

Readme for GOES-R EXIS EUVS Level 1b Data

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1. Summary

This Readme is for the Level 1b (L1b) products for the GOES-R Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS) Extreme Ultraviolet Sensor (EUVS). EUVS measures solar spectral irradiance at discrete wavelengths between 25 and 141 nm and in the vicinity of 280 nm. The L1b data products derived from EUVS observations are irradiances for seven solar lines, the Magnesium core-to-wing ratio (i.e., the Mg II index), and EUV proxy spectra from 5 to 127 nm. The nominal data cadence is 30-s. EXIS was designed and built by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado Boulder.

The science-quality dataset is produced by the NOAA National Centers for Environmental Information (NCEI), and differs from the L1b operational product used at the NOAA Space Weather Prediction Center (SWPC) in that it incorporates retrospective fixes for issues in the operational product and uses the most recent calibrations. The science-quality data have been reprocessed from the start of the mission to the present date. Both the science-quality and the operational data sets contain recovered data due to spurious dropouts. This ReadMe discusses the science-quality L1b data products, as well as current and future improvements to the dataset. Further details on the EUVS instrument can be found in the articles by Eparvier et al. (2009), Snow et al. (2009), and Thiemann et al. (2019), and at <https://www.goes-r.gov/spacesegment/exis.html>.

Higher order products, referred to as L2 data, are produced from the L1b data. In general, science users are advised to use the science-quality L2 data rather than the science-quality L1b data. Links to the science-quality EUVS L1b and L2 data, Readmes, a User's Guide, plots and other documentation can be found at <https://www.ngdc.noaa.gov/stp/satellite/goes-r.html>.

Users of the GOES-R EUVS L1b science-quality data are responsible for inspecting the data and understanding the known caveats described in Section 3 prior to use. Questions about this data set can be sent to janet.machol@noaa.gov and james.mothersbaugh@noaa.gov, while questions about data access should be sent to pamela.wyatt@noaa.gov and josh.riley@noaa.gov.

2. Data Overview

GOES-R EUVS (Eparvier et al., 2009; Snow et al., 2009) makes extreme ultraviolet (EUV) and far ultraviolet (FUV) high-spectral-resolution measurements of distinct solar emission lines representative of different layers of the solar atmosphere. EUVS measurements are made for seven solar lines and the Mg core-to-wing ratio (Mg II index) as shown in Table 1. An empirical

proxy model (Thiemann et al. 2019) uses the EUVS measurements to reconstruct an EUV spectrum from 5 to 127 nm. The model outputs solar spectral irradiance (SSI), i.e., the solar irradiance as a function of wavelength, which can be used in conjunction with wavelength- and altitude-dependent absorption cross-sections as inputs to atmospheric models (e.g., Solomon and Qian, 2005). The L1b data is stored in netCDF format, and can be readily accessed via pre-packaged routines in many programming languages, including IDL and Python.

Table 1. Solar lines measured by GOES-R EUVS. The Mg II index is derived from measurements near 280 nm.

Wavelength [nm]	Line(s)	Source region
25.632	He II	transition region
28.415	Fe XV	corona
30.378	He II	transition region
117.5	CIII	chromosphere
121.567	H I	transition region
133.57	C II	chromosphere
140.5	Si IV, O IV	transition region
279.5528, 280.2704	Mg II h, k	chromosphere

Flags are provided to indicate data outages and reliability. The EUVS model spectrum data quality is indicated in the variable “qualityFlags” which have individual bits regarding the reliability of pointing, temperature, irradiance, and other issues. An overall flag value of 0 indicates good quality data. Since the GOES instruments operate in geostationary orbit, they experience two eclipse seasons per year around the equinox. The “qualityFlags” variable indicates these events.

Extended coronal imaging (ECI) tests were performed for Solar Ultraviolet Imager (SUVI) on GOES-17 in the fall of 2019 and during other shorter periods. To do this, the platform shared by SUVI and EXIS was repeatedly slewed at a high cadence across a wide field-of-view. For EUVS, this resulted in a high fraction of data gaps as well as new spatial and temporal degradation trends during this period which require further analysis and long-term trending measurements to correct.

