# Readme File For
# NASA's Solar Dynamics Observatory (SDO)
# Extreme Ultraviolet Variability Experiment (EVE)

## Level 2 Version 4 Data Products

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# Introduction

EVE level 2 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 is a new release of EVE Level 2 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.

***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 acknowledgement 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.***

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.
http://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.
http://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 2 Products

Two types of EVE level 2 products are routinely created: **Spectra** (EVS) and **Lines** (EVL). Level 2 spectra are the merged spectral measurements from the two spectrographs, MEGS A and B. The A detector is designed to measure from 6-17 nm, and 17-37 nm using two filters, while the B detector is designed to measure 37-106 nm. Level 2 processing stitches these pieces to form one spectrum. This version includes all of measured wavelengths spanning 5.8-106.2 nm. All level 2 irradiances are adjusted to 1 AU. Level 2 line files contain selected lines derived form the level 2 spectra, ESP diode values and bands that correspond to other SDO instruments and some derived proxies.

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

## Naming Convention

Level 2 products follow this naming convention ***EV?_L2_YYYYDDD_HH_vvv_rr.fit*** where:
***EV*** designates this as an EVE product
***?*** is either S (spectrum) or L (lines/bands)
***L2*** designates this as a level 2 product
***YYYY*** is the year
***DDD*** is the day of year (001-366)
***HH*** is the UT hour of day (00-23)
***vvv*** is the version number (004)
***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 2 will be the final revision.

# Level 2 Lines/Bands Products

The EVE level 2 line files contain 6 header data units, containing data and corresponding information pertaining to 30 extracted solar emission lines. Each file contains one hours worth of observations with each observation being reported at the instruments nominal integration time of 10 seconds, except the 4 Hz ESP diode values that are averaged to 10 seconds to correspond with other EVE instrument observations.

The LinesMeta data unit contains information about lines derived from the EVE level 2 spectrum. It contains wave length 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 very 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 the 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 diode measurements (ESP and MEGS-P) are averaged down to the 10-second spectrum cadence from the 4 Hz measurements to create a more convenient way to compare the data to other measurements. 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. During flare periods, the difference of flare and pre-flare measurements indicates the flare position.

**QuadMeta:**

| Column Name | Type | Description |
|---|---|---|
| Name | String | Name of the band example (Q0) |
| Type | String | SDO instrument example (ESP) |

The LinesDataUnits data unit contains unit information for corresponding entries in the LinesData data unit.  The contents of the data unit are described in the table below.

**LinesDataUnits:**

| Column Name | Type | Description |
|---|---|---|
| TAI | String | seconds // International Atomic Time seconds since Jan 1, 1958 at center of integration |
| YYYYDOY | String | NA // 4-digit year and 3-digit day of year designator with Jan 1=001 |
| SOD | String | seconds // seconds of the UT day at the center of the integration |
| FLAGS | String | NA // 0=good, other values indicate data may be suspect |
| SC_FLAGS | String | NA // 0=good, other value indicate spacecraft events like eclipses, lunar transits, etc |
| Line_Irradiance | String | W m^-2 // Power per unit area at 1-AU over the integrated line with no background subtraction, MEGS-A provides the spectrum shorter than 37 nm and MEGS-B longer than 37 nm |
| Line_Precision | String | NA // relative precision |
| Line_Accuracy | String | NA // relative accuracy |
| Band_Irradiance | String | Mixed: W m^-2 or avg counts AIApixel^-1 second^-1 // Power per unit area at 1-AU over the integrated band with MEGS-A providing the spectrum shorter than 37 nm and MEGS-B longer than 37 nm, not |
| Band_Precision | String | NA // relative precision |
| Band_Accuracy | String | 'NA // relative accuracy |
| Diode_Irradiance | String | W m^-2 // Power per unit area at 1-AU measured by the diode |
| Diode_Stdev | String | NA // relative one-sigma spread of 4 hz integrations over the 10 second window |
| Diode_Precision | String | NA // relative precision |
| Diode_Accuracy | String | Relative accuracy of diode measurements |
| Quad_Fraction | String | NA // fraction of the 0.1-7 nm irradiance in each of the quadrant diodes with the sum=1., useful for finding location of center of irradiance |
| Quad_Stdev | String | NA // relative one-sigma spread of 4 Hz integrations over the 10 second window |
| Quad_Precision | String | Relative precision of quadrant diode measurements |
| Quad_Accuracy | String | Relative accuracy of quadrant diode measurements |

