table of Contents

1.0 Introduction

This document provides basic information for using the Version 6 Level-3 Spectral Outgoing Longwave Radiation (OLR) from the Atmospheric InfraRed Sounder (AIRS) instrument on the EOS-Aqua spacecraft.

This product was derived using AIRS radiance to spectral flux algorithms developed by Xianglei Huang at the University of Michigan.

The Aqua AIRS Huang Level-3 Spectral OLR product contains OLR parameters derived from the AIRS data: all-sky and clear-sky OLR both spectrally resolved at 10 cm^{-1} bandwidth and integrated to a single value per grid square. This is a monthly product on a 2x2 degree latitude/longitude grid. This product has been annotated with both file and variable level attributes to fully describe their contents.

1.1 Mission Description

The EOS-Aqua satellite was launched on May 4, 2002 from Vandenburg Air Force Base in California into an orbit with an altitude of 705 km above the Earth surface, an inclination angle of 98.2 deg and a 13:30 local time ascending node. The Aqua spacecraft is part of the "A-train" (Aqua in the lead and Aura at the tail, the nominal separation between Aqua and Aura is about 15 minutes) or "afternoon constellation" (a loose formation flight which started sometime after the Aura launch July 15, 2004). The objective is to coordinate observations and to provide a coincident set of data on aerosol and cloud properties, radiative fluxes and atmospheric state essential for accurate quantification of aerosol and cloud radiative effects.

1.2 AIRS Instrument Description

The Atmospheric Infrared Sounder (AIRS) is a grating array spectrometer having 2378 channels sensitive in the range 3.7 to 15.4 microns. The spectral resolution ($\lambda/\Delta\lambda$) is about 1200. A combination of a design philosophy having radiometric accuracy as a foremost goal, cooled and temperature-controlled spectrometer hardware (including most of the optics), and thorough pre-flight calibration have made AIRS a superb instrument that produces very high-quality radiance data (Strow 2003).

This product was produced using version 5 of the AIRS Level-1B product, AIRIBRAD_005 (Chahine 2007).

1.3 Data Disclaimer

Version 6.1 AIRS Spectral OLR Level-3 data are released to the public as is. Every effort has been made to properly represent the data which this document describes.

1.4 Where to find the Product

The AIRS Level-3 Spectral OLR product can be found at and downloaded from the Goddard Distributed Active Archive Center (GDAAC). There you will find additional information and documentation about this product and other products of interest. Use search string "AIRSIL3MSOLR" under Data Collections.

https://disc.gsfc.nasa.gov

The product can also be accessed via doi: 10.5067/5P7KQ31XI7XJ

1.5 Contact Information

For information, questions or concerns with this AIRS Spectral OLR Level-3 data set, please send your questions to: askairs@jpl.nasa.gov.

2.0 Level-3 Product Overview

Level-2 products are created from AIRS v5 Level-1B observations using AIRS radiance to spectral flux algorithms developed by X. Huang and his collaborators. The results of these algorithms are then collected into 1-month gridded Level-3 files.

2.1 Product Granulation

The Level-3 product is produced for every month from September 2002 to present. Each monthly file corresponds to a calendar month. Data is separated by the "orbit_pass" dimension into observations taken while the spacecraft is moving northwards (ascending) and while it is moving southwards (descending). For non-polar regions, ascending data is daytime and descending is nighttime, but at the poles the sun may be over the horizon for neither or both. The first element in the orbit_pass dimension is the ascending element, with data taken around its nominal 13.5 hour equatorial orbit pass time (1:30 PM local time). The second element is the descending element, with data taken around 1.5 hours or 1:30 AM local time. Variables orbit_pass, obs_time_tai93, obs_time_tai93_bnds, and obt_time_utc can help with interpretation.

2.2 Level-2 Algorithm Background

The AIRS Spectral OLR Level-3 data product is a product of processing AIRS Level 0 data through Level 1A, Level 1B, Level-2, and Level-3. For a definition of the NASA Data Processing Levels go to: https://earthdata.nasa.gov/earth-science-data-systems-program/policies/data-information-policy/data-levels

The algorithm to derive the observed spectral flux has been described in detail in Huang et al. (2008, 2010, and 2014) and Chen et al. (2013). In brief, the AIRS radiances of two thermal-IR bands (6.20–8.22 and 8.8–15.4μm) are used. The scene type info was taken from the collocated CERES SSF (single satellite footprint) data product (Loeb et al., 2005). A spectral anisotropic distribution model for each AIRS channel in the two thermal-IR bands was developed for every scene type defined in the CERES SSF. Spectral flux at each AIRS channel can then be estimated by applying the spectral anisotropic distribution model to the actual AIRS L1b radiance. A multiple linear regression scheme based on the principal component decomposition was then used to estimate the spectral flux over the spectral regions not covered by the AIRS observations (e.g., the far-IR region). In the end, spectral fluxes for each 10 cm^{-1} interval over the entire LW spectrum were derived. Note that, in the entire process, only the CERES SSF ancillary information about the scene type of each collocated AIRS and CERES footprint was used in the derivations. The collocated CERES radiometric measurements and CERES broadband OLR have never been used in the derivations. The footprint-level spectral fluxes were then averaged onto 2° latitude by 2°

longitude grids to form monthly averages for both all-sky and clear-sky observations. The monthly mean of clear-sky spectral flux is an average of the spectral flux from all collocated AIRS and CERES FOVs deemed as clear sky by the CERES SSF algorithm. The clear sky in the CERES SSF algorithm is defined as the FOV with coincident Moderate Resolution Imaging Spectroradiometer (MODIS) pixel-level cloud coverage within the FOV less than 0.1% (Loeb et al., 2005).

