# *Outgoing Longwave Radiation (OLR) – Monthly CDR (01B-06)*
# User Guide

## 1. Document Purpose

### 1.1 Intent

This document is intended for users who wish to use the *Outgoing Longwave Radiation (OLR) - Monthly*. Users are not expected to be experts in the data. This document summarizes essential information needed to understand the context of the dataset observations and issues that affect its fitness for purpose. References at the end of this document provide additional resources and information.

### 1.2 Dataset information

| | |
|---|---|
| Dataset name and version: | *Outgoing Longwave Radiation (OLR) – Monthly v3.0* |
| Digital Object Identifier (DOI): | *doi:10.25921/edx3-v958* |
| Email address: | *monthly_olr_contacts@noaa.gov* |

# Table of Contents

# 2. Revisions

## 2.1 Document revision history

| Revision Number | Date | Summary of changes |
|---|---|---|
| 0 | 10/23/2025 | First release of user guide describing version *v03r00 (or v3.0)*. |
| | | |
| | | |

## 2.2 Dataset history

The Outgoing Longwave Radiation (OLR) – Monthly v03r00 CDR product released in 2025 is a major upgrade to the previous version v02r07. In this new release, radiance observations from the long historical operational sounder HIRS and the currently operational hyperspectral sounding instruments, IASI and CrIS, are integrated consistently to generate the time series of globally gridded monthly OLR maps at a spatial resolution of 2.5° from 1979 to present.

The previous version v01r02 is generated with HIRS radiance observations only.

# 3. CDR Overview

## 3.1 Summary of the dataset

OLR is one of the most fundamental environment variables for describing the earth-atmospheric system. It is one of the three components at the top of the atmosphere that determine the radiation balance for the earth, as an isolated system. It is an essential parameter for monitoring climate variability. As the OLR is an integrated quantity that depends on the earth surface and atmospheric conditions, it is a powerful diagnostic tool for understanding various processes and for numerical weather prediction model evaluation. Beside radiation and energy balance research, many applications use OLR as surrogate to cloud activities for dynamical and ocean-atmospheric coupling processes, e.g., for large-scale precipitation estimation and tropical dynamics diagnostics (MJO, ENSO).

## 3.2 File naming convention

The file naming convention for the Final OLR – Monthly CDR product is
"*OLR-Monthly_v03r00_s197901_eYYYYMM.nc",*
where "sYYYYMM" specifies the starting date as Jan 1979, while the "eYYYYMM" specifies the ending date is monthly "MM" of year "YYYY".

## 3.3 File Format

NOAA Climate Data Records (CDRs) are provided in netCDF format. More information on this format is provided by Unidata. Most every programming language and several stand-alone software packages (both free and paid) can process netCDF data.

### 3.4 Spatial Coverage

The OLR – Monthly CDR product contains time series of globally gridded maps. The spatial resolution is 2.5°x2.5° equal-angle grid with 144x72 grid boxes. The OLR value is considered representative at the center of a grid box.

### 3.5 Temporal Coverage

The OLR – Monthly CDR product time series span from 1979-01 to the present. The lags of the data availability are about 5 days.

## 4. CDR production

### 4.1 Observational data sources (input data)

The primary input for OLR – Monthly CDR derivation is the radiance observations from operational sounder instruments, including HIRS, IASI, and CrIS. OLR is also estimated with radiance observations from Geostationary Imagers to assist resolving diurnal variation in temporal integration.

**A. HIRS**

HIRS is one of the three sounding instruments that constitute the TIROS Operational Vertical Sounder (TOVS, and later becomes Advanced TOVS, ATOVS) system onboard the NOAA TIROS-N series and Eumetsat Metop-A/B satellites. The detailed description of HIRS instrument characteristics, Level-1b data format, the TOVS system, and the system configurations for the NOAA TIROS-N series polar orbiters can be found in the NOAA Polar Orbiter Data (POD) User's Guide (1998 version) and NOAA KLM User's Guide (2009 version).

There are some relatively minor variations in HIRS instrument design. **Table 1** lists the HIRS instrument parameters for the variant versions (cf. NOAA POD User’s Guide Table 4.0-1; NOAA KLM User’s Guide Section 3.2.2 and Appendix J). It’s noteworthy to point out that the onboard warm target calibration reference has been changed from two blackbodies in HIRS/2 and HIRS/2I to one blackbody in HIRS/3 and 4. The HIRS/4 FOV resolution is enhanced to 10 km, which is about a two-fold improvement over the earlier HIRS versions.

HIRS consists of nineteen infrared channels (channels 1-19) and one visible channel (channel 20). **Table 2** lists the central wavenumbers and the sensing properties for the HIRS/2 on NOAA-9 as an example, with the channels used in HIRS OLR algorithm indicated. Specifications for HIRS/3 and 4 are available on NOAA KLM User’s Guide.

**Table 3** describes the HIRS instrument types and the availability of HIRS Level-1B data. The near real-time instrument health condition is available at NESDIS POES Status Monitoring website (http://www.oso.noaa.gov/poesstatus/ as of July 18, 2011). The satellite ID is the code name for these polar orbiters that will be referred in the OLR – Monthly CDR production package and in this document henceforth.

