Solar Dynamics Observatory (SDO)
Extreme Ultraviolet Variability Experiment (EVE):
Version 8 science data product Release Notes

Level 3 Science Data Product README
06/13/2024

Table of Contents

Table of Tables

Introduction

EVE level 3 data files were created at the Laboratory for Atmospheric and Space Physics in Boulder, Colorado for the NASA Solar Dynamics Observatory (SDO) Extreme Ultraviolet Variability Experiment (EVE). The Science Processing and Operations Center (SPOC) is responsible for creating and maintaining access to all EVE products. For a high-level introduction to the EVE instrumentation please visit:
https://lasp.colorado.edu/home/eve/science/instrument/

Level 3 products are defined to contain daily averages beginning on 2010, day 120, April 30. This version change includes updated long-term degradation corrections for MEGS-B and ESP. A small dark adjustment was applied to MEG-B and large degradation changes were applied based on SDO EVE sounding rocket measurements. The MEGS-P (Lyman-alpha) diode processing has been updated to replace the Kalman filter with a Fourier transform filter, and the calibration has been updated to match SORCE SOLSTICE version 17.

This release of EVE data products replaces all previous versions. We have made every effort at verification and validation, but if you have any questions or encounter any problems with the data, please let us know about them.

For access and data product issues please contact Don.Woodraska at lasp.colorado.edu.

For science issues please contact Frank.Eparvier at lasp.colorado.edu.

Responsible Data Usage

Please refer to the Goddard Space Flight Center SDO web page for data rights and rules for use:
https://sdo.gsfc.nasa.gov/data/rules.php

Reference Publications

More information about the EVE instrument measurements, and calibrations can be found in these references:

Woods, T. N., F. G. Eparvier, R. Hock, A. R. Jones, D. Woodraska, D.Judge, L. Didkovsky, J. Lean, J. Mariska, H. Warren, D. McMullin, P. Chamberlin, G. Berthiaume, S. Bailey, T. Fuller-Rowell, J. Sojka, W. K. Tobiska, and R. Viereck, "Extreme Ultraviolet Variability Experiment (EVE) on the Solar Dynamics Observatory (SDO): Overview of Science Objectives, Instrument Design, Data Products, and Model Developments", *Solar Physics, 275*, 115-143,
doi: 10.1007/s11207-009-9487-6, 2012.
https://lasp.colorado.edu/home/eve/files/2011/06/EVE_Overview_SolarPhys.pdf

Hock, R. A., P. C. Chamberlin, T. N. Woods, D. Crotser, F. G. Eparvier, D. L. Woodraska, and E. C. Woods, "Extreme Ultraviolet Variability Experiment (EVE) Multiple EUV Grating Spectrographs (MEGS): Radiometric Calibrations and Results", *Solar Physics, 275*, 145-178,
doi: 10.1007/s11207-010-9520-9, 2012.
https://lasp.colorado.edu/home/eve/files/2011/06/Final_Sol_Phy_Hock_1April_2010.pdf

Didkovsky, L., D. Judge, S. Wieman, T. Woods, and A. Jones, "EUV SpectroPhotometer (ESP) in Extreme Ultraviolet Variability Experiment (EVE): Algorithms and Calibrations", *Solar Physics, 275*, 179-205, doi: 10.1007/s11207-009-9485-8, 2012.

Level 3 Science Products

Level 3 spectra are the merged spectral measurements from the two spectrographs, MEGS-A and MEGS-B. The A detector is designed to measure from about 6–17 nm and 17–37 nm using two filters on two different optical paths to two different parts of the detector. The B detector can measure from about 33 to 105 nm using a double dispersion grating design with no filters. All level 3 irradiance are adjusted to 1AU.

The level 3 products contain daily averages of the level 2B spectrum measurements (EVS) at the same wavelength sampling as level 2B. The level 3 products also contain daily average measurements of the diodes, extracted bands, and selected lines reported in the level 2B products (EVL).

The level 3 data products are available as one file per day and as merged dataset files updated daily with new measurements. The mission length merged datasets are provided at three sampling sizes for user convenience; specifically, native level 2 sampling (0.02nm), 1 angstrom, and 1 nm. See the section “Merged Datasets” below for more details. The optical resolution is about 0.1 nm, so the 0.02nm spectra contain 5 samples per resolution element.

> **WARNINGS**: The MEGS-A detector experienced a capacitor short on May 26, 2014 (day 146) that prevents the detector from working. No solar spectra are measured for wavelengths shorter than 33 nm after that anomaly. MEGS-B has been extended to its shortest possible wavelength of 33.34 nm. EUV spectra are only available when MEGS-B is exposed, usually for 3 hours per day.

For an in-depth discussion of EVE instrumentation please visit:
https://lasp.colorado.edu/home/eve/science/instrument/

Naming Convention

Level 3 products follow this naming convention

`EVE_L3_YYYYDDD_vvv_rr.fit` where:
`EVE` designates this as an SDO EVE product

`L3` designates this as a level 3 product
`YYYY` is the year
`DDD` is the day of year (001-366)
`vvv` is the version number (006)
`rr` is the revision number (01-99)

The version number only increments after major software changes or after major calibration updates. These are expected to change after incorporation of suborbital rocket instrument information is available.

Merged File Naming Convention

Level 3 merged products follow a similar naming convention.

`EVE_L3_merged_YYYYDDD_vvv.fit`
Contains the full resolution (0.02 nm) sampling.