The Level-2 algorithms have been validated extensively in Huang et al. (2008), Huang et al. (2010), Chen et al. (2013), and Huang et al. (2014). For example, Figure 6 in Huang et al. (2008), Figure 3 in Huang et al. (2010), and Figure 3 in Chen et al. (2013) describes the fractional error for the 10-cm^{-1} spectral flux derived using Level-2 algorithms. For all 10cm^{-1} spectral intervals, the fractional error is usually well within 2% with maximum being around 5%. The validation against collocated CERES OLR was also presented in aforementioned references. At the FOV level, the difference between OLR summed up from Huang Spectral OLR and the CERES OLR is 2.15±5.51 Wm^{-2} for cloudy footprint and 0.67±1.52 Wm^{-2} for clear-sky footprint. Such difference is stable and within or comparable to the CERES radiometric calibration uncertainty (i.e., ~1%). Moreover, such difference also does not change with time as shown in Figure 2 in Huang et al. (2014).

Technical details of the Level-2 processing steps and calibrations can be found in the Algorithm Theoretical Basis Document (ATBD) and scientific references. See references.

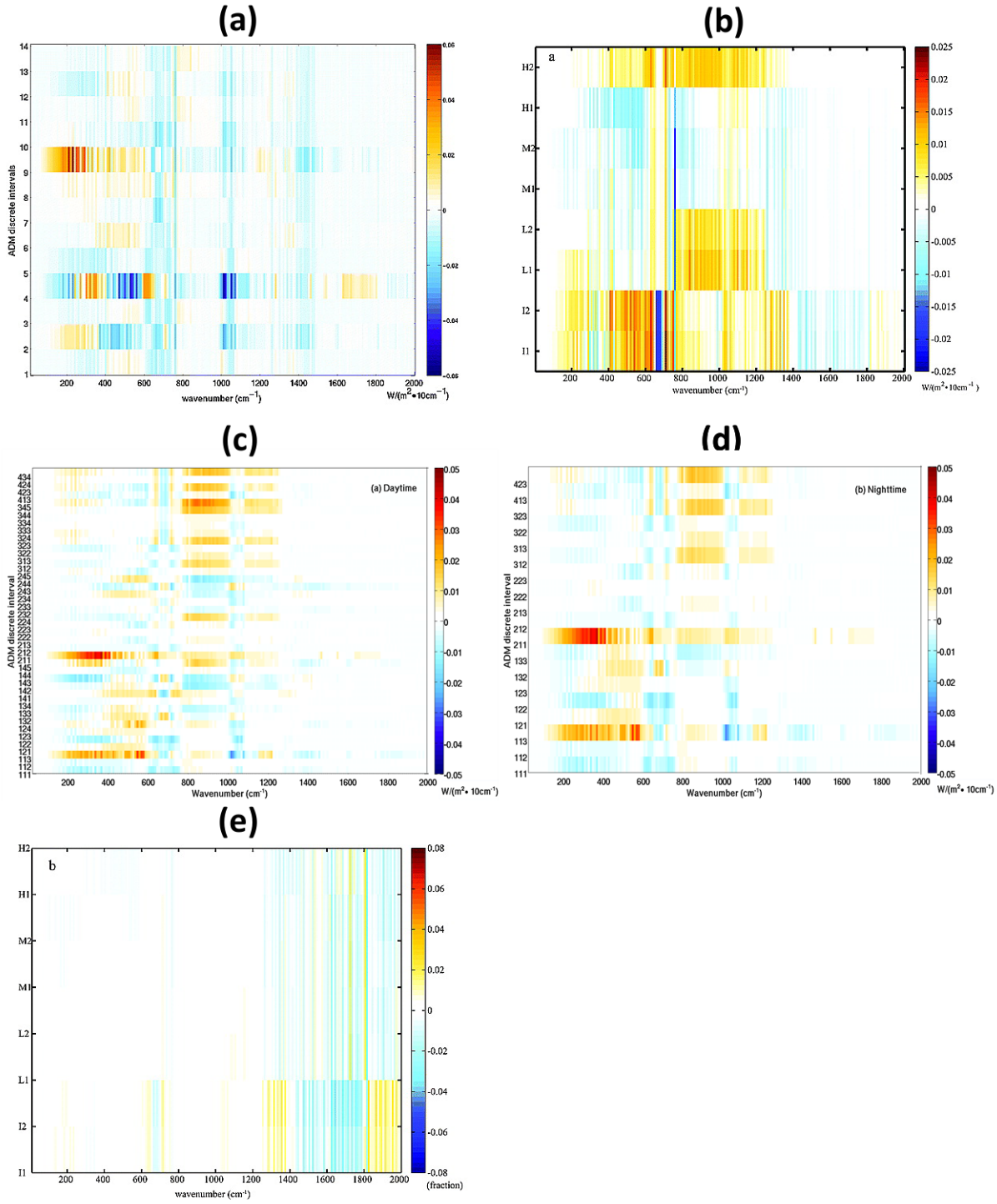


Figure 2.2.1 The mean differences between the predicted spectral fluxes based on synthetic AIRS spectra and the directly computed ones from MODTRAN5 for different discrete intervals defined in the CERES SSF data. (a) Adopted from Figure 6 in Huang et al. (2008) for 14 clear-sky discrete intervals over tropical ocean. (b) Adopted from Figure 3 in Huang et al. (2010) for 8 cloudy intervals. I, L, M, and H refer to inverse layer, low cloud, middle cloud, and high cloud, respectively. (c) and (d) Adopted from Figure 3 in Chen et al. (2013) for clear-sky discrete intervals

over near globe. (c) is for daytime and (d) is for nighttime. (e) Same as (b) but for fractional difference.