The LinesData data unit contains the actual science measurements for the observation period for lines, bands and diodes. The diode measurements are averaged to 10 seconds to provide measurements at the same cadence as the line and band measurements.

**LinesData:**

| Column Name | Type | Description |
|---|---|---|
| TAI | Double | International Atomic Time of center of observation |
| YYYYDOY | Long | Year and day of year of observation |
| SOD | Double | Seconds of day of the center of observation |
| FLAGS | Byte | EVE specific flags † |
| SC_FLAGS | Byte | SDO specific flags † |
| Line_Irradiance | Float | An array of irradiance values. One value per line. ‡ |
| Line_Precision | Float | An array of precision values. One value per line. |
| Line_Accuracy | Float | An array of accuracy values. One value per line. |
| Band_Irradiance | Float | An array of irradiance values. One value per band. |
| Band_Precision | Float | An array of precision values. One value per band. |
| Band_Accuracy | Float | An array of accuracy values. One value per band. |
| Diode_Irradiance | Float | An array of irradiance values. One value per diode. ‡ |
| Diode_Stdev | Float | An array of standard deviation values. One value per diode. |
| Diode_Precision | Float | An array of precision values. One value per diode. |
| Diode_Accuracy | Float | An array of accuracy values. One value per diode. |
| Quad_Fraction | Float | The fractional amount of the diode per total of all quad diodes |
| Quad_Stdev | Float | The standard deviation of the observations for the diode |
| Quad_Precision | Float | The precision of the observations for the diode |
| Quad_Accuracy | Float | The accuracy of the observations for the diode |

There are two sets of flags included. One is EVE-specific flags, and the other is Spacecraft flags. Generally, any flags being set mean some data are missing or possibly suspect. The following tables describe the values for each bit in the flag.

Values in the FLAGS field are the bitwise OR of these values.

| | |
|---|---|
| Bit 0 (value 1) | MEGS-A data is missing |
| Bit 1 (value 2) | MEGS-B data is missing |
| Bit 2 (value 3) | ESP data is missing |
| Bit 3 (value 4) | MEGS-P data is missing |
| Bit 4 (value 5) | Possible clock adjust in MEGS-A |
| Bit 5 (value 6) | Possible clock adjust in MEGS-B |
| Bit 6 (value 7) | Possible clock adjust in ESP |
| Bit 7 (value 8) | Possible clock adjust in MEGS-P |

Values in the SC_FLAGS field are the bitwise OR of these values.

| | |
|---|---|
| Bit 0 (value 1) | 4-bit obstruction indicator (0 is no obstruction) |
| Bit 1 (value 2) | 4-bit obstruction indicator (0 is no obstruction) |
| Bit 2 (value 4) | 4-bit obstruction indicator (0 is no obstruction) |
| Bit 3 (value 8) | 4-bit obstruction indicator (0 is no obstruction) |
| Bit 4 (value 16) | Observatory is off-pointed by more than 1 arc minute |

If more than one obstruction is taking place, only the highest-numbered one will be indicated.
Obstruction flag values:

| | |
|---|---|
| Value 0 | No obstruction |
| Value 1 | Warmup from Earth eclipse |
| Value 2 | Atmosphere penumbra |
| Value 3 | Atmosphere umbra |
| Value 4 | Penumbra of Mercury |
| Value 5 | Umbra of Mercury |
| Value 6 | Penumbra of Venus |
| Value 7 | Umbra of Venus |
| Value 8 | Penumbra of Moon |
| Value 9 | Umbra of Moon |
| Value 10 | Penumbra of solid Earth |
| Value 11 | Umbra of solid Earth |

Lines are integrated from low to high bounds, and the 4 Hz photometer data are averaged down to the same time-scale as the spectrum, nominally 10 seconds. No continuum is subtracted from the line irradiances.