**Table 1** Description of instrument parameters for variant versions of HIRS instruments with an assumed satellite altitude of 833 km.

| Parameters | HIRS/2 | HIRS/2I | HIRS/3 | HIRS/4 |
|---|---|---|---|---|
| Calibration | Two Stable blackbodies and space background | Two Stable blackbodies and space background | One Stable blackbody (290K) and space background | One Stable blackbody (286K) and space background |
| Cross-track scan angle (degrees from nadir) | ± 49.5 | ± 49.5 | ± 49.5 | ± 49.5 |
| Scan time (seconds) | 6.4 | 6.4 | 6.4 | 6.4 |
| Number of steps | 56 | 56 | 56 | 56 |
| Angular FOV (degrees) | 1.22 | 1.40 | 1.40 (Ch1-12)<br>1.3 (Ch13-19) | 0.69 |
| Step angle (degrees) | 1.8 | 1.8 | 1.8 | 1.8 |
| Step time (seconds) | 0.1 | 0.1 | 0.1 | 0.1 |
| Ground IFOV at nadir (km diameter) | 17.4 | 20.4 | 20.3 (Ch1-12)<br>18.9 (Ch13-19) | 10 |
| Ground IFOV at end of scan | 58.5 km cross-track x 29.9 km along-track | 68.3 km cross-track x 34.8 km along-track | 68.3 km<br>cross-track x 34.8 km<br>along-track | 34.2 km<br>cross-track x<br>17.4 km<br>along-track |
| Distance between IFOV centers (km along-track) | 42.0 | 42.0 | 42 | 42 |
| Swath width | ± 1120 km | ± 1124 km | ± 1124 km | ± 1107 km |
| Data precision (bits) | 13 | 13 | 13 | 13 |

**Table 2** Description of HIRS channel spectral locations and sensing properties. The channels that are used by OLR algorithm are shown. Note that the OLR retrieving channels for HIRS/3 and 4 are different from those of HIRS/2. There are seven channels that are used in the OLR retrieval.

| Channel | Central wavenumber ($cm^{-1}$) | Used in HIRS/2 OLR Algorithm | Sensing Properties |
|---|---|---|---|
| 1 | 667.67 | | 15 μm $CO_2$ band |
| 2 | 679.84 | | 15 μm $CO_2$ band |
| 3 | 691.46 | ✓ | 15 μm $CO_2$ band |
| 4 | 703.37 | | 15 μm $CO_2$ band |
| 5 | 717.16 | ✓ | 15 μm $CO_2$ band |
| 6 | 732.64 | | 15 μm $CO_2$ band |
| 7 | 749.48 | ✓ | 15 μm $CO_2$ band |
| 8 | 898.53 | ✓ | Window |
| 9 | 1031.61 | ✓ | Ozone |
| 10 | 1224.74 | | Water Vapor |
| 11 | 1365.12 | ✓ | Water Vapor |
| 12 | 1483.24 | ✓ | Water Vapor |
| 13 | 2189.97 | | 4.3 μm $CO_2$ band |
| 14 | 2209.18 | | 4.3 μm $CO_2$ band |
| 15 | 2243.14 | | 4.3 μm $CO_2$ band |
| 16 | 2276.46 | | 4.3 μm $CO_2$ band |
| 17 | 2359.05 | | 4.3 μm $CO_2$ band |
| 18 | 2518.14 | | Window |
| 19 | 2667.80 | | Window |
| 20 | 14549.27 | | Visible Window |

**Table 3** Description of HIRS instrument type and Level-1b data set coverage available for the OLR – Monthly CDR production.

| Satellite | Satellite ID | Data coverage | Instrument Type |
|---|---|---|---|
| TIROS-N (TN) | N05 | 1978 d294 – 1980 d054 | HIRS/2 |
| NOAA-6 (NA) | N06 | 1979 d181 – 1983 d064<br>1985 d098 – 1985 d181<br>1985 d290 – 1986 d319 | HIRS/2 |
| NOAA-7 (NC) | N07 | 1981 d236 – 1985 d032 | HIRS/2 |
| NOAA-8 (NE) | N08 | 1983 d123 – 1984 d163<br>1985 d182 – 1985 d287 | HIRS/2 |
| NOAA-9 (NF) | N09 | 1984 d348 – 1988 d312 | HIRS/2 |
| NOAA-10 (NG) | N10 | 1986 d329 – 1991 d259 | HIRS/2 |
| NOAA-11 (NH) | N11 | 1988 d313 – 1995 d100<br>1997 d196 – 2000 d117 | HIRS/2I |
| NOAA-12 (ND) | N12 | 1991 d259 – 1998 d348 | HIRS/2 |
| NOAA-14 (NJ) | N14 | 1995 d001 – 2006 d283 | HIRS/2I |
| NOAA-15 (NK) | N15 | 1998 d299 – 2009 d120 | HIRS/3 |
| NOAA-16 (NL) | N16 | 2001 d001 – 2014 d165 | HIRS/3 |
| NOAA-17 (NM) | N17 | 2002 d191 – 2013 d099 | HIRS/3 |
| NOAA-18 (NN) | N18 | 2005 d156 – 2025 d150 | HIRS/4 |
| NOAA-19 (NP) | N19 | 2009 d153 – 2025 d166 | HIRS/4 |
| Metop-A | M02 | 2006 d325 – 2021 d304 | HIRS/4 |
| Metop-B | M01 | 2013 d015 – 2023 d076 | HIRS/4 |

## B. IASI

The IASI instrument is an infrared Fourier Transform Spectrometer, with cross-track scanning pattern, measuring the upwelling infrared radiances at very high spectral resolution. It is currently flying on Metop-1 and Metop-3 satellites and will also fly on the subsequent Metop satellites. The Metop-series polar satellites are in sun-synchronous orbits with nominal Equator Crossing Time of 2130 and 0930 local time, for ascending and descending orbits, respectively.