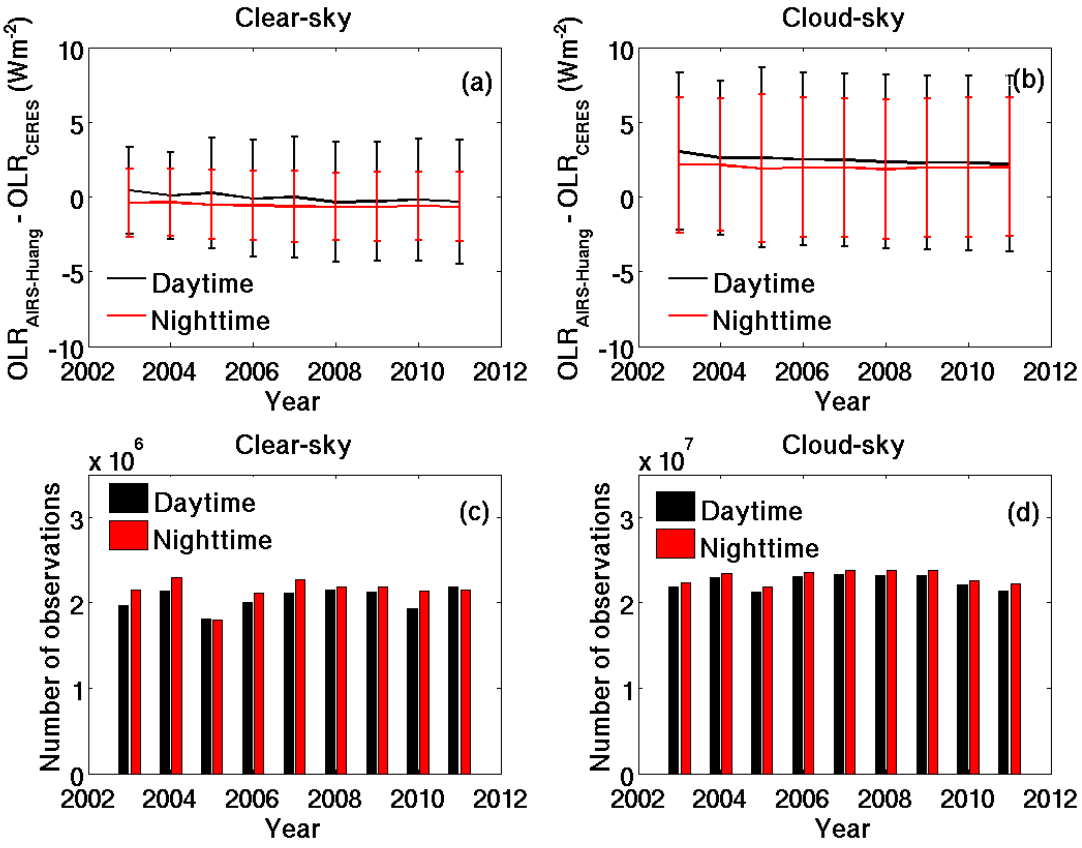


Figure 2.2.2 Adopted from Figure 2 in Huang et al. (2014). (a) Annual means of clear-sky $OLR_{AIRS\_Huang} - OLR_{CERES}$ differences over the entire globe for 2003–11. The vertical lines with ticks denote the ±1σ from the mean. Daytime and nighttime results are plotted separately. (b) As in (a), but for cloudy-sky observations. (c) Number of collocated AIRS and CERES clear-sky observations in each year from 2003 to 2011. Daytime and nighttime results are shown separately. (d) As in (c), but for cloudy-sky observations.

2.3 Level-3 Algorithm Summary

The Level-3 monthly algorithm selects which observations belong to each grid cell, determines which observations pass quality control, and averages the accepted observations.

Level-2 observations are determined to be ascending (A) or descending (D) according to the "scan_node_type" Level-1B variable.

Level-2 observations are associated with the 2x2 degree latitude/longitude grid cell in which the beam center {Longitude, Latitude} falls.

2.4 File Format and Structure

The files are in Network Common Data Form, version 4 (netCDF4/HDF5) format.

The product format takes advantage of the netCDF4 data model and makes use of groups, dimensions, variables and attributes to fully describe the science data.

2.5 Metadata

Every effort has been made to ensure that metadata conforms to the Climate and Forecasting (CF), Version 1.6, and Attribute Conventions for Data Discovery (ACDD), Version 1.3, guidelines.

See the full product specifications in Appendix B.

For more information on CF, refer to:
http://cfconventions.org/

For more information on ACDD, refer to:
http://wiki.esipfed.org/index.php?title=Category:Attribute_Conventions_Dataset_Discovery

2.6 File Naming Convention

File names for AIRS Spectral OLR products are composed of tokens separated by the delimiter '.'. They have the form:
AIRS.AQUA.AIRS.yyyymmdd.ggg.L3)SpecOLR.std.vmm_mm_mm.F.ttttttttttt.nc

where:

AIRS.AQUA.AIRS identifies the project, platfrom and instrument. This as an AIRS-instrument-suite product.

yyyymmdd is the year/month/day of the start of the granule.

L3_SpecOLR is the processing level (L3) and product type (spectral OLR).

std is for standard product

vmm.mm.mm is the product version. "v" is the literal character 'v'. It is followed by three pairs of numbers separated by "_"s. These are the major & minor version numbers.

- Version 6.1 Level-3 products are derived from version 5 Level-1B products, but are tagged v06_01_00 because their release is between AIRS v6 and v7 release cycles.

F is processing facility ID:
"G" for NASA GSFC GES DISC official archival system

"J" for NASA JPL AIRS TLSCF official processing
"X" for anything else

`ttttttttttt` is AIRS run tag (00000000000 - 99999999999).
This field is designed to ensure LocalGranuleIDs are unique, even when the same software is used to reprocess the same data. It is local processing time as yymmddhhmmss. (year, month, day, hour, minute, second).
Note: this corresponds to Product-Specific Attribute (PSA) "AIRSRunTag".

`.nc` is the filetype extension for all netCDF products

Example Filename: Monthly Spectral OLR Level-3 product for July 2004:

```
AIRS.AQUA.AIRS.20040701.M01.L3_SpecOLR.std.v06_01_00.M.191024142907.nc
```

2.7 Time Representation

Observation times are provided in both UTC and TAI93 representations as a convenience to users.

Coordinated Universal Time (UTC) is the international standard for representation of time. UTC times are expressed in human-readable form, as a set of values indicating year, month, day, hour and so on. In the data stream received from the satellite, observation times are represented as UTC.