# Level 2 Spectra Products

The level 2 spectrum files contain 3 header data units, SpectrumMeta, SpectrumUnits and Spectrum. These data units contain the fully calibrated 10 second spectral irradiance values along with supplemental information.

The SpectrumMeta data unit contains two arrays, one being the center wavelengths of each spectral bin. The other array contains the estimate of accuracy of the irradiance on a per bin basis.

**SpectrumMeta:**

| Column Name | Type | Description |
|---|---|---|
| Wavelengths | Float (array) | Center wavelength for each bin |
| Accuracy | Float (array) | Estimate of accuracy of the irradiance on a per bin basis |

The SpectrumUnits data unit provides information on the units for each element in the Spectrum data unit. The table below describes each entry.

**SpectrumUnits:**

| Column Name | Type | Description |
|---|---|---|
| TAI | String | seconds // International Atomic Time seconds since Jan 1, 1958 at center of integration |
| YYYYDOY | String | NA // 4-digit year and 3-digit day of year designator with Jan 1=001 |
| SOD | String | seconds // seconds of the UT day at the center of the integration |
| FLAGS | String | NA // 0=good, other values indicate data may be suspect |
| SC_FLAGS | String | NA // 0=good, other value indicate spacecraft events like eclipses, lunar transits, etc |
| Int_Time | String | seconds // the duration of the exposure |
| Irradiance | String | W m^-2 nm^-1 // Spectral power per unit area per nanometer at 1-AU with MEGS-A providing the spectrum shorter than 37 nm and MEGS-B longer than 37 nm |
| Count_Rate | String | counts s^-1 // Dark corrected count rate per pixel per second |
| Precision | String | NA // relative precision, 0=perfect measurement, 1=signal equals noise, multiply by the irradiance to get units (absolute) |
| Bin_Flags | String | NA // flag for each spectral bin, 0=good, 255=missing |

The Spectrum data unit contains the actual data for the observation period.  It holds the irradiance spectrum as well as other values as described in the following table.

**Spectrum:**

| Column Name | Type | Description |
|---|---|---|
| TAI | Double | International Atomic Time in seconds at the center of the observation |
| YYYYDOY | Long | 4-digit year and 3-digit day of year of the observation |
| SOD | Double | Seconds of day for the middle of the observation period |
| FLAGS | Byte | EVE instrument flags |
| SC_FLAGS | Byte | Space craft flags |
| Int_Time | Double | The duration of the exposure |
| Irradiance | Float | 5200 element array containing the irradiance for each bin |
| Count_Rate | Float | 5200 element array containing the count rate on a per bin basis |
| Precision | Float | 5200 element array containing Precision information for each bin |
| Bin_Flags | Byte | 5200 element array containing quality information for each bin |

# Data Processing

## FITS Definition and Software

The EVE Level 2 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., Greisen, E. W., and Harten, R. H., Astronomy & Astrophysics Supplement Series, 44, 363-370, 1981.
http://adsabs.harvard.edu/cgi-bin/nph-bib_query?bibcode=1981A%26AS...44..363W&db_key=AST&high=3db47576cf05627

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.
http://adsabs.harvard.edu/cgi-bin/nph-bib_query?bibcode=1995A%26AS..113..159C&db_key=AST&high=3db47576cf06210

Additional detailed documentation is available on-line.
http://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.
http://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. read_whole_fits.pro may be downloaded here http://lasp.colorado.edu/eve/data_access/software/eve_read_whole_fits.pro.