IASI Level-1C (L1C) is apodized Level 1b to obtain a nominal Instrument Spectral Response Function. Eumetsat performs and provides the L1C data sets (refer to the IASI Products webpage https://iasi.cnes.fr/en/IASI/A_products.htm).

The IASI interferometer field of view is square, seen under an angle of 3.33° x 3.33° (~15km). Information matrix of 2 x 2 circular pixels is seen under an angle of 1.25°. The overall swath is ± 48.3° with respect to the nadir direction, corresponding to 30 mirror positions. (cf. https://www.esa.int/Applications/Observing_the_Earth/Meteorological_missions/ MetOp/About IASI).

The IASI L1C data covers the spectral range from 645 to 2760 $cm^{-1}$ continuously, at a resolution of 0.5$cm^{-1}$, sampled at every 0.25$cm^{-1}$. The IASI L1C data files are grouped by ~3 minutes granules, at ~60MB per file, or, about 28GB per day. The IASI L1C product format is described by the "IASI Level 1 Product Format Specification (Eumetsat EUM.EPS.SYS.SPE.990003)" document. More descriptions for IASI L1C data can be found at https://navigator.eumetsat.int/product/ EO:EUM:DAT:METOP:IASIL1C-ALL.

The IASI L1C data set availability is described in **Table 4**.

**Table 4** Description of IASI instrument data set type and coverage available for the OLR – Monthly CDR production.

| Satellite | Satellite ID | Data coverage | Data Type |
|---|---|---|---|
| Metop-A | M02 | 2007.05.21 – 2021.10.15 | L1C |
| Metop-B | M01 | 2013.08.01 – present | L1C |
| Metop-C | M03 | 2019.07.06 – present | L1C |

## C. CrIS

The CrIS instrument is an infrared Fourier Transform Spectrometer, with cross-track scanning pattern, measuring the upwelling infrared radiances at very high spectral resolution. It has been flown on Sumi-NPP satellite and are currently operational on NOAA-20/21 satellites, and will be flown on the JPSS-3, and 4 satellites. The JPSS-series polar satellites have a nominal Equator Crossing Time of 0130/1330.

CrIS spectral coverage includes three bands: SWIR: 3.92-4.64 micron; MWIR: 5.71-8.26 micron; LWIR: 9.14-15.38 micron. For the nominal model, Normal Spectral Resolution (NSR), there are 1305 spectral channels, with spectral resolution at 0.625, 1.25, and 2.5 $cm^{-1}$ for the LWIR, MWIR, SWIR bands, respectively. While for the Full Spectral Resolution (FSR), there are 2211 spectral channels, at 0.625 $cm^{-1}$ resolution for all three bands.

One CrIS cross-track scan contains 30 Field of Regards (FOR), while each FOR is consist of 9 (3x3) FOVs.

**Table 5** shows the CrIS spectral resolution, frequency range, number of channels of the Unapodized spectrum and SDR product radiance spectra. (Taken from Table 4 of Cross Track Infrared

Sounder (CrIS) Sensor Data Record (SDR) User's Guide Version 1.1 (April 2018)). **Table 6** lists the CrIS SDR data set availability.

**Table 5** CrIS spectral resolution, frequency range, number of channels of the Unapodized spectrum and SDR product radiance spectra.

| | | Unapodized Spectrum | | SDR Specification | |
|---|---|---|---|---|---|
| **Band/Spectral Resolution** | **Resolution ($cm^{-1}$)** | **Frequency Range ($cm^{-1}$)** | **Number of Channels** | **Spectral Range ($cm^{-1}$)** | **Number of Channels** |
| LWIR | 0.625 | 648.75 – 1096.25 | 717 | 650-1095 | 713 |
| MWIR NSR | 1.25 | 1207.5 – 1752.5 | 437 | 1210-1750 | 433 |
| MWIR FSR | 0.625 | 1208.75 – 1751.25 | 869 | 1210-1750 | 865 |
| SWIR NSR | 2.5 | 2150 - 2555 | 163 | 2155-2550 | 159 |
| SWIR FSR | 0.625 | 2153.75 – 2551.25 | 637 | 2155-2550 | 633 |

**Table 6** Description of CrIS instrument data set type and coverage available for the OLR – Monthly CDR production.

| Satellite | Satellite ID | Data coverage | Data Type |
|---|---|---|---|
| S-NPP | NPP | 2012.04.01 – 2021.05.21 | SDR (NSR, FSR) |
| JPSS-1 (J01) | N20 | 2018.01.17 – present | SDR FSR |
| JPSS-2 (J02) | N21 | 2023.04.12 – present | SDR FSR |