The time variable, $\text{time[secs]} = \text{Time[UTC]} - \text{base time[UTC]}$, is an elapsed time in units of “secs since base time” where base time[UTC] and was calculated without including leap seconds that occurred since base time. Time stamps can be calculated by the user in Coordinated Universal Time (UTC) as

$$\text{Time[UTC]} = \text{base time[UTC]} + \text{time[secs]} + n[\text{secs}]$$

where $n = 0$ for a time conversion function which ignores leap seconds (e.g., Python `cftime.num2date` or `netCDF4.num2date`) and $n =$ number of leap seconds since base time if the function includes leap seconds. It should be noted that the reference epoch for GOES-R data of “2000-01-01 12:00:00 UTC” is not the same as the J2000 epoch, because the latter is given in terrestrial time (TT) units which differ by more than a minute from UTC. For a table of leap seconds, see

<https://www.nist.gov/pml/time-and-frequency-division/time-realization/leap-seconds>.

3. Data Caveats

The following is a list of caveats for the GOES-R EUVS L1b science-quality data as of the date of this document. Some of these issues will be corrected in future versions of the data. It is important to note that operational EUVS L1b data, especially for earlier dates, has considerably more errors.

1. The spacecraft eclipse flag is incorrect early in the mission. The flag “`degraded_due_to_eclipse_state_received_from_ground_qf`” in the “`qualityFlags`” variable should be used to identify Earth eclipses.
2. The solar array currents variable is bad for all GOES-17 and -18 data.
3. Some bands in the spectral model have jumps when entering and exiting the geocoronal period. The model will be revised with improvements in a future data version.
4. The Mg II index may have small improvements in the future to account for non-linear behavior in the wings and lines and to remove spikes in the data.
5. The eclipse flag was set too narrowly around eclipses for the line irradiances in February and March 2017. This also impacts the spectral model.
6. An annual cycle oscillation artifact impacts four of the EUVS line irradiances with a maximum peak near the winter solstice. For GOES-16, the approximate magnitudes of the artifact are $\pm 1.5\%$ (117 nm), $\pm 1.3\%$ (121 nm), $\pm 1\%$ (133 nm) and $\pm 0.9\%$ (140 nm). These oscillations will also impact the spectral model. Similar oscillations occur in the GOES-17 irradiances. This artifact will be removed in a future version of the data.
7. There are multi-hour post eclipse thermal dips in the spectral lines and some model bins. The effect is most pronounced in the 25.6, 117.5, 133.5 and 140.5 nm lines. Due to the overlying geocoronal dip, it is unclear if this artifact occurs for the 121.6 nm line.
8. Mercury transits are not flagged. There are only two Mercury transits in the GOES mission lifetimes (11 November 2019 and 13 November 2032) and they cause no noticeable decrease in irradiance.
9. EUVS-A and -B have a nominal cadence of 1-second to within a few microseconds. If the cadence is slightly less than 1-second, one second's worth of data at the start or end of the day is discarded to maintain the standard array sizes of data reported at 1-second cadence. This should have a negligible effect on the data quality.

10. EUVS data is not good during periods of extended coronal imaging (ECI) for SUVI.
These dates are
 - a. G16: 2018-02-12, 2018-02-13;
 - b. G17: 2018-04-30, 2018-06-04 through 2018-06-07, 2018-08-06 through 2018-09-13, 2019-08-28 through 2019-12-16, 2021-04-27 through 2021-04-30;
 - c. G18: 2022-08-11 through 2022-09-08
11. The ECEF variables are bad for most of 2017.
12. Eclipse penumbra events occurring without a full eclipse are not flagged. This results in dips in the irradiances with no associated flags. This will be corrected in the future.
13. Solar array current decreases by 1-3% during arc jet firing, which occurs for roughly one hour per day.
14. There are small discrepancies in the cross_dispersion_angle of about 0.003° (1 arcsec) for about an hour after eclipses.
15. GOES-18 science-quality data has a data gap from 2022-06-20 through 2022-08-11 due to a processing issue. This data should become available in 2024.
16. The final day of GOES-17 science-quality data, 2023-01-10, is missing the solar line irradiances due to a processing issue. This data should become available in early 2024.

4. Data Versions

Table 2. Science-quality L1b data versions.

Version	Release date	Updates
v1.0.2	20 Sep 2023	Corrected indices used to calculate SignalsEUVSC_{h,k}Line. No impact to Mg II index. Initial GOES-18 data release..
v1.0.1	20 Dec 2022	Data reprocessed with updated calibration tables. Initial GOES-17 data release.
v1.0.0	4 May 2022	Filled data gaps, fixed EUVS-C checksum flag error, improved time temperature correction calibration for early mission data, fixed ECEF_Z valid_range, include line irradiances during eclipses when pointing is good
v0.0.0	25 April 2021	N/A

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