`EVE_L3_merged_`**`1nm`**`_YYYYDDD_vvv.fit`
Contains the spectrum resampled to a 1 nm grid with 0.5-nm bin centers.

`EVE_L3_merged_`**`1a`**`_YYYYDDD_vvv.fit`
Contains the spectrum resampled to 1 angstrom with 0.5-angstrom bin centers.

For automation scripts, links are created with static names that point to selected files. Browse this URL:
https://lasp.colorado.edu/eve/data_access/evewebdataproducts/merged/
to locate the links that start with "latest_EVE_L3_merged".

Note that all merged files are also available in NetCDF 3 format and can also be downloaded as IDL sav files. The NetCDF and IDL sav files are generated from the FITS files, since FITS is the officially supported data format.

Level 3 Daily Averaged Data

Each daily file spans one UT day centered at noon UTC. Regardless of data collection time, all good data within the 24-hour window is averaged together.

The EVE level 3 files contain 8 FITS header data units that contain data and corresponding metadata information pertaining to daily averaged spectra, diode measurements, lines, and bands. This includes two new header data units that contain data and corresponding metadata for lines extracted from each channel (MEGS-A slit 1, MEGS-A slit 2, and MEGS-B).

SpectrumMeta HDU

The SpectrumMeta data unit contains one array representing the center wavelengths of each spectral bin. This array of wavelengths has 5200 elements beginning at 3.01 nm and extending to 106.99 nm, though this extends to where there is no signal on the detectors, so fill values will be present at the extreme ends of the range. This is beyond the ~~capability of the~~ measurement range of MEGS-A and MEGS-B~~EVE~~.~~,~~ The wavelength sampling~~and~~ corresponds to the spectra in the data HDU sp_irradiance variable and the other variables beginning with "sp_".

Table 1 SpectrumMeta Description

Column Name	Type	Description
Wavelength	Float	Wavelength in nm is the center value of each irradiance bin in the Spectrum table.

LinesMeta HDU

The LinesMeta data unit contains information about lines derived from the EVE level 2B full resolution spectrum. It contains wavelength information describing the line (min, center, max), line temperature, the line name, line type, and other blended lines included within the wavelength range defined by wave_min and wave_max. The LinesMeta variables are described in Table 2 and the enumerated contents are shown in **Error! Reference source not found.**~~**Error! Reference source not found.**~~~~Table 3~~. This is the order corresponding to the Data HDU variable Line_Irradiance and other variables beginning with "Line_". Note that new lines have been added in version 8, but the order of the lines from version 7 is preserved (so new lines are added at the end, and lines are not necessarily in order of increasing wavelength).

Table 2 LinesMeta Descriptions

Column Name	Data Type	Units	Description
Wave_center	Float	nm	The wavelength of electronic transition
Wave_min	Float	nm	Minimum wavelength of integrated line
Wave_max	Float	nm	Maximum wavelength of integrated line
LogT	Float	Log(K)	Log (base 10) temperature of emission line
Name	String	NA	Element and ionization stage of the dominant emission, e.g. He I
Type	String	NA	The isoelectronic series neutral atom for the dominant ion
Blends	String	NA	A partial ion list that is blended within this line

Note that all wavelengths shorter than 33.33 nm are only available from MEGS-A from 2010 through 2014 day 146 when the MEGS-A power anomaly occurred. The table remains the same dimensions, but the values become fill values after MEGS-A data is unavailable. MEGS-B is used for all other lines for the whole mission.

Also, almost all lines contain some blends, but not all are listed here. The NIST atomic spectra database (https://physics.nist.gov/PhysRefData/ASD/lines_form.html) and the CHIANTI line list (https://www.chiantidatabase.org/chianti_linelist.html) can be useful for identifying blends.

Table 3 LinesMeta Enumerated Values

Wave_center	Wave_min	Wave_max	LogT	Name	Type	Blends
9.3926	9.33	9.43	6.81	Fe XVIII	F	
13.124	13.04	13.17	5.57	Fe VIII	K	Fe VIII
13.285	13.23	13.32	6.97	Fe XX	N	Fe XXII
17.107	17.02	17.24	5.81	Fe IX	Ar	
17.7243	17.63	17.83	5.99	Fe X	Cl	Fe VII
18.0407	17.96	18.15	6.07	Fe XI	S	Fe X, Fe VII
19.512	19.43	19.61	6.13	Fe XII	P	
20.2044	20.14	20.32	6.19	Fe XIII	Si	Fe XI, Fe XII
21.1331	21.07	21.2	6.27	Fe XIV	Al	Fe XII
25.6317	25.55	25.68	4.75	He II	H	
28.415	28.3	28.5	6.3	Fe XV	Mg	
30.3783	30.25	30.5	4.7	He II	H	
33.541	33.49	33.61	6.43	Fe XVI	Na	
36.0758	36.03	36.15	6.43	Fe XVI	Na	
36.8076	36.75	36.87	5.99	Mg IX	Be	Fe VIII-XIV
44.57	44.53	44.65	6.44	S XIV	Li	
46.5221	46.47	46.61	5.71	Ne VII	Be	
49.9406	49.89	50.01	6.29	Si XII	Li	
52.1	52.03	52.13	6.28	Si XII	Li	
52.5795	52.53	52.65	4.92	O III	C	O II
53.703	53.65	53.77	3.84	He I	He	
55.437	55.39	55.51	5.19	O IV	B	O IV
56.813	56.73	56.85	6.96	Al XI	Li	Ne V, Fe XX
58.4334	58.39	58.51	4.16	He I	He	
59.224	59.17	59.31	6.89	Fe XIX	O	
59.9598	59.93	60.05	4.92	O III	C	
60.98	60.93	61.05	6.1	Mg X	Li	
62.4943	62.45	62.57	6.05	Mg X	Li	
62.973	62.93	63.05	5.37	O V	Be	
71.8535	71.81	71.93	4.48	O II	N	O II
72.156	72.11	72.21	6.96	Fe XX	N	
77.0409	76.99	77.11	5.81	Ne VIII	Li	
79.0199	78.97	79.09	5.19	O IV	B	O III, O IV
83.55	83.25	83.61	4.52	O II	O III	
94.97	94.93	95.05	3.84	H I	H	
97.2537	97.21	97.31	3.84	H I	H	
97.703	97.65	97.77	4.84	C III	Be	
102.572	102.52	102.64	3.84	H I	H	
103.19	103.15	103.25	5.47	O VI	Li	
10.395	10.31	10.47	6.95	Fe XVIII	F	Ni XXII, Ni XXIII
11.723	11.67	11.81	7.10	Fe XXII	B	Fe XXI