For IDL, you may also use mrdfits.pro available at:
http://idlastro.gsfc.nasa.gov/mrdfits.html
http://idlastro.gsfc.nasa.gov/fitsio.html

# Data Processing in IDL

Level 2 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/home/eve/data/data-access/ 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. read_whole_fits.pro may be downloaded here http://lasp.colorado.edu/eve/data_access/software/eve_read_whole_fits.pro. We will use the function in the following examples.

To read in a level 2 data product, simply provide the function with the desired filename.

```
IDL> data = eve_read_whole_fits( "EVS_L2_2013300_00_004_01.fit.gz" )
```

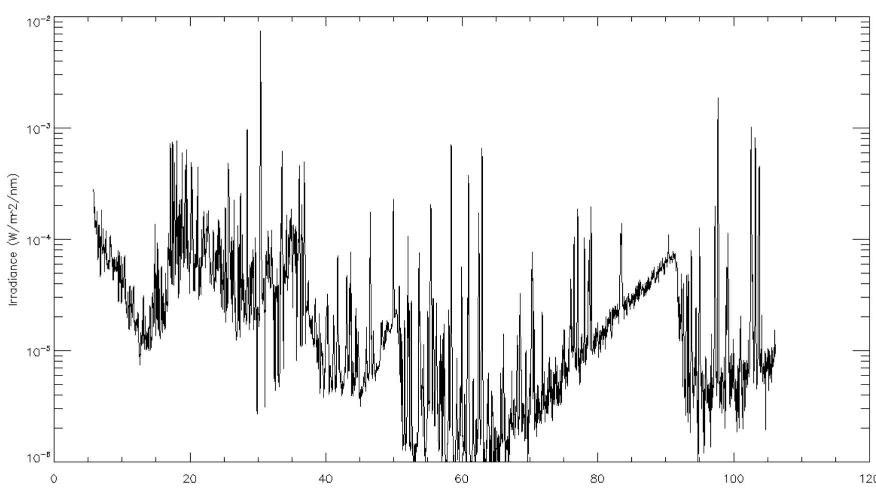
To see a listing of what is in the retrieved structure, perform the following command:

```
IDL> help, data, /STR
** Structure <d4bdb568>, 8 tags, length=24394824, data length=24391220, refs=1:
  PRIMARY         LONG              0
  PRIMARY_HEAD    STRING    Array[5]
  SPECTRUMMETA    STRUCT    -> <Anonymous> Array[5200]
  SPECTRUMMETA_HEADER    STRING    Array[27]
  SPECTRUMUNITS   STRUCT    -> <Anonymous> Array[1]
  SPECTRUMUNITS_HEADER   STRING    Array[41]
  SPECTRUM            STRUCT    -> <Anonymous> Array[360]
  SPECTRUM_HEADER STRING    Array[93]
```

As described above, the wavelength information is stored in the data.spectrummeta structure. Knowing that MEGS B samples infrequently, we will use index 310 in this example to plot a full spectra. To plot the spectra, issue the following command:

IDL > plot, data.*spectrummeta*.*wavelength*, data.*spectrum*[310].*irradiance*, YRANGE=[1.0e-6, 1.0e-2], /YLOG, charsize = 1.5, xtitle = "Wavelength (nm)", ytitle = "Irradiance (W/m^2/nm)"

This command should produce a plot similar to:



Processing the lines, bands and diode file is similar to processing the spectrum files as show below. To read in the lines file issue the following commands:

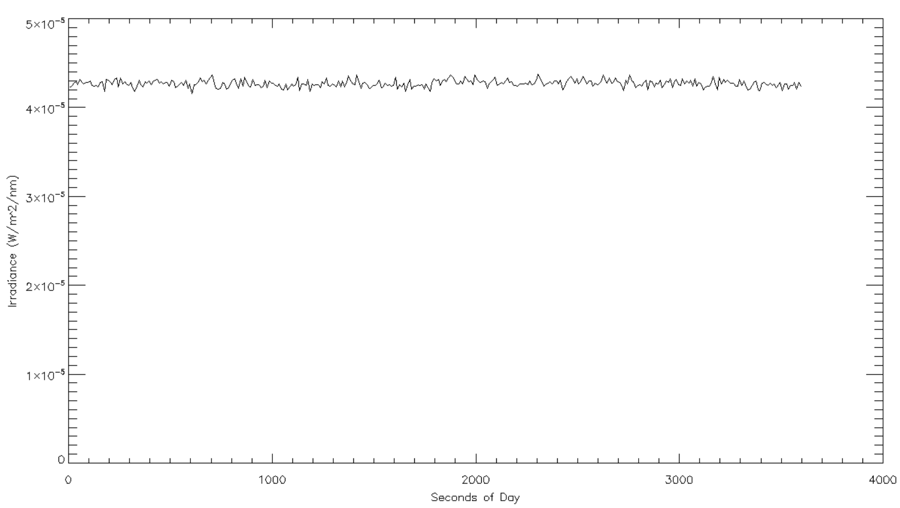
```
IDL> data = eve_read_whole_fits( '/eve_analysis/testing/data/level2/2013/300/EVL_L2_2013300_00_004_01.fit.gz' )
```

To see a listing of what is in the retrieved structure, perform the following command:

```
IDL> help, data, /str
** Structure <d49e7d08>, 14 tags, length=293368, data length=289764, refs=1:
   PRIMARY        LONG              0
   PRIMARY_HEAD              STRING    Array[5]
   LINESMETA        STRUCT    -> <Anonymous> Array[30]
   LINESMETA_HEADER       STRING    Array[46]
   BANDSMETA      STRUCT    -> <Anonymous> Array[20]
   BANDSMETA_HEADER     STRING    Array[28]
   DIODEMETA       STRUCT    -> <Anonymous> Array[6]
   DIODEMETA_HEADER      STRING    Array[27]
   QUADMETA        STRUCT    -> <Anonymous> Array[4]
   QUADMETA_HEADER       STRING    Array[27]
   LINESDATA       STRUCT    -> <Anonymous> Array[360]
   LINESDATA_HEADER       STRING    Array[124]
   LINESDATAUNITS  STRUCT    -> <Anonymous> Array[1]
   LINESDATAUNITS_HEADER STRING    Array[59]
```

In this example we plot the He II line which is at index number 9 in the line_irradiance array.

IDL> plot, data.*linesdata.sod*, data.*linesdata.line_irradiance*[9], xtitle = "Seconds of Day", ytitle = "Irradiance (W/m^2/nm)", charsize = 1.5




View http://lasp.colorado.edu/eve/data_access/software/Three Steps For EVE Data.pdf for a description on how to download and read EVE level 2 data.

## SolarSoft

SolarSoft and IDL users may wish to download the EVE SolarSoft software package. It is available at our web site by browsing the Data Access page.
http://lasp.colorado.edu/home/eve/data/data-access/

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/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 occured 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.

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 4 Data Notes

The major differences between version 3 and version 4 are discussed here.

In the MEGS-A region, the first major change was made by removing the version 3 enforced linear trend between the first (NASA 36.258) and second (NASA 36.275) suborbital rocket calibrations. We no longer apply the second rocket calibration as literally since the uncertainty is larger than previously believed. Version 3 pinned the EVE calibration between the rockets as a linear trend which decreased the irradiance by about 10% in most MEGS-A wavelengths. This was removed in version 4, while we maintain the calibration with only the first rocket.