Timestamps in product filenames and attributes are represented as UTC and formatted according to the "ISO 8601:2004" standard. For example, the time January 25, 2016 at 13:00 may be represented as either of the following:

2016-01-25T13:00Z
20160125T1300

The longer form is used in attributes, and the more compact form is used in filenames. The character "Z" indicates "Zulu time", or UTC.

International Atomic Time (TAI) is expressed as number of seconds elapsed on the surface of the Earth since some reference UTC time. The term "TAI93" indicates that the reference time is the beginning of the year 1993, or 1993-01-01T00:00:00Z. This reference time was chosen to be consistent with data products from other instruments, and to allow for precise representation of times spanning the expected mission length.

3.0 Data Content

The Level-3 data product is written in netCDF4 format and therefore makes use of groups, dimensions, variables and attributes (global & variable). Every netCDF4 file contains, at a minimum, one root group which is unnamed.

A full profile of the contents of the files is included in Appendix B.

Selected fields are highlighted in this section.

3.1 Dimensions

Key dimensions.

Table 3.1 Key Dimensions

Name	**Size**	**Description**
wnum	199	wavenumber
orbit_pass	2	orbit pass: {Ascending, Descending}
lon	180	2-degree longitude grid
lat	90	2-degree latitude grid

3.2 Global Attributes (metadata)

There are two types of attributes: global & variable. In this section we will talk about global attributes. Global attributes, sometimes referred to as 'file-level attributes', provide information about the entire file. This includes observation times, publisher and creator information, and data provenance. Many attributes are required to conform to the CF & ACDD standards while other attributes are written for consistency with legacy products.

A full definition of the global attributes can be found in Appendix B.

Table 3.2.2 Key Global Attributes

Name	Description
date_created	The date on which this version of the data was created
identifier_product_doi	digital signature (DOI)

3.3 Variable Attributes

Each variable has its own associated attributes. Variable attributes are a CF standard and are used to describe the variable in more detail to properly interpret its value.

Table 3.3: Variable Attributes

Attribute	Description
units	units, for variables that represent physical quantities
_FillValue	a single sentinel value indicating the data point contains fill instead of valid data
standard_name	standard name from the CF standard name table, if one exists for the quantity being represented
long_name	a longer name describing the quantity being represented, suitable for a plot title
description	a longer description of the quantity being represented
valid_range	a pair of values indicating the minimum and maximum values to be considered valid
coordinates	a space-separated list of the names of other variables that are coordinates for this variable
coverage_content_type	ACDD/ISO field categorizing types of data: • image • thematicClassification • physicalMeasurement • auxillaryInformation • coordinate • modelResult • qualityInformation • referenceInformation https://geo-ide.noaa.gov/wiki/index.php?title=ISO_19115_and_19115-2_CodeList_Dictionaries#MD_CoverageContentTypeCode
ancillary_variables	a space-separated list of the names of other variables that contain information about this variable
bounds	defines the extent, for cell variables including obs_time_tai93, lon, lat, and cld_pres_lay
cell_methods	describes statistical methods used to derive data, for cell variables

3.4 Group Structure

One feature which was added to netCDF4 is the ability to structure files with "groups", which are similar to a directory hierarchy. SounderCDF files are designed so that all of the most commonly needed information is contained in "/", the root group. Subgroups contain more specialized information.

These are the groups:

Group	Purpose
/ (root)	Main group, with temperature and water vapor profiles, along with supporting location and quality information
/nobs	The number of observations for the gridded physical quantities

3.5 Geolocation

This product use a simple latitude/longitude 2x2 degree grid.

Longitudes run from -180 to 180 degrees East, with grid centers at {-179.0, -177.0, …179.0} as recorded in variable "lon". Associated bounds variable lon_bnds gives the boundaries of each cell: { [-180, -178], [-178, -176], … [178, 180]}.

Latitudes run from -90 to 90 degrees North, with grid centers at {-89.0, -87.0, …89.0} as recorded in variable "lat". Associated bounds variable lat_bnds gives the boundaries of each cell: { [-90, -88], [-88, -86], … [88, 90]}.

3.6 Science Data Variables

The key science data variables give the all-sky and clear-sky OLR both integrated and over 10-cm^{-1} bands.

For each retrieved variable there is a corresponding variable in the /nobs group giving the number of observations associated with it. For example nobs/olr_clr _nobs gives the number of observations contributing to each element of olr_clr.

Key science data fields are defined below. See Appendix B for a full listing.

Table 3.6 Key Science Data Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
olr	float32	orbit_pass, lat, lon	outgoing longwave radiation flux integrated over 10 to 2000 cm^{-1}	W / m^2	nobs
olr_clr	float32	orbit_pass, lat, lon	outgoing longwave radiation flux integrated over 10 to 2000 cm^{-1} where clear-sky	W / m^2	nobs
olr_spectral	float32	orbit_pass, wnum, lat, lon	All-sky outgoing longwave radiation flux per 10 cm^{-1}	W / m^2	nobs
olr_clr_spectral	float32	orbit_pass, wnum, lat, lon	Outgoing longwave radiation flux per 10 cm^{-1} where clear-sky	W / m^2	nobs

See Appendix A for some images made from these variables.

3.8 Missing Data / Fill Values

Fill values are used where there is no valid data, including profiles level with pressures greater than the surface pressure. The fill value is indicated by the attribute '_FillValue'. It is advised to check the data for fill values before it is used. The fill values per variable datatype are listed in the table below.

Table: 3.8.1 Fill Values

Variable Type	Fill Value
unsigned 8-bit integer	255UB
unsigned 16-bit integer	65535US
unsigned 32-bit integer	4294967295U
floating point	9.96921e+36

3.9 Key supporting information variables for profiles

These variables provide supporting information to interpret the science variables.