14.837	14.77	14.93	6.20	Ni XI	Ar	Fe XXIII
17.453	17.38	17.52	6.05	Fe X	Cl	
20.383	20.33	20.45	6.30	Fe XIII	Si	
21.516	21.45	21.57	6.40	O V	Be	Ne V
21.710	21.64	21.76	5.90	Fe IX	Ar	
21.912	21.85	21.95	6.30	Fe XIV	Al	
23.387	23.31	23.49	6.40	Fe XV	Mg	Ni XVIII
23.851	23.79	23.95	5.20	O IV	B	O III
24.174	24.12	24.22	5.90	Fe IX	Ar	
24.919	24.89	25.01	6.80	Ni XVII	Na	
26.479	26.37	26.55	6.30	Fe XIV	Al	Fe XVI
27.039	26.97	27.13	5.70	Mg VI	C	Fe XIV
38.421	38.35	38.47	7.05	Fe XX	N	
38.907	38.86	38.96	7.05	Ar XVI	Li	Fe XVII
41.766	41.68	41.83	7.05	S XIV	Li	Fe XV
46.985	46.91	47.07	5.20	Ne IV	N	
50.808	50.67	50.91	4.90	O III	C	
54.199	54.05	54.29	5.20	Ne IV	N	Ca IX, Fe XII
54.389	54.29	54.53	5.20	Ne IV	N	Ca VII, Fe XIV
55.003	54.92	55.10	6.90	Al XI	B	
57.230	57.13	57.31	5.40	Ne V	C	
57.428	57.34	57.48	4.95	C III	Be	
76.040	75.97	76.13	5.30	O V	Be	
76.515	76.41	76.63	5.10	N IV	Be	Fe VII
78.769	78.71	78.89	5.20	O IV	B	S V
84.550	84.52	84.64	7.10	Fe XXII	B	
90.409	90.31	90.51	4.60	C II	Be	
92.320	92.25	92.39	5.10	N IV	Be	
93.338	93.25	93.45	5.30	S VI	Na	
103.761	103.53	103.89	5.40	O VI	Li	C II

BandMeta HDU

The BandsMeta data unit describes the extracted bands from the EVE spectrum that correspond to the 7 AIA spectral bands, two GOES-14 (NOP) bands, 4 extracted MEGS spectral bands corresponding to the ESP diodes, two very broad bands used for creating the Q_{EUV} proxy, two MEGS-A broadbands representing each slit, and 3 MEGS-B bands. The BandsMeta data unit is described in Table 4. Table 5 shows the order of the data included in the LinesData HDU for the variables Band_Irradiance and other variables beginning with "Band_".

Note that all bands are calculated from the MEGS spectrum, to represent the equivalent measurement. Many bands ceased to be measured after the MEGS-A anomaly.

Table 4 BandsMeta Descriptions

Column Name	DataType	Units	Description

Name	String	NA	A name representing the wavelength band. Names can represent different instruments and are enumerated in Table 5
Type	String	NA	The band type being emulated such as AIA, GOES, ESP, or MEGS
Low_Wavelength_nm	Float	nm	The minimum wavelength defining the band
High_Wavelength_nm	Float	nm	The maximum wavelength defining the band

Table 5 BandsMeta Enumerated Values

Name	Type	Units	Low_wavelength_nm	High_wavelength_nm
AIA_A94	AIA	Counts /AIA pixel/second	9.275	9.515
AIA_A131	AIA	Counts /AIA pixel/second	12.595	13.475
AIA_A171	AIA	Counts /AIA pixel/second	15.205	18.965
AIA_A193	AIA	Counts /AIA pixel/second	17.715	20.955
AIA_A211	AIA	Counts /AIA pixel/second	19.355	22.755
AIA_A304	AIA	Counts /AIA pixel/second	23.265	37.445
AIA_A335	AIA	Counts /AIA pixel/second	10.325	35.865
GOES-14 EUV-A	GOES	W/m^2	5.005	14.995
GOES-14 EUV-B	GOES	W/m^2	25.005	33.995
MA171	ESP	W/m^2	14.505	22.195
MA257	ESP	W/m^2	22.005	29.195
MA304	ESP	W/m^2	26.715	33.785
MA366	ESP	W/m^2	33.005	38.995
E7-37	MEGS	W/m^2	7.000	37.000
E37-45	MEGS	W/m^2	37.000	45.000
MEGS-A1	MEGS	W/m^2	5.800	17.240
MEGS-A2	MEGS	W/m^2	17.240	33.340
MEGS-B short	MEGS	W/m^2	33.340	61.000
MEGS-B both	MEGS	W/m^2	61.000	79.100
MEGS-B long	MEGS	W/m^2	79.100	107.000

DiodeMeta HDU

The DiodeMeta data unit contains metadata information about spectral bands measured by EVE diodes from ESP and MEGS P. The DiodeMeta data unit is described in Table 6 and represent the same order of information included in the Data HDU variable Diode_Irradiance and other variable names beginning with “Diode_”.