## 4.2 Other data sources (ancillary data)

N/A

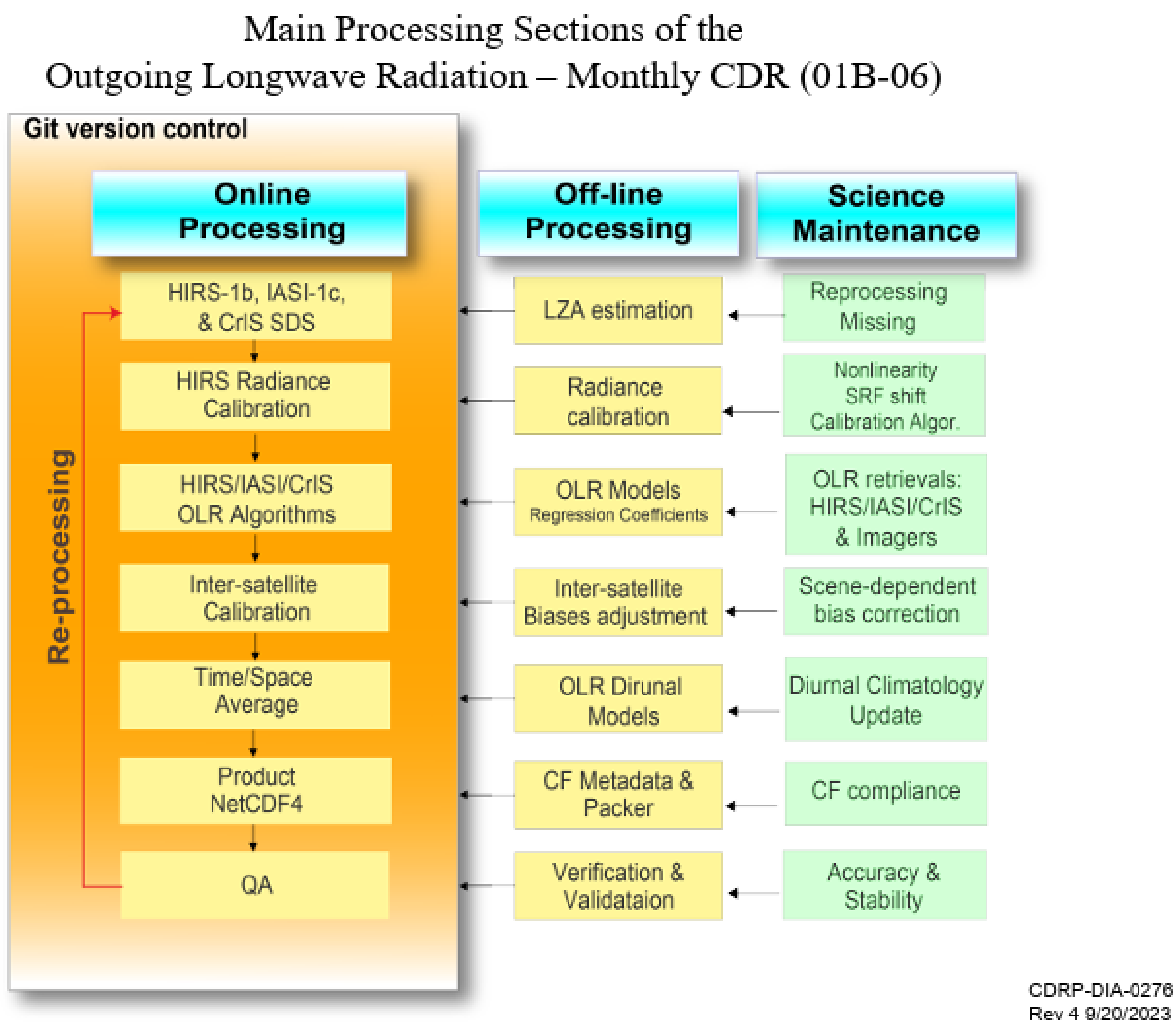
## 4.3 High-level processing overview

1. Primary Sensor Data Acquisition and Radiance Calibration:
   - Initial Data Sources: The core of the OLR – Monthly CDR production relies on radiance observations from various polar-orbiting satellites, specifically the High-resolution Infrared Sounder (HIRS) instruments (on TIROS-N series and Metop-A/B satellites), the Infrared Atmospheric Sounding Interferometer (IASI) (on Metop-series satellites), and the Cross-Track Infrared Sounder (CrIS) (on JPSS-series satellites).
   - HIRS Radiance Calibration: The OLR – Monthly CDR production independently derives HIRS radiances from HIRS Level-1B data using the McMillin method, ensuring consistency across the time series.
   - IASI and CrIS Radiance Calibration: For IASI Level-1C and CrIS SDR data, the radiance calibration is performed by operational or reprocessing algorithms, and their hyperspectral radiance data is used as is.
2. OLR Retrieval:
   - Multi-spectral OLR Estimation: A multi-spectral OLR estimation technique, initially developed by Ellingson et al. (1989), is applied to retrieve OLR from the radiances of selected channels.
   - HIRS OLR Model (v3.0): This model uses a linear combination of radiances from specific HIRS channels, including non-linear terms. The regression coefficients are determined from IASI-

simulated HIRS radiances and IASI-estimated OLR fluxes, improving consistency between narrow-band and hyperspectral instruments.
- IASI and CrIS OLR Algorithms: These algorithms use a 3-predictor multiple linear regression model in quadratic forms, with predictors being the natural log of aggregated IASI radiances.

