

Solar Dynamics Observatory (SDO)

Extreme Ultraviolet Variability Experiment (EVE): Release notes for version 7 science data products

Level 3 Science Data Products 2/15/21

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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.

This version change includes updated long-term degradation corrections for MEGS- B and ESP. A small dark adjustment was applied to MEGS-B and large degradation changes were applied based on SDO sounding rocket measurements. The MEGS-P (Lyman-alpha) diode measurements have 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 is a new release of EVE Level 3 data products. 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@lasp.colorado.edu.

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

Responsible Data Usage:

SDO Mission scientific and model results are open to all, however users should contact the PI or designated EVE team member early in an analysis project to discuss appropriate use of instrument data results. Appropriate acknowledgment to institutions, personnel, and funding agencies should be given. Version numbers should also be specified. Pre-prints of publications and conference abstracts should be widely distributed to interested parties within the mission.

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, "EUVSpectroPhotometer (ESP) in Extreme Ultraviolet Variability Experiment (EVE): Algorithms and Calibrations", *Solar Physics*, 275, 179-205, doi: 10.1007/s11207-009-9485-8, 2012.

Explanation and Examples in IDL

Level 3 data products are stored in FITS format and may be read by a variety of software, see the documentation section at http://lasp.colorado.edu/eve/data_access/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.

https://lasp.colorado.edu/eve/data_access/software/eve_read_whole_fits.pro

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_006_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 <17ea5928>, 14 tags, length=123496, data length=123486, refs=1:
```

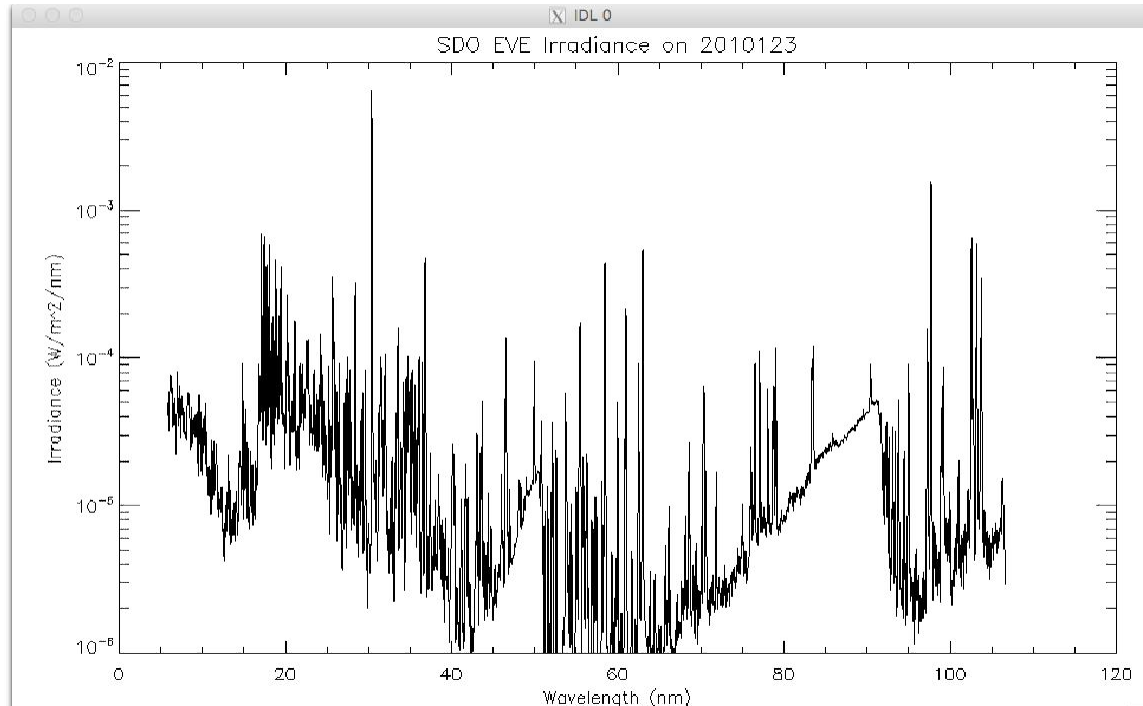
PRIMARY	LONG	0
PRIMARY_HEAD	STRING	Array[5]
SPECTRUMMETA	STRUCT	-> <Anonymous> Array[5200]
SPECTRUMMETA_HEADER	STRING	Array[28]
LINESMETA	STRUCT	-> <Anonymous> Array[39]
LINESMETA_HEADER	STRING	Array[48]
BANDSMETA	STRUCT	-> <Anonymous> Array[20]
BANDSMETA_HEADER	STRING	Array[32]
DIODEMETA	STRUCT	-> <Anonymous> Array[6]
DIODEMETA_HEADER	STRING	Array[27]
QUADMETA	STRUCT	-> <Anonymous> Array[4]
QUADMETA_HEADER	STRING	Array[27]
DATA	STRUCT	-> <Anonymous> Array[1]
DATA_HEADER	STRING	Array[105]

Making a plot

As described above, the wavelength information is stored in the `data.spectrummeta` structure. To plot the daily averaged spectrum, issue the following command:

```
IDL> plot, evel3.spectrummeta.wavelength, evel3.data.sp_irradiance, yrange=[1e-6,1e-2], /ylog, charsize=1.5, xtitle='Wavelength (nm)', ytitle='Irradiance (W/m^2/nm)', title='SDO EVE Irradiance on '+strtrim(evel3.data.yyydoy,2)
```

This command will produce a plot similar to the following:



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 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 irradiances are adjusted to 1 AU. The level 3 products contain daily averages of the level 2 spectrum measurements at the same wavelength sampling as level 2. The level 3 products also contain daily average measurements of the diodes, extracted bands, and selected lines reports in the level 2 products. The level 3 data products are available as one file per day, and also as merged dataset files that are updated daily with new measurements. The mission length merged datasets are provided at three sampling sizes for user convenience; specifically, native level 2 sampling, 1 Angstrom, and 1 nm. See the section “Merged Datasets” below for more details.

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 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 the incorporation of each suborbital rocket calibration flight. When referencing EVE data in scientific papers, users agree to mention this version number.

The revision increments whenever updated information are available. Generally, revision 1 is considered "preliminary". After 30 days, products become "definitive" since no new telemetry can be delivered after this period of time due to finite storage capacity of the SDO ground station. For most days, revision 1 will be the final revision, but newer revisions take precedence over older ones if they exist.

Merged File Naming Convention

Level 3 merged products have the following naming convention that has similar date and version elements as described above.

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 6 FITS header data units, containing data and corresponding metadata information pertaining to daily averaged spectra, diode measurements, lines, and bands.

The SpectrumMeta data unit contains one array representing the center wavelengths of each spectral bin. The previous version had accuracy as a second array in this HDU, but that was moved into the data HDU in version 5 data products.

SpectrumMeta:

Column Name	Type	Description
Wavelength	Float (array)	Center wavelength for each bin

The LinesMeta data unit contains information about lines derived from the EVE level 2 full resolution spectrum. It contains wavelength information describing the line, line temperature, the line name, line type, and other lines included within the wavelength band of the line as described in the following table.

LinesMeta:

Column Name	Type	Description
wave_center	Float	Center wavelength of line
wave_min	Float	Minimum wavelength of line
wave_max	Float	Maximum wavelength of line
LogT	Float	Log (base 10) temperature of line (K)
Name	String	Line name example (Fe XVIII)
Type	String	Type of line example (F)

Blend	String	Other lines included in this line
-------	--------	-----------------------------------

The BandsMeta data unit describes the extracted bands from the EVE spectrum that correspond to the 7 AIA spectral bands, two GOES-14 bands, 4 extracted MEGS spectral bands corresponding to the ESP diodes, two broadbands 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 the following table.

BandsMeta:

Column Name	Type	Description
Name	String	Name of band example (AIA_304)
Type	String	SDO instrument example (AIA)

The DiodeMeta data unit contains information about spectral bands derived from EVE level 2 spectra that corresponds to measurements made by EVE diodes from ESP and MEGS P. The DiodeMeta data unit is described in the following table.

DiodeMeta:

Column Name	Type	Description
Name	String	Name of the band example (171)
Type	String	SDO instrument example (ESP)

The ESP central quad diode contains information about the center of brightness for the 0.1-7 nm bandpass. These are normalized to provide a relative measure of the distribution of irradiance.

QuadMeta:

Column Name	Type	Description
Name	String	Name of the quadrant (Q0)
Type	String	SDO instrument example (ESP)

The last Data HDU contains the actual data. It holds the irradiance spectrum as well as

other values as described in the following table.

Data:

Column Name	Type	Description
YYYYDOY	Long	4-digit year and 3-digit day of year of the observation
Capture	ULong	Seconds in the day where the spectrum is measured.
MEGSA_Valid	ULong	Number of valid spectral measurements from MEGS-A (primary science filter)
MEGSB_Valid	ULong	Number of valid spectral measurements from MEGS-B (filter wheel open)
SP_Irradiance	Float (array)	Power per unit area at 1-AU in W/m ² /nm. 5200 element array containing the irradiance for each wavelength bin
SP_StDev	Float (array)	Relative one-sigma spread, the standard deviation for each bin (fractional)

SP_Precision	Float (array)	Relative Precision information for each bin. This represents the uncertainty based only on counting statistics. (fractional)
SP_Accuracy	Float (array)	Relative uncertainty representing the NIST combined standard uncertainty. This includes all known contributing factors including the absolute calibration. (fractional)
SP_Flags	Uint (array)	5200 element array containing quality information for each bin (refer to level 2 data product documentation for descriptions)
Line_Irradiance	Double (array)	Power per unit area at 1-AU over the integrated line with no background subtraction.
Line_StDev	Float (array)	Relative one-sigma spread, the standard deviation for each line (fractional)
Line_Precision	Float (array)	Relative Precision information for each line. This represents the uncertainty based only on counting statistics. (fractional)
Line_Accuracy	Float (array)	Relative uncertainty representing the NIST combined standard uncertainty (fractional)
Band_Irradiance	Float (array)	Power per unit area at 1-AU over the integrated band from the combined MEGS-A and B spectrum. Note that the AIA bands are in counts per second per pixel, not irradiance.
Band_StDev	Float (array)	Relative one-sigma spread, the standard deviation for each band (fractional)
Band_Precision	Float (array)	Relative Precision information for each band. This represents the uncertainty based only on counting statistics. (fractional)
Band_Accuracy	Float (array)	Relative uncertainty representing the NIST combined standard uncertainty (fractional)
Diode_Irradiance	Float (array)	Power per unit area at 1-AU measured by the diodes.
Diode_StDev	Float (array)	Relative one-sigma spread, the standard deviation for each diode (fractional)
Diode_Precision	Float (array)	Relative Precision information for each diode. This represents the uncertainty based only on counting statistics. (fractional)
Diode_Accuracy	Float (array)	Relative uncertainty representing the NIST combined standard uncertainty (fractional)
Quad_Fraction	Float (array)	The fraction of the total signal on each quadrant diode comprising the 0.1-7 nm measurement.
Quad_StDev	Float (array)	Relative one-sigma spread, the standard deviation for each of the ESP central order quadrant diodes (fractional)
Quad_Precision	Float (array)	Relative Precision information for each bin. This represents the uncertainty based only on counting statistics. (fractional)

Data Processing

All data products are generated at LASP, and the Level 3 products described in this document are all publicly available at the EVE website. We caution users to carefully consider their data needs. The level 3 products are free for responsible public use; however, downloading the entire dataset from one of the merged files is probably the best solution for most users.

FITS Definition and Software

The EVE Level 3 products are stored in the scientific format called FITS as binary tables. FITS was first introduced in 1979. As one of the oldest scientific data formats, it continues to be widely used and expanded.

FITS reference: FITS: A Flexible Image Transport System, Wells, D. C., Grisen, E. W., and Harten, R. H., *Astronomy & Astrophysics Supplement Series*, 44, 363-370, 1981.

<https://ui.adsabs.harvard.edu/abs/1981A%26AS...44..363W/abstract>

FITS Binary Table reference: Binary Table Extension to FITS, Cotton, W. D., Tody, D. B., and Pence, W. D., *Astronomy & Astrophysics Supplement Series*, 113, 159-166, 1995.

<https://ui.adsabs.harvard.edu/abs/1995A%26AS..113..159C/abstract>

Additional detailed documentation is available at evenetapp/eveweb/data/products/level3ble online.

https://fits.gsfc.nasa.gov/fits_documentation.html

Standard reader software is available from GSFC for many different languages. A graphical program called "fv" is useful for browsing the contents without writing any programs.

<https://heasarc.gsfc.nasa.gov/docs/software/ftools/fv/>

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. [eve_read_whole_fits.pro](#) may be downloaded from the EVE web site.

https://lasp.colorado.edu/eve/data_access/software/eve_read_whole_fits.pro

For IDL, you may also use `mrdfits.pro` available at:

<https://idlastro.gsfc.nasa.gov/mrdfits.html>

<https://idlastro.gsfc.nasa.gov/fitsio.html>

Diving deeper into the data

The metadata regarding the line name, wavelength ranges, temperature, and other useful information are contained in the `linesmeta` HDU. These are stored the same way as the

level 2 data files, and can be accessed to generate a table as follows:

```
IDL> for i=0,n_elements(data.linesmeta)-1 do print,data.linesmeta[i].name,  
data.linesmeta[i].wave_center, data.linesmeta[i].logt, I
```

Fe XVIII	9.39260	6.81000	0
Fe VIII	13.1240	5.57000	1
Fe XX	13.2850	6.97000	2
Fe IX	17.1070	5.81000	3
Fe X	17.7243	5.99000	4
Fe XI	18.0407	6.07000	5
Fe XII	19.5120	6.13000	6
Fe XIII	20.2044	6.19000	7
Fe XIV	21.1331	6.27000	8
He II	25.6317	4.75000	9
Fe XV	28.4150	6.30000	10
He II	30.3783	4.70000	11
Fe XVI	33.5410	6.43000	12
Fe XVI	36.0758	6.43000	13
Mg IX	36.8076	5.99000	14
S XIV	44.5700	6.44000	15
Ne VII	46.5221	5.71000	16
Si XII	49.9406	6.29000	17
Si XII	52.1000	6.28000	18
O III	52.5795	4.92000	19
He I	53.7000	3.84000	20
O IV	55.4370	5.19000	21
Fe XX	56.7870	6.96000	22
He I	58.4334	4.16000	23
Fe XIX	59.2240	6.89000	24
O III	59.9598	4.92000	25
Mg X	60.9800	6.10000	26
Mg X	62.4943	6.05000	27
O V	62.9730	5.37000	28
O II	71.8535	4.48000	29
Fe XX	72.1560	6.96000	30
Ne VIII	77.0409	5.81000	31
O IV	79.0199	5.19000	32
O II	83.5500	4.52000	33
H I	94.9700	3.84000	34
H I	97.2537	3.84000	35
C III	97.7030	4.84000	36
H I	102.572	3.84000	37
O VI	103.190	5.47000	38

FITS file header metadata

The FITS file header metadata is accessible in the `data_header` structure:

```
IDL> for i=0,n_elements(data.data_header)-1 do print,data.data_header[i]

XTENSION      =      'BINTABLE'    /Binary table written by MWRFITS v1.11
BITPIX        =          8        /Required value
NAXIS         =          2        /Required value
NAXIS1        =       94938      /Numberof bytes per row
NAXIS2        =          1        /Numberof rows
PCOUNT        =          0        /Normally 0 (no varying arrays)
GCOUNT        =          1        /Required value
TFIELDS       =          25      /Numberof columns in table
COMMENT       =      '*** End of mandatory fields ***'
COMMENT
COMMENT      =      '          SDO/EVE          SPOC' // LASP, University of Colorado, Boulder
ORIGIN DATE   =      '2017-05-05T18:52:19.000Z' // UTC file creation time (per ISO8601)
TAI_OBS       =      1651536034.000 //          TAI time at start of obs
DATE_OBS      =      '2010-05-03T00:00:00.000Z' // UTC at start of obs
T_OBS        =      '2010-05-03T12:00:00.000Z' // UTC at center of obs
EXPTIME       =      86400.000 //          seconds exposed, or integration time
TIME          =          0.000 //          UTC seconds of day at start of obs
TELESCOP      =          'SDO/EVE'
INSTRUME      =      '          EVE_MEGS_ESP'          006 //          major code/cal version
VERSION       =          7
REVISION      =      1 //          reprocess number
FILENAME      =      'EVE_L3_2010123_006_01.fit'
COMMENT       =      '*** Column names ***'
COMMENT
COMMENT
COMMENT
TTYPE1        =      'YYYYDOY'    /
TTYPE2        =      'CAPTURE'    /
TTYPE3        =      'MEGSA_VALID' /
TTYPE4        =      'MEGSB_VALID' /
TTYPE5        =      'SP_IRRADIANCE' /
TTYPE6        =      'SP_STDEV'   /
TTYPE7        =      'SP_PRECISION' /
TTYPE8        =      'SP_ACCURACY' /
TTYPE9        =      'SP_FLAGS'   /
TTYPE10       =      'LINE_IRRADIANCE' /
TTYPE11       =      'LINE_STDEV' /
TTYPE12       =      'LINE_PRECISION' /
TTYPE13       =      'LINE_ACCURACY' /
TTYPE14       =      'LINE_FLAGS' /
TTYPE15       =      'BAND_IRRADIANCE' /
TTYPE16       =      'BAND_STDEV' /
TTYPE17       =      'BAND_PRECISION' /
TTYPE18       =      'BAND_ACCURACY' /
TTYPE19       =      'DIODE_IRRADIANCE' /
TTYPE20       =      'DIODE_STDEV' /
TTYPE21       =      'DIODE_PRECISION' /
TTYPE22       =      'DIODE_ACCURACY' /
TTYPE23       =      'QUAD_FRACTION' /
TTYPE24       =      'QUAD_STDEV' /
TTYPE25       =      'QUAD_PRECISION' /
```

```

COMMENT      *** Column formats ***
COMMENT
COMMENT      =      'J      '      /
TFORM1
TFORM2      =      'J      '      /
TFORM3      =      'J      '      /
TFORM4      =      'J      '      /
TFORM5      =      '5200E '      /
TFORM6      =      '5200E '      /
TFORM7      =      '5200E '      /
TFORM8      =      '5200E '      /
TFORM9      =      '5200I '      /
TFORM10     =      '39D  '      /
TFORM11     =      '39E  '      /
TFORM12     =      '39E  '      /
TFORM13     =      '39E  '      /
TFORM14     =      '39I  '      /
TFORM15     =      '20E  '      /
TFORM16     =      '20E  '      /
TFORM17     =      '20E  '      /
TFORM18     =      '20E  '      /
TFORM19     =      '6E   '      /
TFORM20     =      '6E   '      /
TFORM21     =      '6E   '      /
TFORM22     =      '6E   '      /
TFORM23     =      '4E   '      /
TFORM24     =      '4E   '      /
TFORM25     =      '4E   '      /
COMMENT      *** Unsigned integer column scalings *
COMMENT
COMMENT      =      1 /
TSCAL2
TSCAL3      =      1 /
TSCAL4      =      1 /
TSCAL9      =      1 /
TSCAL14     =      1 /
TZERO2      =      0 /Modified by MRDFITS V2.20
TZERO3      =      0 /Modified by MRDFITS V2.20
TZERO4      =      0 /Modified by MRDFITS V2.20
TZERO9      =      0 /Modified by MRDFITS V2.20
TZERO14     =      0 /Modified by MRDFITS V2.20
COMMENT      Website reference http://lasp.colorado.edu/home/eve
COMMENT      EVE Principal Investigator T. N. Woods
COMMENT      Laboratory for Atmospheric and Space Physics
COMMENT      1234 Innovation Drive, Boulder, CO 80303
COMMENT      SDO Mission scientific and model results are open to all.
COMMENT      Users should contact the PI or designated EVE team member early in an
COMMENT      analysis project to discuss appropriate use of instrument data results.
COMMENT      Appropriate acknowledgement to institutions, personnel, and funding
COMMENT      agencies should be given. Version numbers should also be specified.
COMMENT      Pre-prints of publications and conference abstracts should be widely
COMMENT      distributed to interested parties within the mission.
EXTNAME     =      'Data'
END

```

FITS spectrum header metadata

The FITS spectrum header metadata is accessible in the `spectrummeta_header` structure:

```
IDL> for i=0,n_elements(data.spectrummeta_header)-1 do
print,data.spectrummeta_header[i]
```

```
XTENSION      =      'BINTABLE'    /Binary table written by MWRFITs v1.11
BITPIX        =      8            /Required value
NAXIS         =      2            /Required value
NAXIS1        =      4            /Number of bytes per row
NAXIS2        =      5200         /Number of rows
PCOUNT        =      0            /Normally 0 (no varying arrays)
GCOUNT        =      1            /Required value
TFIELDS       =      1            /Number of columns in table
COMMENT       =      '*** End of mandatory fields ***'
COMMENT
COMMENT       =      'SpectrumMeta'
EXTNAME
TUNIT1        =      'nm'
COMMENT       =      '*** Column names ***'
COMMENT
COMMENT       =      'WAVELENGTH/'
TTYPE1
COMMENT       =      '*** Column formats ***'
COMMENT
COMMENT       =      'E      '      /
TFORM1
COMMENT       =      'Wavelength (nm) is the center value of each bin of sp_irradiance
COMMENT       =      'in the Data table
COMMENT       =      'Accuracy is the relative accuracy of the entire MEGS measurement at
COMMENT       =      'each wavelength.
COMMENT       =      'Precision is the relative precision of the entire MEGS measurement at
COMMENT       =      'each wavelength.
END
```

```
IDL> help,data.spectrummeta,/str
```

```
** Structure <1ea4f8e8>, 1 tags, length=4, data length=4, refs=2:
```

```
WAVELENGTH      FLOAT      3.01000
IRRADIANCE_UNITS STRING     'W/m^2/nm'
```

FITS lines header metadata

The FITS lines header metadata is accessible in the `linesmeta_header` structure:

```
IDL> for i=0,n_elements(data.linesmeta_header)-1 do  
print,data.linesmeta_header[i]
```

```
XTENSION      =      'BINTABLE'      /Binary table written by MWRFITS v1.11  
BITPIX        =      8              /Required value  
NAXIS         =      2              /Required value  
NAXIS1        =      42             /Number of bytes per row  
NAXIS2        =      39             /Number of rows  
PCOUNT        =      0              /Normally 0 (no varying arrays)  
GCOUNT        =      1              /Required value  
TFIELDS       =      7              /Number of columns in table  
COMMENT       *** End of mandatory fields ***  
COMMENT  
COMMENT      =      'LinesMeta'  
EXTNAME  
TUNIT1        =      'nm'  
TUNIT2        =      'nm'  
TUNIT3        =      'nm'  
TUNIT4        =      'log(K)'  
COMMENT       *** Column names ***  
COMMENT  
COMMENT      =      'WAVE_CENTER'      /  
TTYPE1  
TTYPE2        =      'WAVE_MIN'      /  
TTYPE3        =      'WAVE_MAX'      /  
TTYPE4        =      'LOGT '        /  
TTYPE5        =      'NAME '        /  
TTYPE6        =      'TYPE '        /  
TTYPE7        =      'BLENDS '      /  
COMMENT       *** Column formats ***  
COMMENT  
COMMENT      =      'E '            /  
TFORM1  
TFORM2        =      'E '            /  
TFORM3        =      'E '            /  
TFORM4        =      'E '            /  
TFORM5        =      '8A '          /  
TFORM6        =      '5A '          /  
TFORM7        =      '13A '         /  
COMMENT       For every element in the LINE_* column in the Data table, there is  
COMMENT       one row here describing the spectral line for that element  
COMMENT       wave_center is the nominal 'center' or 'peak'  
COMMENT       wave_min is the lower edge of the integration window  
COMMENT       wave_max is the upper edge of the integration window  
COMMENT       logt is the base-10 log of the temperature of this line in Kelvin  
COMMENT       name is the primary ion  
COMMENT       type is the electron configuration of the primary ion  
COMMENT       blends is other ions that may be in this line  
COMMENT       lines below 37nm are derived from MEGS A  
COMMENT       lines above 37nm are derived from MEGS B  
END
```