Table 6 DiodeMeta Description

Column Name	DataType	Description
Name	String	The diode or diode group name
Type	String	The instrument (ESP or MEGS-P)
Units	String	W/m^2

Table 7 DiodeMeta Enumerated Values

* The Channel 1 irradiance has a low shunt resistance that is problematic, but solar cycle changes can be measured.

The diode bandpasses are broadband and may include many emissions. The MEGS-P Lyman-alpha diode is sensitive to a band about 7 nm wide around 121.6 nm, however, the Lyman-alpha calibration is adjusted to the 1 nm band from 121–122 nm.

The name "Quad Diode" refers to the zero-order, central quadrant diode that is designed to measure soft X-rays. More detailed ESP information is in the ESP level 1 README file. https://lasp.colorado.edu/eve/data_access/eve_data/products/level1/esp/EVE_ESP_L1_V8_README.pdf

QuadMeta HDU

The ESP central (zero order) diode is a quadrant diode. In addition to irradiance, it contains information about the center of brightness for the 0.1–7 nm bandpass. The relative quadrant contributions to the whole signal are provided in the Quad_Fraction variable in the LinesData HDU. It provides a relative measure of the distribution of irradiance. During flare periods, the difference of flare and pre-flare measurements can be used to indicate the flare position.

Table 8 QuadMeta Description

Column Name	DataType	Description
Name	String	Quadrant diode number
Type	String	Instrument ESP

Table 9 QuadMeta Enumerated Values

Name	Type	Position
Q0	ESP	Northeast
Q1	ESP	Northwest
Q2	ESP	Southeast
Q3	ESP	Southwest

Note that ESP is not centered with the guide telescope, so the central order is not perfectly split. For dim flares this non-centering could impact positioning information more on one side than the other. Also, the ESP slit is 10 times taller in cross-dispersion (East-West) than in the dispersion direction (North-South).

ChannelLinesMeta HDU

Similar to the LinesMeta data unit, the ChannelLinesMeta data unit contains information about lines derived from the EVE level 2B spectrum. It contains wavelength information describing the line, line temperature, the line name, line type, and other blended lines included within the wavelength range of the line. The ChannelLinesMeta variables are identical to those described in Table 1 LinesMeta Descriptions, and the contents are shown in Table 10 ChannelLinesMeta Enumerated Values. This is the order corresponding to the ChannelLinesData HDU variables for irradiance, precision, and accuracy from each channel: MEGSA1_LINE_IRRADIANCE, MEGSA1_LINE_PRECISION, MEGSA1_LINE_ACCURACY, MEGSA2_LINE_IRRADIANCE, MEGSA2_LINE_PRECISION, MEGSA2_LINE_ACCURACY, MEGSB_LINE_IRRADIANCE, MEGSB_LINE_PRECISION, and MEGSB_LINE_ACCURACY.

Table 9 ChannelLinesMeta Descriptions

Column Name	DataType	Units	Description
Wave_center	Float	nm	The wavelength of electronic transition
Wave_min	Float	nm	Minimum wavelength of integrated line
Wave_max	Float	nm	Maximum wavelength of integrated line
LogT	Float	Log(K)	Log (base 10) temperature of emission line
Name	String	NA	Element and ionization stage of the dominant emission, such as He I
Type	String	NA	The isoelectronic series neutral atom for the dominant ion
Blends	String	NA	A partial ion list that is blended within this line

As with the lines in the LinesMeta HDU, almost all lines contain some blends, but not all are listed here.

Table 10 ChannelLinesMeta Enumerated Values

Wave_center	Wave_min	Wave_max	LogT	Name	Type	Blends
9.3926	9.33	9.43	6.81	Fe XVIII	F	
10.395	10.31	10.47	6.95	Fe XVIII	F	Ni XXII, Ni XXIII
11.723	11.67	11.81	7.10	Fe XXII	B	Fe XXI
13.124	13.04	13.17	5.57	Fe VIII	K	Fe VIII
13.285	13.23	13.32	6.97	Fe XX	N	Fe XXII
14.837	14.77	14.93	6.20	Ni XI	Ar	Fe XXIII
17.107	17.02	17.24	5.81	Fe IX	Ar	
17.453	17.38	17.52	6.05	Fe X	Cl	
17.7243	17.63	17.83	5.99	Fe X	Cl	Fe VII
18.0407	17.96	18.15	6.07	Fe XI	S	Fe X, Fe VII
19.512	19.43	19.61	6.13	Fe XII	P	
20.2044	20.14	20.32	6.19	Fe XIII	Si	Fe XI, Fe XII
20.383	20.33	20.45	6.30	Fe XIII	Si	
21.1331	21.07	21.2	6.27	Fe XIV	Al	Fe XII
21.516	21.45	21.57	6.40	O V	Be	Ne V
21.710	21.64	21.76	5.90	Fe IX	Ar	
21.912	21.85	21.95	6.30	Fe XIV	Al	
23.387	23.31	23.49	6.40	Fe XV	Mg	Ni XVIII