3. Intersatellite Calibration:
    - Bias Adjustments: Inter-satellite calibration is performed by applying pre-determined bias adjustments to OLR retrievals from HIRS, IASI, and CrIS.
    - Radiometric Reference: For both daily and monthly products (v2.0 and v3.0 respectively), Metop-A (M02) IASI OLR retrieval serves as the absolute radiometric reference due to its higher accuracy and well-maintained on-orbit calibration. This ensures long-term time series stability. The biases are determined from collocated observations, primarily in polar regions.
4. Data Merging and Temporal Integration:
    - Gridding: The OLR retrievals (at Field of View (FOV) level) are gridded into two 2.5°x2.5° equal-angle global maps per month, distinguishing between ascending and descending orbit observations.
    - Temporal Integration: Monthly mean OLR is derived from these gridded orbital maps using climatological OLR diurnal models. This approach helps reduce artifacts from orbital drift, though it assumes inter-annual/decadal variations in the diurnal cycle are much smaller than the diurnal cycle itself, an assumption that might be less accurate over oceans during events like El Niño. Future enhancements include updating these models with current data.
5. NetCDF Packing:
    - The final step for both CDRs involves packing the processed data into NetCDF-4 product files. The OLR – Monthly CDR is a single NetCDF file containing the entire time series, while the OLR – Daily CDR files are packed annually.

**Fig. 1** is the flow chart for OLR – Monthly CDR production. The OLR regression models for each of the sounding/Imager instruments are responsible to retrieve OLR at the field of view level.



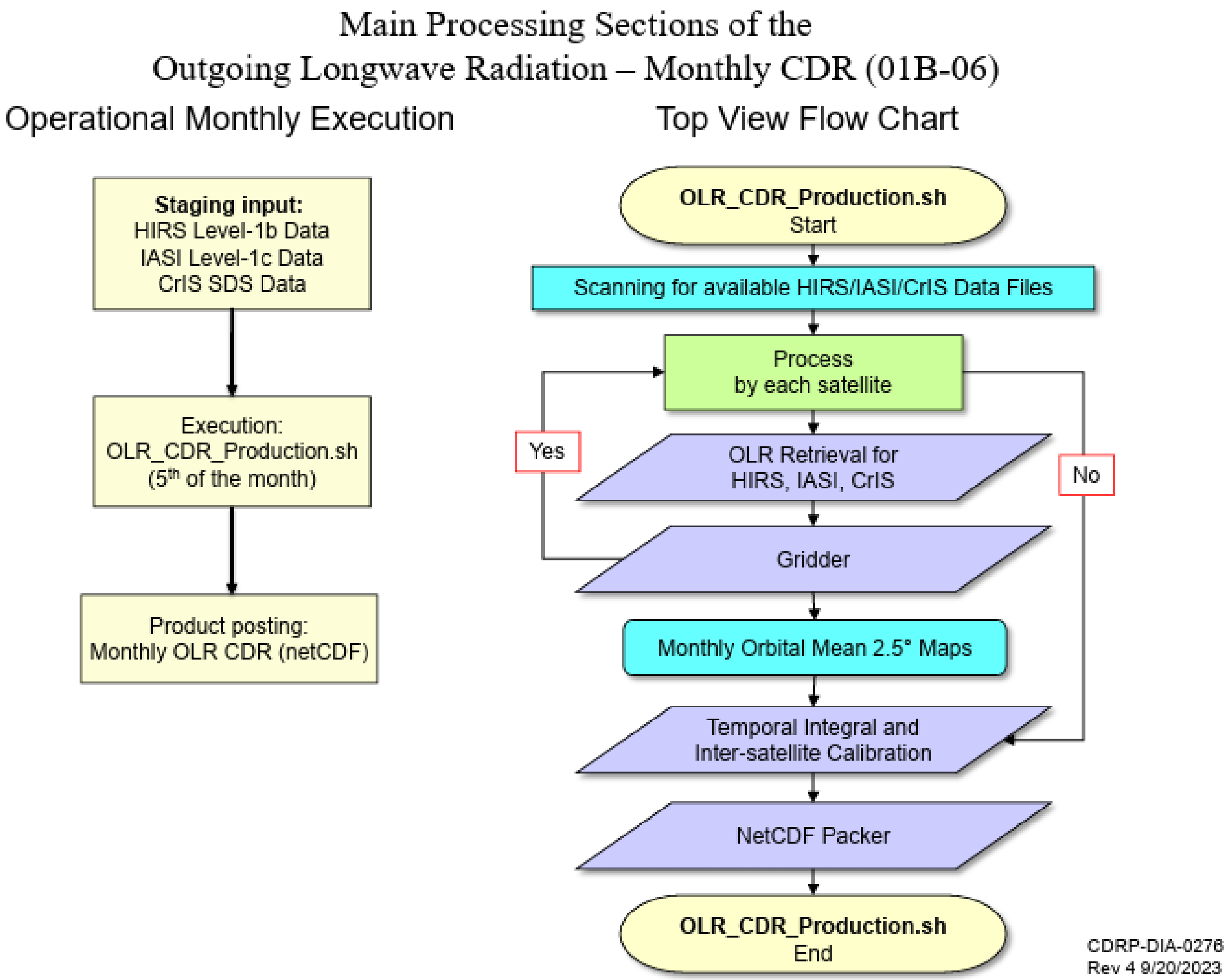



**Figure 1** OLR – Monthly CDR production flow chart.

# 5. Using the CDR

## 5.1 Known or recommended applications

Key applications for OLR – Monthly CDR include:

- Investigations of Cloud, Water Vapor, and Radiative Interaction Processes: OLR is a crucial component for understanding how clouds and water vapor interact with the Earth's radiation budget.
- Climate Variability Studies: OLR data is used to analyze changes and patterns in climate over time.
- Climate Change Monitoring: As an "Essential Climate Variable" identified by the WMO Global Climate Observing System (GCOS), OLR is vital for tracking long-term climate changes. The OLR – Monthly CDR time series has demonstrated stability, meeting the climate quality data requirement of approximately 0.3 Wm-2 per decade, supporting its use for such monitoring.
- Numerical Model Evaluation and Diagnostics: OLR data provides observational benchmarks for assessing the performance and accuracy of climate and weather models.