Name	Type	Dimensions	Description	Units	Ancillary Variables
wnum	float32	wnum	OLR wavenumber band centers	cm^{-1}	bnds

Name	Type	Dimensions	Description	Units	Ancillary Variables
lon	float32	lon	Degrees longitude (2-degree cell size)	degrees_east	bnds
lat	float32	lat	Degrees latitude (2-degree cell size)	degrees_north	bnds
orbit_pass	float32	orbit_pass	Nominal solar time when the spacecraft passes over the equator. Orbit pass bounds are defined by closest approach of the spacecraft to the poles.	hours	

4.0 Options for Reading the Data

The product files are written in netCDF4/HDF5. Because netCDF4 builds upon the classic netCDF data model using HDF5 as the storage layer, a user of the data product can take full advantage of tools and libraries readily available to access the data.

Every netCDF4 file is considered an HDF5 file, however, not every HDF5 file is necessarily a netCDF4 file. A limited subset of the HDF5 data model and file format features are used in netCDF4 files. Conformance to the earlier mentioned CF & ACDD standards allows for users to take advantage of most netCDF interfaces.

Tools and libraries for reading netCDF4 as well as a netCDF Users' Guide are written and maintained by Unidata and can be found online at:
http://www.unidata.ucar.edu/software/netcdf/

Panoply is a good tool for visualizing these files. See Appendix A for images generated using Panoply with this product. https://www.giss.nasa.gov/tools/panoply/

There are a number of interfaces available for reading netCDF for different programming languages including: C/C++, Fortran, Matlab, IDL, Python and Perl.

The files can also be accessed with HDF5 tools and libraries available at:
https://www.hdfgroup.org/products/hdf5_tools/

An example to read data in Matlab:

```
lat = ncread(fname,'lat');

lon = ncread(fname,'lon');
```

```
olr_spectral = ncread(fname,'olr_spectral');
olr_spectral_nobs = ncread(fname,'nobs/olr_spectral_nobs');
```

5.0 Data Services

The product is available to the user community via the Goddard Distributed Active Archive Center (GDAAC). https://disc.gsfc.nasa.gov/
Data at the GDAAC is organized by unique shortnames and version numbers.

shortname.version	**Description**
Product described in this document	
AIRSIL3MSOLR_6.1	AIRS Community Level-3 monthly spectral OLR product
Related data sets at GDAAC	
AIRIBRAD_005	Level-1B AIRS product used as input
AIRX3SPM_006, AIRS3SPM_006	AIRS Science-team Level-3 monthly support product, including a differently-derived, coarser spectral OLR

6.0 References

[1] Strow, L. L., Scott E. Hannon, Margaret Weiler, Kenneth Overoye, Steven L. Gaiser, and Hartmut H. Aumann, Prelaunch Spectral Calibration of the Atmospheric Infrared Sounder (AIRS), IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 41, NO. 2 (2003).

[2] AIRS Science Team/Moustafa Chahine (2007), AIRS/Aqua L1B Infrared (IR) geolocated and calibrated radiances V005, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), https://disc.gsfc.nasa.gov/datacollection/AIRIBRAD_005.html

[3] Huang, X. L., et al., Aqua AIRS Huang Spectral OLR Algorithm Theoretical Basis Documents version 1.0.

[4] Huang, X. L., W. Z. Yang, N. G. Loeb, and V. Ramaswamy, 2008: Spectrally resolved fluxes derived from collocated AIRS and CERES measurements and their application in model evaluation: 1. clear sky over the tropical oceans. J. of Geophys. Res. Atmos, 113, D09110, doi: 10.1029/2007JD009219.

[5] Huang, X.L., N.G. Loeb, and W.Z. Yang, 2010: Spectrally resolved fluxes derived from collocated AIRS and CERES measurements and their application in model evaluation: 2. cloudy sky and band-by-band cloud radiative forcing over the tropical oceans, J. of Geophys. Res. Atmos, 115, D21101, doi:10.1029/2010JD013932.

[6] Chen, X.H., X.L. Huang, N. G. Loeb, H. L. Wei, 2013: Comparisons of clear-sky outgoing far-IR flux inferred from satellite observations and computed from three most recent reanalysis products, J. Climate, 26(2), 478-494, doi:10.1175/JCLI-D-12-00212.1.

[7] Huang, X. L., X.H. Chen, G. L. Potter, L. Oreopoulos, J. N.S. Cole, D.M. Lee, N. G. Loeb, 2014: A global climatology of outgoing longwave spectral cloud radiative effect and associated effective cloud properties, J. Climate, 27, 7475-7492, doi:10.1175/JCLI-D-13-00663.1.

[8] Chen, X. H., X. L. Huang, 2016: Deriving clear-sky longwave spectral flux from space-borne hyperspectral radiance measurements: a case study with AIRS observations, Atmospheric Measurement Techniques, 9, 6013-6023, doi:10.5194/amt-9-6013-2016.

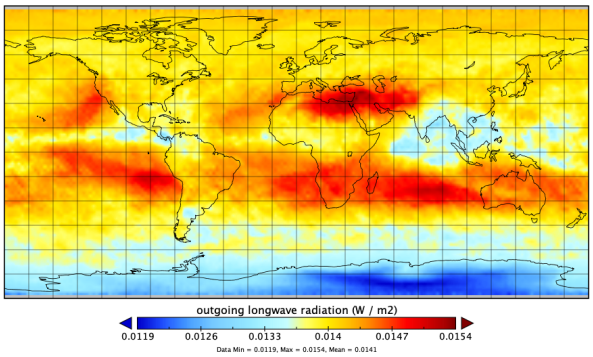
[9] Loeb, N. G., S. Kato, K. Loukachine, and N. Manalo-Smith, 2005: Angular distribution models for top-of-atmosphere radiative flux estimation from the Clouds and the Earth's Radiant Energy System instrument on the Terra satellite. Part I: Methodology. J. Atmos. Oceanic Technol., 22, 338–351, doi:10.1175/JTECH1712.1.