Wave_center	Wave_min	Wave_max	LogT	Name	Type	Blends
23.851	23.79	23.95	5.20	O IV	B	O III
24.174	24.12	24.22	5.90	Fe IX	Ar	
24.919	24.89	25.01	6.80	Ni XVII	Na	
25.6317	25.55	25.68	4.75	He II	H	
26.479	26.37	26.55	6.30	Fe XIV	Al	Fe XVI
27.039	26.97	27.13	5.70	Mg VI	C	Fe XIV
28.415	28.3	28.5	6.3	Fe XV	Mg	
30.3783	30.25	30.5	4.7	He II	H	
33.541	33.49	33.61	6.43	Fe XVI	Na	
36.0758	36.03	36.15	6.43	Fe XVI	Na	
36.8076	36.75	36.87	5.99	Mg IX	Be	Fe VIII-XIV
38.421	38.35	38.47	7.05	Fe XX	N	
38.907	38.86	38.96	7.05	Ar XVI	Li	Fe XVII
41.766	41.68	41.83	7.05	S XIV	Li	Fe XV
44.57	44.53	44.65	6.44	S XIV	Li	
46.5221	46.47	46.61	5.71	Ne VII	Be	
46.985	46.91	47.07	5.20	Ne IV	N	
49.9406	49.89	50.01	6.29	Si XII	Li	
50.808	50.67	50.91	4.90	O III	C	
52.1	52.03	52.13	6.28	Si XII	Li	
52.5795	52.53	52.65	4.92	O III	C	O II
53.703	53.65	53.77	3.84	He I	He	
54.199	54.05	54.29	5.20	Ne IV	N	Ca IX, Fe XII
54.389	54.29	54.53	5.20	Ne IV	N	Ca VII, Fe XIV
55.003	54.92	55.10	6.90	Al XI	Li~~B~~	
55.437	55.39	55.51	5.19	O IV	B	O IV
56.813	56.73	56.85	6.96	Al XI	Li	Ne V, Fe XX
57.230	57.13	57.31	5.40	Ne V	C	
57.428	57.34	57.48	4.95	C III	Be	
58.4334	58.39	58.51	4.16	He I	He	
59.224	59.17	59.31	6.89	Fe XIX	O	
59.9598	59.93	60.05	4.92	O III	C	
60.98	60.93	61.05	6.1	Mg X	Li	
62.4943	62.45	62.57	6.05	Mg X	Li	
62.973	62.93	63.05	5.37	O V	Be	
71.8535	71.81	71.93	4.48	O II	N	O II
72.156	72.11	72.21	6.96	Fe XX	N	
76.040	75.97	76.13	5.30	O V	Be	
76.515	76.41	76.63	5.10	N IV	Be	Fe VII
77.0409	76.99	77.11	5.81	Ne VIII	Li	
78.769	78.71	78.89	5.20	O IV	B	S V
79.0199	78.97	79.09	5.19	O IV	B	O III, O IV

Wave_center	Wave_min	Wave_max	LogT	Name	Type	Blends
83.55	83.25	83.61	4.52	O II	N	O III
84.550	84.52	84.64	7.10	Fe XXII	B	
90.409	90.31	90.51	4.60	C II	Be	
92.320	92.25	92.39	5.10	N IV	Be	
93.338	93.25	93.45	5.30	S VI	Na	
94.97	94.93	95.05	3.84	H I	H	
97.2537	97.21	97.31	3.84	H I	H	
97.703	97.65	97.77	4.84	C III	Be	
102.572	102.52	102.64	3.84	H I	H	
103.19	103.15	103.25	5.47	O VI	Li	
103.761	103.53	103.89	5.40	O VI	Li	C II

Data HDU

The Data HDU contains the science measurements of the irradiance spectrum, extracted line irradiances, band irradiances, and diode irradiances. The extracted lines and bands are integrated from the calibrated spectrum. Lines are integrated from low to high bounds. No continuum is subtracted from the line irradiances. No background spectrum or blended lines are removed, so the magnitude and variability include those contributions.

Table 11 LinesData Description

Column Name	DataType	Description
YYYYDOY	Long	UTC year and day of year
TAI_TIME	Long	Seconds since Jan 1, 1958 at noon UTC for this day
CAPTURE	ULong	A data capture metric of seconds where spectra were measured to produce the daily average
MEGSA_VALID	ULong	Number of valid spectral measurements from MEGS-A in the primary science filter
MEGSB_VALID	ULong	Number of valid spectral measurements from MEGS-B with the filter wheel in the open position
SP_IRRADIANCE	Float (array)	Solar Spectral Irradiance as power per unit area in W m^-2 nm^-1 adjusted to 1-AU for each wavelength bin defined in the SpectrumMeta Wavelength array.
SP_STDEV	Float (array)	Relative standard deviation (one-sigma) for each spectral wavelength bin, (fractional)
SP_PRECISION	Float (array)	Relative Precision for each bin (fractional) is the uncertainty based on counting statistics of the detector.
SP_ACCURACY	Float (array)	Relative NIST combined standard uncertainty includes all known contributing terms in the absolute calibration (fractional)
SP_FLAGS	UInt	Spacecraft flags, 0=good, 4 LSBs are an enumeration with 12 decimal values 0 = Clear, no obstructions 1 = Warmup during post-eclipse 2 = Penumbra of Earth atmosphere 3 = Umbra of Earth atmosphere 4 = Mercury penumbra