- Applications in Tropical Dynamics and Precipitation: OLR is particularly useful in studying atmospheric processes in tropical regions, including the dynamics of weather systems and precipitation patterns. For example, the OLR – Daily CDR has applications in identifying tropical subseasonal variability.

## 5.2 Uncertainty Quantification

The OLR – Monthly CDR v3.0 is assessed to have a precision within 2 $Wm^{-2}$ and an accuracy of about 2 $Wm^{-2}$ when compared to the CERES EBAF Ed4.2 OLR product Over the period of March 2000 to December 2023.

Global statistics indicate a relative bias of approximately 0.1 $Wm^{-2}$ and a precision of about 1.9 $Wm^{-2}$ compared to CERES EBAF OLR.

The OLR – Monthly CDR time series demonstrates stability that satisfies the climate quality data requirement, at approximately 0.3 $Wm^{-2}$ per decade for the 2004-2023 period. For the Terra-Aqua co-existent period (2004-2023), the trend of OLR anomalies differences for global and tropical domains are 0.014 ± 0.027 $Wm^{-2}$/decade and 0.240 ± 0.039 $Wm^{-2}$/decade (at 2-sigma level), respectively, which falls within the ±0.3 $Wm^{-2}$/decade climate quality data stability requirement.

The possible sources of error for OLR – Monthly CDR derivation are listed in Table 7. The best estimates of their magnitude of errors are given. Note that those errors shall not be aggregated in a simple form.

**Table 7** Error sources and best estimated magnitude for HIRS OLR – Monthly CDR production.

| Error Sources | Magnitude of Errors | Prospective Improvements |
|---|---|---|
| Radiance Calibration | bias at ~0.5°K | non-linear calibration method.<br>account for post-launch spectral response function |
| OLR retrieval | RMS errors ~0.5 to 2.5 $Wm^{-2}$ | Scene and angular dependent OLR estimation algorithms; OLR estimation from hyperspectral instruments (Lee et al., 2010) |
| Intersatellite calibration | biases at ~0.5 $Wm^{-2}$ | Scene dependent bias adjustments |
| Temporal integral | < 5 $Wm^{-2}$ RMS | Using higher temporal resolution of geostationary observations, e.g., SEVIRI, GOES-R |

## 5.3 Limitations and Caveats

General limitations and caveats (applicable to both OLR – Monthly and OLR – Daily CDRs)

Radiative Transfer Model Simulations:

- The OLR regression models are statistical and assume to be globally representative for all sky conditions. This assumption can lead to scene-dependent errors, and modeling improvements are necessary to eliminate such errors.
- The current hyperspectral OLR model uses 10 cm-1 bands due to resolution limitations in the Warner-Ellingson Radiative Transfer Model (RTM). Improving the band resolution to 0.5

or 0.25 $cm^{-1}$ with LBLRTM simulations could enhance the accuracy of spectral flux estimation.

Intersatellite Calibration:

- Inter-satellite bias adjustments are determined from collocated observations, primarily occurring in polar regions. This means the derived biases may not be fully representative for other climate zones.
- Despite revisions in OLR regression models (v3.0) have improved consistency and reduced dependencies, the possibility of scene-dependent inter-satellite biases still exists, which can affect stability and trend analysis.

CrIS OLR Retrieval Biases:

- The inter-satellite calibration adjustments for CrIS OLR are unexpectedly large, around 1.4 $Wm^{-2}$. The cause of this significant bias is currently unclear and further investigation is necessary.

Sensor Performance:

- Radiometric Calibration: The HIRS radiance calibration method (McMillin method) does not handle nonlinear responses, which, if accounted for, could improve radiance accuracy.
- Radiometric Noise: OLR retrieval might still be performed even if the sensor's radiometric noise exceeds instrument specifications, provided the quality flag is not activated. Recent HIRS instruments (since NOAA-15) have shown sporadic problems that require ad hoc quality control procedures.
- Spectral Response Function (SRF): Errors in OLR estimation can be introduced if the pre-launch SRF characterization is inaccurate or if the response functions have changed post-launch.
- Instrument Scanning Alignment: Known errors in HIRS scanning on NOAA-15 and NOAA-16, where scanning is believed to be off by one step position. Although corrections are applied in Level-1b data, users should exercise caution when using these data.

Navigation:

- The production assumes that HIRS Level-1b data's navigation parameters (coordinates, viewing geometry) are correct. However, known errors, such as incorrect local zenith angle data in NOAA-14 post-March 1999, can degrade OLR retrieval quality.

Specific Limitations and Caveats for OLR – Monthly CDR

OLR Diurnal Model:

- The accuracy of monthly mean temporal integration is limited by the sampling rate and integration method. The current approach uses climatological OLR diurnal models, which assume that inter-annual/decadal variations in the diurnal cycle are much smaller than the diurnal cycle itself. This assumption is generally valid over land but may not always hold true over oceans, particularly during events like El Niño, which involve large changes in cloudiness in areas such as the equatorial Pacific. While these models help reduce artifacts from orbital drift, more accurate temporal integration could be achieved with OLR data from geostationary satellites. An enhancement is planned to update these models with current data.