```
IDL> help,data.linesmeta,/str
```

```
** Structure <1ea4e058>, 7 tags, length=64, data length=64, refs=2:
```

```
WAVE_CENTER    FLOAT      9.39260
WAVE_MIN       FLOAT      9.33000
WAVE_MAX       FLOAT      9.43000
LOGT           FLOAT      6.81000
NAME           STRING     'Fe XVIII'
TYPE           STRING     'F      '
BLENDS         STRING     '      '
```

FITS bands header metadata

The FITS bands header metadata is accessible in the bandsmeta_header structure:

```
IDL> for i=0,n_elements(data.bandsmeta_header)-1 do
print,data.bandsmeta_header[i]
```

```
XTENSION      =      'BINTABLE'    /Binary table written by MWRFITS v1.11
BITPIX        =      8             /Required value
NAXIS         =      2             /Required value
NAXIS1        =      25            /Number of bytes per row
NAXIS2        =      20            /Number of rows
PCOUNT        =      0             /Normally 0 (no varying arrays)
GCOUNT        =      1             /Required value
TFIELDS       =      4             /Number of columns in table
COMMENT       =      '*** End of mandatory fields ***'
COMMENT
COMMENT
EXTNAME       =      'BandsMeta'
COMMENT       =      '*** Column names ***'
COMMENT
COMMENT       =      'NAME '        /
TTYPE1
TTYPE2        =      'TYPE '        /
TTYPE3        =      'LOW_WAVELENGTH_NM' /
TTYPE4        =      'HIGH_WAVELENGTH_NM' /
COMMENT       =      '*** Column formats ***'
COMMENT
COMMENT       =      '13A '         /
TFORM1
TFORM2        =      '4A '          /
TFORM3        =      'E '           /
TFORM4        =      'E '           /
COMMENT       =      'For every element in the BAND_* column in the Data table, there is
COMMENT       =      'one row here describing the band.
COMMENT       =      'name is the name of the band
COMMENT       =      'type describes the source of the band weighting
COMMENT       =      'No matter the type, all irradiance data used here comes from MEGS A/B
END
```



```
IDL> help,data.bandsmeta,/str
```

```
** Structure <1ea5db88>, 4 tags, length=40, data length=40, refs=2:
```

NAME	STRING	'AIA_A94	'
TYPE	STRING	'AIA	'
LOW_WAVELENGTH_NM	FLOAT	9.27500	
HIGH_WAVELENGTH_NM	FLOAT	9.51500	

FITS diode header metadata

The FITS diode header metadata is accessible in the diodemeta_header structure:

```
IDL> for i=0,n_elements(data.diodemeta_header)-1 do  
print,data.diodemeta_header[i]
```

```
/Binary table written by MWRFITs v1.11
```

```
XTENSION      =      'BINTABLE'  
BITPIX        =      8      /Required      value  
NAXIS         =      2      /Required      value  
NAXIS1        =     10      /Number of bytes per row  
NAXIS2        =      6      /Number of rows  
PCOUNT        =      0      /Normally 0 (no varying arrays)  
GCOUNT        =      1      /Required value  
TFIELDS       =      2      /Number of columns in table  
COMMENT       *** End of mandatory fields ***  
COMMENT  
COMMENT  
EXTNAME       =      'DiodeMeta'  
COMMENT       *** Column names ***  
COMMENT  
COMMENT       =      'NAME '      /  
TTYPE1  
TTYPE2        =      'TYPE '      /  
COMMENT       *** Column formats ***  
COMMENT  
COMMENT       =      '4A '      /  
TFORM1  
TFORM2        =      '6A '      /  
COMMENT       For every element in the DIODE_* column in the Data table, there  
COMMENT       is one row here describing the diode.  
COMMENT       name is a designation      for the diode bandpass  
COMMENT       type describes the source of the band  
END
```

```
IDL> help,data.diodemeta,/str
```

```
** Structure <1ea5d9b8>, 2 tags, length=32, data length=32, refs=2:
```

NAME	STRING	'Quad'	'
TYPE	STRING	'ESP	

FITS quadrant diode header metadata

The FITS quad diode header metadata is accessible in the `quadmeta_header` structure:

```
IDL> for i=0,n_elements(data.quadmeta_header)-1 do
    print,data.quadmeta_header[i]
```

```
/Binary table written by MWRFITS v1.11
XTENSION      =      'BINTABLE'
BITPIX        =      8          /Required value
NAXIS         =      2          /Required value
NAXIS1        =      5          /Number of bytes per row
NAXIS2        =      4          /Number of rows
PCOUNT        =      0          /Normally 0 (no varying arrays)
GCOUNT        =      1          /Required value
TFIELDS       =      2          /Number of columns in table
COMMENT       *** End of mandatory fields ***
COMMENT
COMMENT
EXTNAME       =      'QuadMeta'
COMMENT       *** Column names ***
COMMENT
COMMENT       =      'NAME '           /
TTYPE1
TTYPE2       =      'TYPE '           /
COMMENT       *** Column formats ***
COMMENT
COMMENT       =      '2A '            /
TFORM1
TFORM2       =      '3A '            /
COMMENT       For every element in the QUAD_* column in the Data table, there is
COMMENT       one row here describing the quadrant.
COMMENT
COMMENT
END
```

name is the name of the quadrant

type is the instrument channel (always ESP)