Appendix A: Sample images

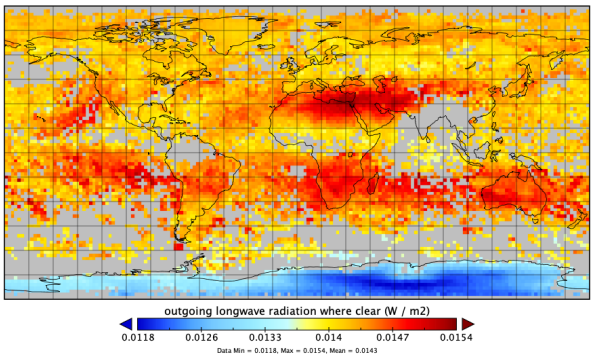
These images for July 2004 were generated with Panoply.

2004-07 monthly Spectral OLR Ascending/day

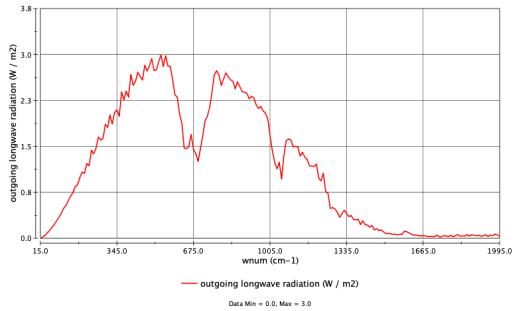
outgoing longwave radiation 15 cm-1



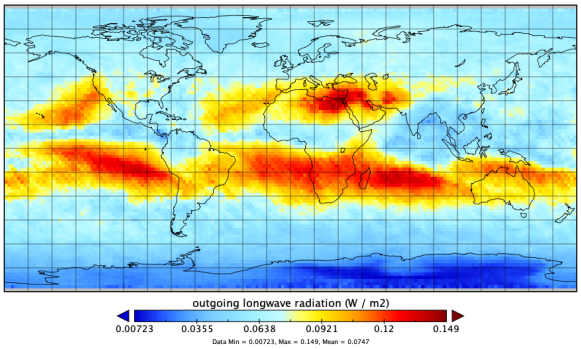
outgoing longwave radiation where clear 15 cm-1



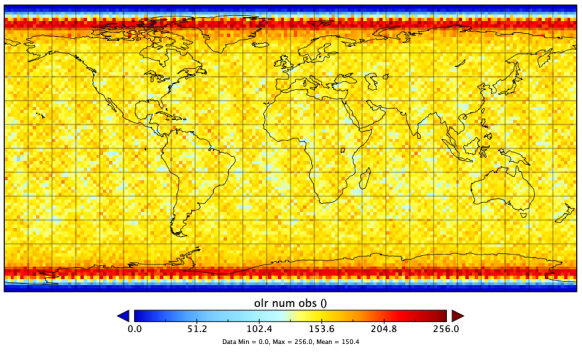
outgoing longwave radiation



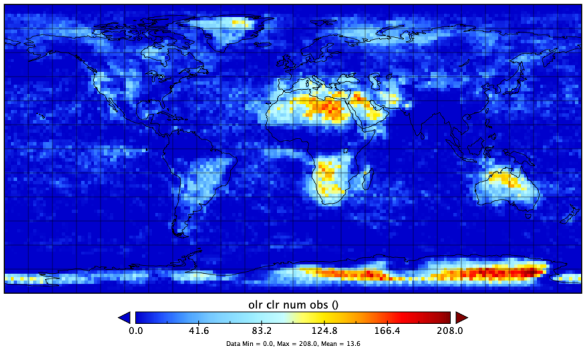
outgoing longwave radiation 1805 cm-1



olr num obs



olr clr num obs



Appendix B: Detailed file formats

These tables show all of the dimensions, global attributes, and variables in the AIRS L3 monthly Spectral OLR product.

For clarity, some variable attributes are omitted, including long_name, standard_name, coverage_content_type, axis, valid_range, coordinates, and _FillValue.

To get a complete listing including all variable attributes, apply "ncdump -h" to any netCDF4 product file.

L3 HUANG Spectral OLR AIRS Monthly Interface Specification
Interface Specification Version 02.01.04
11-01-2019

Global Groups

Path	Description
/	Science means
/nobs	Counts of observations

Global Dimensions

Name	Size	Description
wnum	199	wavenumber
orbit_pass	2	orbit pass: {Ascending/Day, Descending/Night}
lon	180	2-degree longitude grid
lat	90	2-degree latitude grid
bnds_1d	2	Boundaries for 1-d fields like lon: min, max
utc_tuple	8	parts of UTC time

Global Attributes

Name	Type	Size	Value	Description
keywords	string	1	ATMOSPHERE > ATMOSPHERIC RADIATION > OUTGOING LONGWAVE RADIATION	A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute).
Conventions	string	1	CF-1.6, ACDD-1.3	A comma-separated list of the conventions that are followed by the dataset.
history	string	1		Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance.
source	string	1	AIRS instrument telemetry	The method of production of the original data. If it was model-generated, source should name the model and its version. If it is observational, source should characterize it. This attribute is defined in the CF Conventions. Examples: 'temperature from CTD #1234'; 'world model v.0.1'.

Name	Type	Size	Value	Description
processing_level	string	1	3	A textual description of the processing (or quality control) level of the data.
product_name_type_id	string	1	L3_SpecOLR	Product name as it appears in product_name (L1A, L1B, L2, SNO_AIRS_CrIS)
comment	string	1		Miscellaneous information about the data or methods used to produce it. Can be empty.
acknowledgment	string	1	Support for this research was provided by NASA.	A place to acknowledge various types of support for the project that produced this data.
license	string	1	Freely Distributed	Provide the URL to a standard or specific license, enter "Freely Distributed" or "None", or describe any restrictions to data access and distribution in free text.
standard_name_vocabulary	string	1	CF Standard Name Table v28	The name and version of the controlled vocabulary from which variable standard names are taken. (Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.) Example: 'CF Standard Name Table v27'.
date_created	string	1		The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended, as described in

Name	Type	Size	Value	Description
				the Attribute Content Guidance section.
creator_name	string	1	Xianglei Huang and Xiuhong Chen	The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_email	string	1	xianglei@umich.edu; xiuchen@umich.edu	The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_url	string	1	http://www-personal.umich.edu/~xianglei/	The URL of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
institution	string	1	University of Michigan	Processing facility that produced this file
project	string	1	AIRS	The name of the project(s) principally responsible for originating this data. Multiple projects can be separated by commas, as described under Attribute Content Guidelines. Examples: 'PATMOS-X', 'Extended Continental Shelf Project'.
product_name_project	string	1	AIRS	The name of the project as it appears in the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
publisher_name	string	1	Goddard Earth Sciences Data and Information Services Center	The name of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.