## 5.4 Using quality flags

*Not available*

# 6. References

ATBD and Technical Notes

Lee, H.-T., 2025: CDRP-ATBD-0097 Rev 5 Outgoing Longwave Radiation - Monthly C-ATBD (01B-06) (DSR-2063).

Lee, H.-T., 2025: CDRP-ATBD-0526 Rev 2 Outgoing Longwave Radiation - Daily C-ATBD (01B-21) (DSR-2062).

Algorithm and Methodology

Turner, E. C., H.-T. Lee and S. F. B. Ba, M., R. G. Ellingson and A. Gruber, 2003: Validation of a technique for estimating OLR with the GOES sounder. J. Atmos. Ocean. Tech., 20, 79-89.

Ellingson, R. G. and J. C. Gille, 1978: An infrared radiative transfer model. Part 1: Model description and comparison of observations with calculations. J. Atmos. Sci., 35, 523-545.

Ellingson, R. G., D. J. Yanuk, H.-T. Lee and A. Gruber, 1989: A technique for estimating outgoing longwave radiation from HIRS radiance observations. J. Atmos. Ocean. Tech., 6, 706-711.

Ellingson, R. G., H.-T. Lee, D. Yanuk and A. Gruber, 1994: Validation of a technique for estimating outgoing longwave radiation from HIRS radiance observations, J. Atmos. Ocean. Tech., 11, 357-365.

Gruber, A., H.-T. Lee and R. G. Ellingson, 2004: Climate monitoring with HIRS outgoing longwave radiation data. The 13th Conference on Satellite Meteorology and Oceanography. September 20-23, 2004, Norfolk, VA.

Jackson, D. L., J. J. Bates and D. P. Wylie, 2003: The HIRS Pathfinder radiance data set (1979-2001). Proceedings of 12th Conference on Satellite Meteorology and Oceanography, Long Beach, California, February 10-13, 2003.

Jacobowitz, H., L. L. Stowe, G. Ohring, A. Heidinger, K. Knapp, and N. R. Nalli, 2003: The Advanced Very High-Resolution Radiometer Pathfinder Atmosphere (PATMOS) climate dataset: a resource for climate research. Bull. of Amer. Meteo. Soc., 84, 785-793.

Knapp, K. R., S. Ansari, C. L. Bain , M. A. Bourassa , M. J. Dickinson , C. Funk , C. N. Helms , C. C. Hennon, C. Holmes , G. J. Huffman , J. P. Kossin, H.-T. Lee , A. Loew , G. Magnusdottir, 2011: Globally gridded satellite (GridSat) observations for climate studies. Bulletin of American Meteorology Society., 893-907. (doi: 10.1175/2011BAMS3039.1)

Lee, H.-T., 2023: CDRP-RPT-1442 Rev 0 OLR - Daily Technical Note (01B-21) (DSR-1840). NCEI Climate Data Record Program.

Lee, H.-T., 2023: CDRP-RPT-1443 Rev 0 OLR - Monthly Technical Note (01B-06) (DSR-1841). NCEI Climate Data Record Program.

Lee, H.-T., A. Heidinger, A. Gruber and R. G. Ellingson, 2004: The HIRS Outgoing Longwave Radiation product from hybrid polar and geosynchronous satellite observations. Advances in Space Research, 33, 1120-1124.

Lee, H.-T., A. Gruber, and J. Lee, 2010b: Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record. Scientific Data Stewardship Annual Meeting. Sept 14-15, 2010. NCDC, Asheville, NC.

Lee, H.-T., R. G. Ellingson, and A. Gruber, 2010: Development of IASI outgoing longwave radiation algorithm. Proceedings of the 2nd IASI International Conference, Annecy, France, January 25-29, 2010.

Lee, H.-T., R. G. Ellingson, and A. Gruber, 2010: Development of IASI outgoing longwave radiation algorithm. Proceedings of the 2nd IASI International Conference, Annecy, France, January 25-29, 2010.

Lee, H.-T., 2014b: Daily OLR Climate Data Record – A challenge to homogenize operational satellite observations for climate applications. EGU General Assembly 2014, 27 April – 2 May 2014, Vienna, Austria.

Lee, H.-T., C. J. Schreck, K. R. Knapp, 2014c: Generation of the Daily OLR Climate Data Record. 2014 EUMETSAT Meteorological Satellite Conference, 22-26 September 2014, Geneva, Switzerland.

GCOS: http://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables (as of July 19, 2011).

NOAA Polar Orbiter Data (POD) User's Guide: 1998 version available online at http://www.ncei.noaa.gov/oa/pod-guide/ncei/docs/intro.htm as of July 18, 2011.

NOAA KLM User's Guide: Feb. 2009 version available online at http://www.ncei.noaa.gov/oa/pod-guide/ncei/docs/intro.htm as of July 18, 2011.

Ohring, G., A. Gruber and R. G. Ellingson, 1984: Satellite determinations of the relationship between total longwave radiation flux and infrared window radiance. J. climate & Appl. Meteor., 23, 416-425.