		5 = Mercury umbra 6 = Venus penumbra 7 = Venus umbra 8 = Lunar penumbra 9 = Lunar umbra 10 = Earth penumbra (solid earth) 11 = Earth umbra (solid earth) Upper 4-bit nibble uses 1 bit 32 = Spacecraft pointing over 1 arcmin from sun center (Maneuver)
LINE_IRRADIANCE	Float	Line irradiances in the order specified in the LinesMeta table
LINE_STDEV	Float	Standard deviation (one-sigma) of line irradiances
LINE_PRECISION	Float	Count rate-based error propagation
LINE_ACCURACY	Float	Total uncertainty including calibration uncertainty
LINE_FLAGS	Uint	See SP_FLAGS
BAND_IRRADIANCE	Float	Irradiance or counts in the band defined in the BandsMeta HDU
BAND_STDEV	Float	Standard deviation (one-sigma) of band irradiances
BAND_PRECISION	Float	Count rate-based uncertainty from error propagation
BAND_ACCURACY	Float	Total uncertainty including calibration uncertainty
DIODE_IRRADIANCE	Float	Diode irradiance in the order specified in the DiodesMeta HDU
DIODE_STDEV	Float	Standard deviation (one-sigma) of diode irradiances
DIODE_PRECISION	Float	Count rate-based uncertainty from error propagation
DIODE_ACCURACY	Float	Total uncertainty including calibration uncertainty
QUAD_FRACTION	Float	Fraction of the signal in each quadrant diode over 10 seconds
QUAD_STDEV	Float	One-sigma spread in each quadrant diode
QUAD_PRECISION	Float	Count rate-based uncertainty from error propagation

ChannelLinesData HDU

The ChannelLinesData HDU contains the extracted line irradiances from each channel: MEGS-A slit 1, MEGS-A slit 2, and MEGS-B.

Table 12 ChannelLinesData Descriptions

Column Name	DataType	Description
TAI	Double	Seconds since Jan 1, 1958
YYYYDOY	Long	UTC year and day of year
SOD	Double	UTC seconds of day at the center of the observation
FLAGS	Byte	Processing bit flags, multiple bits may be set at the same time. 0=all present/good Bit 0 set = MEGS-A missing, (decimal 1) Bit 1 set = MEGS-B missing, (decimal 2) Bit 2 set = ESP missing, (decimal 4) Bit 3 set = MEGS-P missing, (decimal 8) Bit 4 set = Too many MEGS-A integrations, (decimal 16) Bit 5 set = Too many MEGS-B integrations, (decimal 32) Bit 6 set = Too many ESP integrations, (decimal 64)

		Bit 7 set = Too many MEGS-P integrations (decimal 128) If the spacecraft clock jumps backwards, additional integrations can occur.
SC_FLAGS	Byte	Spacecraft flags, 0=good, 4 LSBs are an enumeration with 12 decimal values 0 = Clear, no obstructions 1 = Warmup during post-eclipse 2 = Penumbra of Earth atmosphere 3 = Umbra of Earth atmosphere 4 = Mercury penumbra 5 = Mercury umbra 6 = Venus penumbra 7 = Venus umbra 8 = Lunar penumbra 9 = Lunar umbra 10 = Earth penumbra (solid earth) 11 = Earth umbra (solid earth) Upper 4-bit nibble uses 1 bit 32 = Spacecraft pointing over 1 arcmin from sun center (Maneuver)
MEGSA1_LINE_IRRADIANCE	Float	Line irradiances as extracted from MEGS-A slit 1 in the order specified in the ChannelLinesMeta table
MEGSA1_LINE_PRECISION	Float	Count rate-based error propagation for MEGS-A slit 1
MEGSA1_LINE_ACCURACY	Float	Total uncertainty including calibration uncertainty for MEGS-A slit 1
MEGSA2_LINE_IRRADIANCE	Float	Line irradiances as extracted from MEGS-A slit 1 in the order specified in the ChannelLinesMeta table
MEGSA2_LINE_PRECISION	Float	Count rate-based error propagation for MEGS-A slit 1
MEGSA2_LINE_ACCURACY	Float	Total uncertainty including calibration uncertainty for MEGS-A slit 1
MEGSB_LINE_IRRADIANCE	Float	Line irradiances as extracted from MEGS-A slit 1 in the order specified in the ChannelLinesMeta table
MEGSB_LINE_PRECISION	Float	Count rate-based error propagation for MEGS-A slit 1
MEGSB_LINE_ACCURACY	Float	Total uncertainty including calibration uncertainty for MEGS-B

User Guide and Examples in IDL

Level 3 data products are stored in FITS format and may be read using a variety of software. See https://lasp.colorado.edu/eve/data_access/eve-documentation/index.html for more details. LASP provides an IDL function called eve_read_whole_fits.pro which allows easy reading of any EVE data product that is in FITS format. The software eve_read_whole_fits.pro may be downloaded from the EVE website.

Reading a file

We will use the function eve_read_whole_fits.pro in the following examples.