Name	Type	Size	Value	Description
publisher_email	string	1	gsfc-help-disc@lists.nasa.gov	The email address of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_url	string	1	http://disc.sci.gsfc.nasa.gov/	The URL of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
geospatial_bounds	string	1	POLYGON ((-90.0 -180.0, 90.0 -180.0, 90.0 180.0, -90.0 180.0, -90.0 -180.0))	Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are latitude (decimal degrees_north) and longitude (decimal degrees_east), in that order. Longitude values in the default case are limited to the -180, 180) range. Example: 'POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))'.
geospatial_bounds_crs	string	1	EPSG:4326	The coordinate reference system (CRS) of the point coordinates in the geospatial_bounds attribute. This CRS may be 2-dimensional or 3-dimensional, but together with

Name	Type	Size	Value	Description
				geospatial_bounds_vertical_crs, if that attribute is supplied, must match the dimensionality, order, and meaning of point coordinate values in the geospatial_bounds attribute. If geospatial_bounds_vertical_crs is also present then this attribute must only specify a 2D CRS. EPSG CRSs are strongly recommended. If this attribute is not specified, the CRS is assumed to be EPSG:4326. Examples: 'EPSG:4979' (the 3D WGS84 CRS), 'EPSG:4047'.
geospatial_lat_min	float	1	-90.0	Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_min specifies the southernmost latitude covered by the dataset.
geospatial_lat_max	float	1	90.0	Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_max specifies the northernmost latitude covered by the dataset.
geospatial_lon_min	float	1	-180.0	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max.
geospatial_lon_max	float	1	180.0	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_max specifies the easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate

Name	Type	Size	Value	Description
				the bounding box extends from geospatial_lon_max, through the longitude range discontinuity meridian (either the antimeridian for -180:180 values, or Prime Meridian for 0:360 values), to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175).
time_coverage_start	string	1		Nominal start time. Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_first_valid_obs	string	1		Describes the time of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_mid	string	1		Describes the midpoint between the nominal start and end times. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_coverage_end	string	1		Nominal end time. Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_last_valid_obs	string	1		Describes the time of the last valid data point in the data set. Use the ISO 8601:2004 date extended format.

Name	Type	Size	Value	Description
time_coverage_duration	string	1	P0000-01-00T00:00:00	Describes the duration of the data set. Use ISO 8601:2004 duration format, preferably the extended format as recommended in the Attribute Content Guidance section.
product_name_duration	string	1	M01	Product duration as it appears in product_name (M01 means one full month)
creator_type	string	1	University	Specifies type of creator with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the creator is assumed to be a person.
creator_institution	string	1	University of Michigan	The institution of the creator; should uniquely identify the creator's institution. This attribute's value should be specified even if it matches the value of publisher_institution, or if creator_type is institution.
product_version	string	1	v01.00.00	Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version.
keywords_vocabulary	string	1	GCMD:GCMD Keywords	If you are using a controlled vocabulary for the words/phrases in your "keywords" attribute, this is the unique name or identifier of the vocabulary from which keywords are taken. If more than one keyword vocabulary is used, each may be presented with a prefix and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key. Example: 'GCMD:GCMD Keywords,

Name	Type	Size	Value	Description
				CF:NetCDF COARDS Climate and Forecast Standard Names'.
platform	string	1	AQUA > Earth Observing System	Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary.
platform_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "platform" attribute.
product_name_platform	string	1	AQUA	Platform name as it appears in product_name
instrument	string	1	AIRS > Atmospheric Infrared Sounder	Name of the contributing instrument(s) or sensor(s) used to create this data set or product. Indicate controlled vocabulary used in instrument_vocabulary.
instrument_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "instrument" attribute.
product_name_instr	string	1	AIRS	Instrument name as it appears in product_name
product_name	string	1		Canonical fully qualified product name (official file name)
product_name_variant	string	1	std	Processing variant identifier as it appears in product_name. 'std' (shorthand for 'standard') is to be the default and should be what is seen in all public products.
product_name_version	string	1	v06_01_00	Version number as it appears in product_name (v01_00_00)
product_name_producer	string	1	M	Production facility as it appears in product_name (single character)

Name	Type	Size	Value	Description
				'T' is the default, for unofficial local test products
product_name_timestamp	string	1		Processing timestamp as it appears in product_name (yymmddhhmmss)
product_name_extension	string	1	nc	File extension as it appears in product_name (typically nc)
gran_id	string	1		Unique granule identifier yyyymmdd of granule start day, including year, month, and day of granule start time
featureType	string	1	point	structure of data in file
data_structure	string	1	grid	a character string indicating the internal organization of the data with currently allowed values of 'grid', 'station', 'trajectory', or 'swath'. The 'structure' here generally describes the horizontal structure and in all cases data may also be functions, for example, of a vertical coordinate and/or time. (If using CMOR pass this in a call to cmor_set_cur_dataset_attribute.)
cdm_data_type	string	1	Grid	The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.)
id	string	1	10.5067/5P7KQ31XI7XJ	An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be

Name	Type	Size	Value	Description
				globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters.
naming_authority	string	1	http://dx.doi.org	The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: 'edu.ucar.unidata'.
identifier_product_doi	string	1	10.5067/5P7KQ31XI7XJ	digital signature
identifier_product_doi_authority	string	1	http://dx.doi.org	digital signature source
algorithm_version	string	1	L3 SpecOLR: v1.0.0	The version of the algorithm in whatever format is selected by the developers. After the main algorithm name and version, versions from multiple sub-algorithms may be concatenated with semicolon separators. (ex: 'CCAST 4.2; BB emis from MIT 2016-04-01') Must be updated with every delivery that changes numerical results.
production_host	string	1		Identifying information about the host computer for this run. (Output of linux "uname -a" command.)
format_version	string	1	v02.01.04	Format version.
input_file_names	string	1	(Not used in this release)	Semicolon-separated list of names or unique identifiers of files that were used to make this product. There will always be one space after each semicolon. There is no final semicolon.