Schreck, C. J., H.-T. Lee and K. Knapp, 2018: HIRS Outgoing Longwave Radiation—Daily Climate Data Record: Application toward Identifying Tropical Subseasonal Variability. Remote Sens. 2018, 10, 1325; https://doi.org/10.3390/rs10091325.

Tett, 2015: Using IASI to simulate the total spectrum of outgoing long-wave radiances, Atmos. Chem. Phys., 15, 6561-6575, doi:10.5194/acp-15-6561-2015.

Warner, J. X. and R. G. Ellingson, 2000: A new narrowband radiation model for water vapor absorption. J. Atmos. Sci., 57, 1481-1496.

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth s Radiant Energy System (CERES): An Earth Observing System Experiment. Bull. Amer. Meteor. Soc., 77, 853-868.

Wong, T., B. A. Wielicki, R. B. Lee, III, G. L. Smith, K. A. Bush, and J. K. Willis, 2006: Re-examination of the Observed Decadal Variability of Earth Radiation Budget using Altitude-corrected ERBE/ERBS Nonscanner WFOV data. J. Climate.

Young, D. F., P. Minnis, D. R. Doelling, G. G. Gibson and T. Wong, 1998: Temporal Interpolation Methods for the Clouds and the Earth's Radiant Energy System (CERES) Experiment. J. Appl. Meteorology, 37, 572-590.

# Appendices

## Data Access and/or Tools

- **How to Access the Data:**
  - **v03r00: https://archive.data.noaa.gov/cdr#UMD_ESSIC/OLR_CDR/Monthly/**

- **Software and Tools:**
  Panoply for quick viewing; Python/IDL with NetCDF4 library for data manipulation

---

## Description of file types

- Monthly OLR CDR – updated monthly with 5 days lag

---

## Description of variables

- OLR (Outgoing Longwave Radiation) – upward thermal radiative flux density at top of the atmosphere ($Wm^{-2}$).

---

## Known FAQs

- **What OLR CDR products are generated by this algorithm?**
  The algorithm generates a monthly mean OLR time series in 2.5°x2.5° equal-angle gridded global maps, spanning from January 1979 to the present. It also generates a daily mean OLR time series in 1°x1° equal-angle gridded global maps, also from January 1979 to the present. Both products aim to provide continuous global OLR measurements.

- **What is the assessed precision and accuracy of the OLR CDR products?**
  For the OLR – Monthly CDR v3.0, it has a precision within 2 $Wm^{-2}$ and an accuracy of about 2 $Wm^{-2}$ relative to the CERES EBAF Ed4.2 OLR product. For the OLR – Daily CDR v2.0, it has an accuracy of about 2 $Wm^{-2}$ with a precision of about 2 $Wm^{-2}$ relative to CERES EBAF Ed4.2, SYN1deg Ed4A, and ERBS WFOV Non-scanner Ed4.1 OLR products. Both products show excellent stability, meeting the climate quality data requirement of about ±0.3 $Wm^{-2}$/decade.

- **What satellite instruments are used to generate the OLR CDRs?**
  The OLR is primarily estimated from radiance observations by High-resolution Infrared Sounder (HIRS) instruments on NOAA TIROS-N series and Eumetsat Metop-A/B satellites. It has been expanded to include observations from the Infrared Atmospheric Sounding Interferometer (IASI) on Metop-series satellites (A, B, C) and the Cross-Track Infrared Sounder (CrIS) on JPSS-series satellites (S-NPP, J01, J02). For the OLR – Daily CDR, Imagers on operational geostationary satellites are also incorporated to ensure accurate temporal integration.

- **Why might there be scene-dependent errors in OLR retrievals?**
  The OLR regression models are statistical models constructed from radiative transfer model simulations. They are assumed to be globally representative for all sky conditions. This assumption can lead to scene-dependent errors, and improvements in modeling are necessary to eliminate such issues.

- **Are the inter-satellite bias adjustments fully representative for all climate zones?**
  The inter-satellite bias adjustments are determined from collocated observations primarily in polar regions. Therefore, the derived biases may not be fully representative for other climate zones. While revised OLR regression models (v3.0) have improved consistency and reduced dependencies, the possibility of scene-dependent inter-satellite biases still exists, potentially affecting stability and trend analysis.

- **Can errors in the Spectral Response Function (SRF) affect OLR estimation?**
  Yes, errors in OLR estimation can be introduced if the pre-launch SRF characterization is incorrect or if the response functions have changed post-launch. The SRF plays a role in both radiance calibration and radiance simulation.

- **What is the primary limitation for the accuracy of monthly mean OLR temporal integration?**
  The accuracy of monthly mean temporal integration is limited by the sampling rate and the integration method. The OLR – Monthly CDR uses climatological OLR diurnal models. This approach assumes that inter-annual/decadal variations in the diurnal cycle are much smaller than the diurnal cycle itself, which is generally valid over land but may not always hold true over oceans, especially during events like El Niño with large changes in cloudiness. More accurate integration could be achieved with OLR data from geostationary satellites, and an update to these models is a planned future enhancement.

- **What is the spectral resolution limitation in the current hyperspectral OLR model?**
  The current hyperspectral OLR model uses 10 $cm^{-1}$ bands due to resolution limitations in the Warner-Ellingson Radiative Transfer Model (RTM). Improving the band resolution to 0.5 or 0.25 $cm^{-1}$ with LBLRTM simulations and re-deriving IASI spectral flux estimation models are future enhancement goals to improve spectral flux estimation accuracy.