```
IDL> help,data.quadmeta,/str
```

```
** Structure <1ea32ee8>, 2 tags, length=32, data length=32, refs=2:
```

```
NAME          STRING      'Q0'
TYPE          STRING      'ESP'
```

FITS data header metadata (the actual data)

The FITS data header metadata is accessible in the `data_header` structure:

```
IDL> for i=0,n_elements(data.data_header)-1 do print,data.data_header[i]
```

```
XTENSION      =      'BINTABLE'      /Binary table written by MWRFITS v1.11
BITPIX        =      8              /Required value
NAXIS         =      2              /Required value
NAXIS1        =      94938         /Number of bytes per row
NAXIS2        =      1              /Number of rows
PCOUNT        =      0              /Normally 0 (no varying arrays)
GCOUNT        =      1              /Required value
TFIELDS       =      25             /Number of columns in table
COMMENT       =      '*** End of mandatory fields ***'
COMMENT
COMMENT       =      'SDO/EVE      SPOC' // LASP, University of Colorado, Boulder
ORIGIN DATE   =      '2017-05-05T18:52:19.000Z' // UTC file creation time (per ISO8601)
TAI_OBS       =      1651536034.000 // TAI time at start of obs
DATE_OBS      =      '2010-05-03T00:00:00.000Z' // UTC at start of obs
T_OBS        =      '2010-05-03T12:00:00.000Z' // UTC at center of obs
EXPTIME       =      86400.000 // seconds exposed, or integration time
TIME          =      '                0.000 // UTC seconds of day at start of obs
TELESCOP      =      'SDO/EVE'
INSTRUME      =      'EVE_MEGS_ESP'      006 // major code/cal version
VERSION
REVISION      =      1 // reprocess number
FILENAME      =      'EVE_L3_2010123_006_01.fit'
COMMENT       =      '*** Column names ***'
COMMENT
COMMENT       =      'YYYYYDOY ' /
TTYPE1
TTYPE2        =      'CAPTURE ' /
TTYPE3        =      'MEGSA_VALID' /
TTYPE4        =      'MEGSB_VALID' /
TTYPE5        =      'SP_IRRADIANCE' /
TTYPE6        =      'SP_STDEV' /
TTYPE7        =      'SP_PRECISION' /
TTYPE8        =      'SP_ACCURACY' /
TTYPE9        =      'SP_FLAGS' /
TTYPE10       =      'LINE_IRRADIANCE' /
TTYPE11       =      'LINE_STDEV' /
TTYPE12       =      'LINE_PRECISION' /
TTYPE13       =      'LINE_ACCURACY' /
TTYPE14       =      'LINE_FLAGS' /
TTYPE15       =      'BAND_IRRADIANCE' /
TTYPE16       =      'BAND_STDEV' /
TTYPE17       =      'BAND_PRECISION' /
TTYPE18       =      'BAND_ACCURACY' /
TTYPE19       =      'DIODE_IRRADIANCE' /
TTYPE20       =      'DIODE_STDEV' /
TTYPE21       =      'DIODE_PRECISION' /
TTYPE22       =      'DIODE_ACCURACY' /
TTYPE23       =      'QUAD_FRACTION' /
TTYPE24       =      'QUAD_STDEV' /
TTYPE25       =      'QUAD_PRECISION' /
```

```

COMMENT      *** Column formats ***
COMMENT
COMMENT      =      'J      '      /
TFORM1
TFORM2      =      'J      '      /
TFORM3      =      'J      '      /
TFORM4      =      'J      '      /
TFORM5      =      '5200E '      /
TFORM6      =      '5200E '      /
TFORM7      =      '5200E '      /
TFORM8      =      '5200E '      /
TFORM9      =      '5200I '      /
TFORM10     =      '39D   '      /
TFORM11     =      '39E   '      /
TFORM12     =      '39E   '      /
TFORM13     =      '39E   '      /
TFORM14     =      '39I   '      /
TFORM15     =      '20E   '      /
TFORM16     =      '20E   '      /
TFORM17     =      '20E   '      /
TFORM18     =      '20E   '      /
TFORM19     =      '6E    '      /
TFORM20     =      '6E    '      /
TFORM21     =      '6E    '      /
TFORM22     =      '6E    '      /
TFORM23     =      '4E    '      /
TFORM24     =      '4E    '      /
TFORM25     =      '4E    '      /
COMMENT      *** Unsigned integer column scalings *
COMMENT
COMMENT      =      1      /
TSCAL2
TSCAL3      =      1      /
TSCAL4      =      1      /
TSCAL9      =      1      /
TSCAL14     =      1      /
TZERO2      =      0      /Modified by MRDFITS V2.20
TZERO3      =      0      /Modified by MRDFITS V2.20
TZERO4      =      0      /Modified by MRDFITS V2.20
TZERO9      =      0      /Modified by MRDFITS V2.20
TZERO14     =      0      /Modified by MRDFITS V2.20
COMMENT      Website reference http://lasp.colorado.edu/home/eve
COMMENT      EVE Principal Investigator T. N. Woods
COMMENT      Laboratory      for Atmospheric and Space Physics
COMMENT      1234 Innovation Drive,      Boulder, CO 80303
COMMENT      SDO Mission scientific      and model results are open to all.
COMMENT      Users should contact the PI or designated EVE team member early in an
COMMENT      analysis project to discuss appropriate use of instrument data results.
COMMENT      Appropriate acknowledgment to institutions, personnel, and funding
COMMENT      agencies should be given. Version numbers should also be specified.
COMMENT      Pre-prints      of publications and conference abstracts should be widely
COMMENT      distributed to interested parties within the mission.
EXTNAME     =      'Data'
END

```