Name	Type	Size	Value	Description
input_file_types	string	1	(Not used in this release)	Semicolon-separated list of tags giving the role of each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
input_file_dates	string	1	(Not used in this release)	Semicolon-separated list of creation dates for each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
AutomaticQualityFlag	string	1	Passed	"Passed": the granule contains a non-degraded calibrated brightness temperature, radiance, or retrieved value for at least one value in a geolocated FOV; "Suspect": the granule does not qualify as "Passed" but contains a (possibly degraded) calibrated or retrieved value (possibly without associated geolocation); "Failed": the granule contains no calibrated or retrieved values.
qa_no_data	string	1	FALSE	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".
title	string	1	Level-3 Spectral OLR AIRS	a succinct description of what is in the dataset. (= ECS long name)
summary	string	1	The Level-3 spectral Outgoing Longwave Radiation (OLR) monthly product includes retrieved spectral OLR using the Huang algorithm for one month. The main product is OLR in 10-cm^-1 bands.	A paragraph describing the dataset, analogous to an abstract for a paper.
shortname	string	1	AIRSIL3MSOLR	ECS Short Name

Name	Type	Size	Value	Description
metadata_link	string	1	http://disc.sci.gsfc.nasa.gov/	A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute.
references	string	1	Huang, X. L., W. Z. Yang, N. G. Loeb, and V. Ramaswamy, 2008: Spectrally resolved fluxes derived from collocated AIRS and CERES measurements and their application in model evaluation: 1. clear sky over the tropical oceans. J. of Geophys. Res. Atmos, 113, D09110, doi: 10.1029/2007JD009219. Huang, X.L., N.G. Loeb, and W.Z. Yang, 2010: Spectrally resolved fluxes derived from collocated AIRS and CERES measurements and their application in model evaluation: 2. cloudy sky and band-by-band cloud radiative forcing over the tropical oceans, J. of Geophys. Res. Atmos, 115, D21101, doi:10.1029/2010JD013932. Chen, X.H., X.L. Huang, N. G. Loeb, H. L. Wei, 2013: Comparisons of clear-sky outgoing far-IR flux inferred from satellite observations and computed from three most recent reanalysis products, J. Climate, 26(2), 478-494, doi:10.1175/JCLI-D-12-00212.1. Huang, X. L., X.H. Chen, G. L. Potter, L. Oreopoulos, J. N.S. Cole, D.M. Lee, N. G. Loeb, 2014: A global climatology of outgoing longwave spectral cloud radiative effect and	ATDB and design documents describing processing algorithms. Can be empty.

Name	Type	Size	Value	Description
			associated effective cloud properties, J. Climate, 27, 7475-7492, doi:10.1175/JCLI-D-13-00663.1. Chen, X. H., X. L. Huang, 2016: Deriving clear-sky longwave spectral flux from space-borne hyperspectral radiance measurements: a case study with AIRS observations, Atmospheric Measurement Techniques, 9, 6013-6023, doi:10.5194/amt-9-6013-2016.	

Global Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
olr	float32	orbit_pass, lat, lon	outgoing longwave radiation flux integrated over 2 to 2800 cm^{-1}	W / m^2	nobs
olr_clr	float32	orbit_pass, lat, lon	outgoing longwave radiation flux integrated over 2 to 2800 cm^{-1} where clear-sky	W / m^2	nobs
olr_spectral	float32	orbit_pass, wnum, lat, lon	All-sky outgoing longwave radiation flux per 10 cm-1	W / m^2	nobs
olr_clr_spectral	float32	orbit_pass, wnum, lat, lon	Outgoing longwave radiation flux per 10 cm-1 where clear-sky	W / m^2	nobs
wnum	float32	wnum	OLR wavenumber band centers	cm^{-1}	bnds

Name	Type	Dimensions	Description	Units	Ancillary Variables
obs_time_tai93	double	orbit_pass	Nominal midtime for observations included in grid	seconds since 1993-01-01 00:00	bnds
obs_time_utc	uint16	orbit_pass, utc_tuple	Nominal midtime for observations included in grid as an array of integers: year, month, day, hour, minute, second, millisec, microsec		
lon	float32	lon	Degrees longitude	degrees_east	bnds
lat	float32	lat	Degrees latitude	degrees_north	bnds
orbit_pass	float32	orbit_pass	Nominal solar time when the spacecraft passes over the equator. Orbit pass bounds are defined by closest approach of the spacecraft to the poles.	hours	
utc_tuple_lbl	string	utc_tuple	names of the elements of UTC when it is expressed as an array of integers year, month, day, hour, minute, second, millisecond, microsecond		

nobs Variables

Name	Type	Dimensions	Description	Units
olr_nobs	int32	orbit_pass, lat, lon	olr number of observations	unitless
olr_clr_nobs	int32	orbit_pass, lat, lon	olr_clr number of observations	unitless
olr_spectral_nobs	int32	orbit_pass, lat, lon	olr_spectral number of observations	unitless

Name	Type	Dimensions	Description	Units
olr_clr_spectral_nobs	int32	orbit_pass, lat, lon	olr_clr_spectral number of observations	unitless
nobs_max	int32	orbit_pass, lat, lon	Maximum number of observations including those for which no value was retrieved	unitless