To read in a level 3 data product, download a file and call the function with the filename.

```
IDL> eveL3 = eve_read_whole_fits( 'EVE_L3_2010123_008_01.fit' )
```

The variable called data is a structure containing data and metadata. To see the structure contents, perform the following command:

```
IDL> help, eveL3, /structure
** Structure <26a6e38>, 18 tags, length=138080, data length=138064, refs=1:
      PRIMARY         LONG                   0
      PRIMARY_HEAD    STRING    Array[5]
      SPECTRUMMETA    STRUCT    -> <Anonymous> Array[5200]
      SPECTRUMMETA_HEADER
                      STRING    Array[23]
      LINESMETA       STRUCT    -> <Anonymous> Array[71]
      LINESMETA_HEADER
                      STRING    Array[57]
      BANDSMETA       STRUCT    -> <Anonymous> Array[20]
      BANDSMETA_HEADER
                      STRING    Array[34]
      DIODEMETA       STRUCT    -> <Anonymous> Array[6]
      DIODEMETA_HEADER
                      STRING    Array[37]
      QUADMETA        STRUCT    -> <Anonymous> Array[4]
      QUADMETA_HEADER STRING    Array[27]
      CHANNELLINESMETA
                      STRUCT    -> <Anonymous> Array[71]
      CHANNELLINESMETA_HEADER
                      STRING    Array[51]
      DATA            STRUCT    -> <Anonymous> Array[1]
      DATA_HEADER     STRING    Array[164]
      CHANNELLINESDATA
                      STRUCT    -> <Anonymous> Array[1]
      CHANNELLINESDATA_HEADER
                      STRING    Array[104]
```

Making a plot

The wavelength information is stored in the eveL3.spectrummeta structure (from the spectrummeta HDU). To make a plot:

```
IDL> plot, eveL3.spectrummeta.wavelength, eveL3.data.sp_irradiance, yrange=[1e-7,1e-2], $
/ylog, charsize=1.5, xtitle='Wavelength (nm)', ytitle='Irradiance (W/m^2/nm)', $
title='SDO EVE Irradiance on '+strtrim(eveL3.data.yyyydoy,2)
```

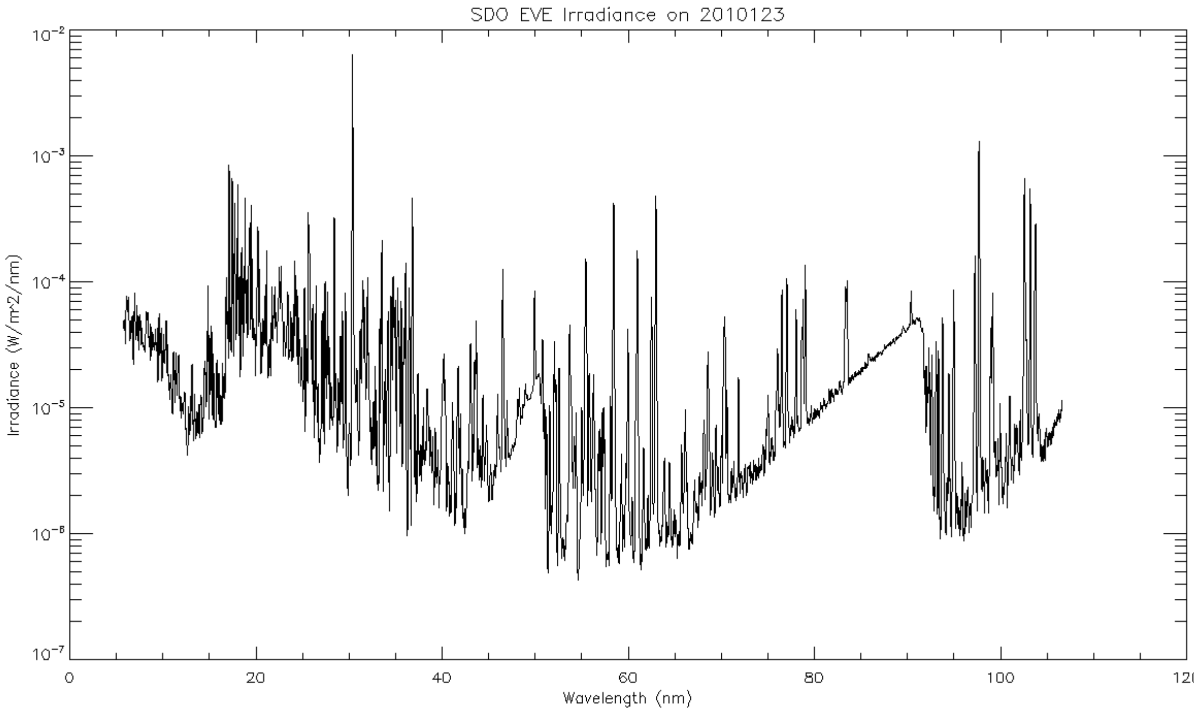

Figure 1 EVE level 3 spectrum for 2010 day of year 123

SolarSoft

SolarSoft and IDL users may wish to download the EVE SolarSoft software package. It is available at our web site by browsing the Documentation page that includes installation instructions. https://lasp.colorado.edu/eve/data_access/eve-documentation/index.html

Additional information about SolarSoft can be found through the LMSAL website, https://www.lmsal.com/solarsoft.
Note that the EVE SolarSoft package can be run in IDL without SolarSoft.