```
IDL> help,data.data,/str
```

```
** Structure <1ea707b8>, 25 tags, length=94944, data length=94938, refs=2:
```

YYYYDOY	LONG	2010123
CAPTURE	ULONG	86390
MEGSA_VALID	ULONG	8639
MEGSB_VALID	ULONG	8639
SP_IRRADIANCE	FLOAT	Array[5200]
SP_STDEV	FLOAT	Array[5200]
SP_PRECISION	FLOAT	Array[5200]
SP_ACCURACY	FLOAT	Array[5200]
SP_FLAGS	UINT	Array[5200]
LINE_IRRADIANCE	DOUBLE	Array[39]
LINE_STDEV	FLOAT	Array[39]
LINE_PRECISION	FLOAT	Array[39]
LINE_ACCURACY	FLOAT	Array[39]
LINE_FLAGS	UINT	Array[39]
BAND_IRRADIANCE	FLOAT	Array[20]
BAND_STDEV	FLOAT	Array[20]
BAND_PRECISION	FLOAT	Array[20]
BAND_ACCURACY	FLOAT	Array[20]
DIODE_IRRADIANCE	FLOAT	Array[6]
DIODE_STDEV	FLOAT	Array[6]
DIODE_PRECISION	FLOAT	Array[6]
DIODE_ACCURACY	FLOAT	Array[6]
QUAD_FRACTION	FLOAT	Array[4]
QUAD_STDEV	FLOAT	Array[4]
QUAD_PRECISION	FLOAT	Array[4]

SolarSoft

SolarSoft and IDL users may wish to download the EVE SolarSoft software package. It is available at our web site by browsing the EVE Data Access page.

http://lasp.colorado.edu/eve/data_access/index.html

Additional information about SolarSoft can be found through the LMSAL website,

<http://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. The EVE SPOC provides an on-line table for users to identify when non-nominal operations activities have occurred.

http://lasp.colorado.edu/eve/data_access/evewebdata/EVE_sciopslog.html

A web-based calendar interface is available with one year pages.

http://lasp.colorado.edu/eve/data_access/evewebdata/misc/eve_calendars/calendar_level3_2020.html

CCD bakeouts have occurred as needed to maintain instrument sensitivity. 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 2 to 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 -1.0 when MEGS-A data is available. After the MEGS-A anomaly (2014146) when no MEGS-B data are available, the spectra file is no longer generated. 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:

http://lasp.colorado.edu/eve/data_access/evewebdata/EVE_sciopslog.html

Version Release Notes

The ESP 30.4nm diode data is now used to correct the trend for the MEGS-A 30.4 nm line, currently the only highly degraded line on the MEGS-A detector. Data from calibration rocket 36.258 is used to pin the calibration on 2010 day123.

We have applied the rocket calibration to MEGS-B in an attempt to recover some of the information that seems to be getting lost in the application of the pre-flight SURF responsivity. This process involved creating a modified responsivity that differs from the ground measurements for wavelengths shorter than 40 nm and longer than 60 nm. This compensates for unexpected sensitivity losses witnessed in early operations at long wavelengths prior to observing the sun for the first time. It also compensates for wavelength uncertainties and lower count rates during the calibration that affect the

shorter wavelengths. Degradation trends in MEGS-B are estimated by comparing count rates measured to multiple linear regression proxy models using ESP, MEGS-P, and the 10.7 cm radio flux. The ratio provides a dimensionless degradation trend that is pinned to the first rocket.

In the version 7 EVE products MEGS-P Lyman-alpha was adjusted to agree with SORCE SOLSTICE version 17.

MEGS-B dark values and long-term degradation trends were updated (see the level 2 readme for more information).

The extracted bands used to produce an effective AIA count rate have not been updated to use newer AIA response functions that would spill over onto the MEGS-B wavelength region. Since MEGS-B is not available all day for most days, including the contribution would cause significant steps up and down in a time series (resulting from the availability of MEGS-B data.)

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.

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 that can cause increases that last several hours. 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 observed on the dark diode. 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 exposure times now move about 3:56 each day to avoid the worst particle contamination time periods.

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.