Readme for GOES-R EXIS EUVS Level 1b Operational Data

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1. Summary

This Readme is for the Level 1b (L1b) operational product 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.

Users are advised to use the science-quality version of the data rather than the operational data. The L1b science-quality data is produced by the NOAA's 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, uses the most recent calibrations, and has been reprocessed from the start of the mission to the present date. Because operational data has many issues, some of which are significant, the operational data should not be used. The earlier data has considerably more errors than the recent data.

Level 2 (L2) EUVS products are created from both the operational and the science-quality data. They are described in the EUVS L2 Readme and EUVS L2 Users Guide. Data access and documentation can be found at https://www.ngdc.noaa.gov/stp/satellite/goes-r.html. Users of the GOES-R EUVS L1b operational data are responsible for inspecting the data and understanding the known caveats prior to use. Questions about this data set can be sent to janet.machol@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

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, time[secs] = Time[UTC]−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

Time[UTC] = base time[UTC] + time[secs] + n[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 operational data as of the date of this document. Most of these errors are corrected in the EUVS science-quality data and will be corrected in later operational data. It is important to note that earlier operational EUVS L1b data has considerably more errors than listed here.

1. There are errors of ~6% in the 121-nm line irradiance due to the way in which the pixels are summed.
2. The 28.4 nm line irradiance may have errors as large as 10% at low signal levels due to errors in the selection of data included in the 30-second averages.
3. The EUVS line irradiances have errors of approximately 0.02% due to errors in the timestamps for the degradation, dark current and flat field calculations.
4. There are significant errors in the model spectra due to inclusion of calibration signals in the daily gliding averages used to calculate the model. These result in offsets of as much as 17% in some model bins and which last for many hours.
5. Model bins that use the 121-nm line irradiance in the daily average have errors of approximately 5% due to incorrect inclusion of the line irradiance during periods of geocoronal absorption.
6. The reported dark diode currents are missing the dark drift correction and delta temperature correction.
7. The EUVS spectral model has a <4% error in the 117-127 nm bin during days with eclipses. Other model bins may also be impacted.
8. The solar array currents variable is incorrect in all GOES 17 operational data.
9. Early values of the yaw_flip_flag variable were not set properly and should not be used. GOES-16 has had no yaw flips prior to the date of this document.
10. The spacecraft eclipse flag is incorrect early in the mission.
11. During lunar transits,the lunar transit flag is not set properly and the irradiances, Mg II ratio, and temperatures are improperly set to fill values.
12. The pointing error flags are not set properly during eclipses and lunar transits.
13. 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.
14. There are small discrepancies in some of the line irradiances after eclipses due to uncorrected temperature impacts.
15. Some bands in the spectral model have signal jumps when entering and exiting geocoronal periods. The model will be revised with improvements in a future data version.
16. 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.
17. In the euvs{a,b,c}QualityFlags variables, the euvs_calibration_in_progress_qf flag is set only when the signal is degraded due to a flatfield LED flash during the sensor integrations.

18. In the qualityFlags variable, the euvs_calibration_in_progress_qf is not currently being set.
19. An artifact is an annual cycle oscillation with a maximum increase near the winter solstice in four of the EUVS line irradiances. For GOES-16, the approximate magnitudes of the artifact are ±1.5% (117 nm), ±1.3% (121 nm), ±1% (133 nm) and ±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.
20. There is a small (<1%) offset between the science-quality and operational data line irradiances. This is under investigation.
21. EUVS data is not good during periods of extended coronal imaging (ECI) for SUVI. These dates are
    a. GOES-16: 2018-02-12, 2011802-13;
    b. GOES-17: 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. GOES-18: 2022-08-11 through 2022-09-08
22. The ECEF variables are bad for most of 2017.
23. Eclipse penumbra events occurring without a full eclipse are not flagged.
24. Approximately 10 minutes of irradiance data immediately preceding and following eclipses is currently flagged as bad_data despite having good pointing. This data will be flagged as good_data in future data versions.
25. Solar array current decreases by 1-3% during arc jet firing, which occurs for roughly one hour per day.
26. There are small discrepancies in the cross_dispersion_angle of about 0.003° (1 arcsec) for about an hour after eclipses.

4. Document Versions

Table 1. Document versions.

Release date	Updates
20 Nov 2023	Minor updates
4 March 2023	Minor updates.
4 May 2022	Added information about time units and conversions.
20 May 2021	Added caveats regarding ECEF, eclipses, time, cross_dispersion_angle, ECI, and irradiance discrepancies.
25 April 2021	First version.

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