Data Availability and Data Gaps

Daily calibrations are performed that last a total of about 30 minutes; however, the channel calibrations are staggered so that one of the science channels is always observing the Sun during the daily calibration. These daily calibrations allow for EVE to directly measure dark signals on the detectors to track changes. For the CCDs, the flatfield LEDs are also used. On Sundays, a slightly longer calibration is performed to increase statistics.

Two annual eclipse outage periods of about 3 weeks occur as the spacecraft orbit aligns with the Earth and Sun. These can last up to 72 minutes each day. After longer eclipses (10+ minutes), some thermal settling causes a wavelength shift on MEGS-A that is not yet corrected. Around the 2 eclipse seasons, additional off-pointing maneuvers are performed including EVE cruciform scans (9 hours), EVE FOV maps (~2 hours), plus maneuvers for the other instruments and the guide telescopes.

The spacecraft is also subject to being blocked by the moon, but this is infrequent. Other infrequent activities include momentum management, and station-keeping thruster firings.

CCD bakeouts have occurred earlier in the mission in attempts to recover instrument sensitivity for MEGS-B. The first bakeout started on June 16 (day 167), 2010 and continued through June 18 (day 169), 2010. The second CCD bakeout was much longer lasting from September 23 (day 266) through September 28 (day 271), 2010. After each bakeout, there is a period of several days where the detectors change rapidly, and this is not corrected in version 3. No future bakeouts will be scheduled.

To minimize the degradation on the MEGS-B detector, MEGS-B only observes the sun for 3 hours per day and the timing of the observation has changed throughout the mission. When not observing the Sun, the MEGS-B portion of the spectra is filled with −1.0when MEGS-A data is available. After the MEGS-A anomaly when no MEGS-B data are available, the spectra file is no longer generated (missing MEGS-A and MEGS-B). The lines/bands file is generated because the ESP data remains continuously available.

Detailed daily information is provided in the Science Operations Mission Log and is available at this location:
https://lasp.colorado.edu/eve/data_access/evewebdata/EVE_sciopslog.html

Data availability can be assessed using the calendars on the EVE website for the particular product and year of interest. This link is for level 3 data for 2024. Green cells indicate data is available.
https://lasp.colorado.edu/eve/data_access/eve_data/misc/eve_calendars/calendar_level3_2024.html

Other Notes

The spectra bins should not be used individually for analysis due to the possibility of small-scale wavelength shifts. Rather, users should integrate over the features of interest. MEGS-A (5-37 nm) is the most sensitive to these small wavelength shifts, but they also occur in MEGS-B.

Since the MEGS-A 30.4 line has suffered detector burn-in and filter degradation, the line shape itself is being adjusted. This is likely to affect attempts to observe Doppler shifts. We recommend using the count rate spectrum to investigate the incredibly small line shifts.

The MEGS-P Lyman-alpha diode measurement is susceptible to low energy particles. Our initial attempt to remove the low energy particle noise using the dark diode needs refinement. Rather than exclude this measurement, we filter it based on those periods of increased particle noise. Therefore, the MEGS-P Lyman-alpha measurement is sometimes very complete. The Lyman-alpha measurement uses the same filter mechanism as MEGS-B, so it is also operating with the same reduced-exposure scenario. The periods of high potential large contributions from particles are fixed to earth's magnetic field, so the UT time shifts about 3:56 each day.

Also, due to random large particle hits, the Lyman-alpha measurement experiences high frequency noise at 4 Hz. The data is filtered using a Fourier transform filter to remove the highest frequency spikes. Unfortunately, the Lyman-alpha measurement can be very noisy, so it is most useful after averaging to a daily value.

History of MEGS-B Initial Calibration and Continuing Degradation

The history of degradation tracking for MEGS-B is long. The first light spectrum in 2010 from MEGS-B was about 1/8 of the expected values on the longer wavelength side of the CCD based on ground calibration results. MEGS-B ground calibrations are not representative of observed flight behavior. The responsivity has been inferred from simultaneous suborbital rocket instrument measurements. Multiple rocket flights are needed to provide tracking of degradation for MEGS-B.

Continuous solar exposure of MEGS-B for the first 2 weeks of the mission resulted in additional unexpected rapid degradation of about 1% per day. Solar exposure time for MEGS-B was severely restricted to decrease the degradation rate soon after this was discovered. Multiple short-term daily exposure schemes were implemented in operations, where short enough exposure allowed some recovery to occur. Eventually a balance was struck to maximize solar exposure and minimize degradation changes. The exposure timing was also altered to move with sideral time to avoid the worst particle background times to increase the chances of obtaining good measurements.

Several CCD bakeouts were performed from 2010 through 2012 to try to recover the signal loss observed, and while some signal was temporarily recovered the previous degradation trends were no longer correct. Multiple bakeouts in close succession failed to recover additional signal in the second bakeout. Each bakeout started a new trend with rapid changes that slowed over time leading to multiple time intervals for curve fitting. The last bakeout was in 2012 which unexpectedly decreased the responsivity on MEGS-A.

Seemingly small changes in operations for the case heater cause the MEGS-B lines to move. This is a detectable continuous change after eclipse exit that lasts for several hours. The MEGS-A failure also caused a temperature change to MEGS-B that abruptly moved all the lines. The impact of this, and other changes, is that small changes in the line location at the detector cause bright lines to illuminate less degraded detector pixels. Some lines have experienced signal losses of over 80% since the beginning of the mission. Small motion can cause the degradation correction to no longer be valid. None of this was corrected in version 6 or earlier versions. Version 8 can only correct this in the past—future motion is not correctable in version 8.