Long-term trends in MEGS-A are determined using the on-board flatfield LEDs and using filter degradation measured on-board with multiple filters. The filter change trend in version 3 used direct measurements over just a few days to perform a daily linear fit to dynamically update the correction factors over time. The noise in the measurements and resulting fits caused steps in the daily irradiance for all wavelengths, but this was magnified for the bright lines. Version 4 uses multiple curve fits over long time periods between CCD bakeouts that remove the daily step in irradiance caused by noisy filter degradation correction factors. This improves the quality of the irradiance time series. Version 4 extrapolates the last trend forward in time so there should be no irradiance steps at day boundaries.

Another source for daily steps was in the flatfield degradation method used. It also used measurements over several days to fit a linear trend. This was also sensitive to noisy measurements and caused steps in some wavelengths and not others across day boundaries. For MEGS-A, this caused a larger effect on lines that are more heavily degraded (30.4 nm). The flatfield degradation trend was also fit over multiple time ranges for each wavelength to remove the steps and increase the quality of the final product. For lines that have not degraded much, the flatfield degradation method seems to work reasonably well. For the most heavily degraded line (30.4 nm) the flatfields were abandoned since the version 3 method assumes the correction factor is small. Version 4 uses direct comparison to the long-term trends from the ESP broadband diode in a similar (exponential) fashion to the filter degradation method described in the Hock thesis (2012). The version 3 product has 30.4 nm increasing without bound, so version 4 is superior. Eventually, all lines that suffer larger degradation will exhibit similar increasing behavior in version 4. This is planned to be repaired in a future version.

The version 3 filter degradation correction is a smooth function of wavelength and magnifies the irradiance in the dim places between bright lines. As the filter degrades, the dim places were artificially increased. Version 4 uses a mask based on the count rates to remove this artificial increase.

The large initial decrease in sensitivity for MEGS-B and non-sensical flatfield trends have forced us to completely re-examine the entire calibration technique for MEGS-B. The new version 4 method uses an inferred responsivity from line-by-line comparisons with the first suborbital rocket, along with linear mapping of the first rocket measurements to enforce agreement. The responsivity is now applied to the spectra (not images). The short wavelengths and long wavelengths changed significantly, while the 40-50 nm region did not. The short wavelength change is likely caused by inaccuracies in wavelength from the initial ground calibration, and the long wavelength changes were known since early in the mission, but the changes were applied differently. Long-term degradation correction factors were derived from an empirical multiple linear regression model trained using the end of 2012. Version 4 follows a completely new measurement equation, and no longer directly uses the flatfield LED measurements. This new method improves version 4 data quality compared to version 3. The last trend is extrapolated forward in time and unfortunately will likely drift over time.

The MEGS-B exposure has been extraordinally inconsistent over the entire mission as we tried to grapple with understanding the trends and preserve sensitivity, so the detector will continue to make measurement through the end of the normal mission. The most recent change to the MEGS-B exposure duration increased the daily solar viewing time by 50%, and occurred on Dec 10, 2013. The previous trend is extrapolated into the future, so the MEGS-B irradiances are likely to begin drifting very soon from the last trend. The exposure time changes can be viewed from the EVE web site:

http://lasp.colorado.edu/eve/data_access/evewebdata/interactive/megsb_daily_exposure_hours.html.

This is also a useful page for finding all of the MEGS-B flare campaigns. It lists all of the hours in each day of the mission where MEGS-B was exposed for more than 50% of the time.

A periodic feature was discovered in the dark correction for MEGS-B, that was fixed in version 4. After each daily calibration where the flatfield LEDs are powered on, there is a fairly large 20-minute ramp down in the dark values that persists before the dark levels return to the pre-calibration values. This caused over-correction, daily steps, and increased noise in the version 3 time series with a periodic cycle of about 2 weeks. The version 4 dark estimates disregard all data near the daily calibrations.

Version 4 contains a new array of the integrated count rates for each wavelength bin in each 10-second measurement. These count rates have no corrections applied, except for the exposure time.

The MEGS-P lyman-alpha measurement was calibrated to match SORCE SOLSTICE version 12 (from 2010 day 120 through 2013 day 161). The daily averages agree within a few percent. The lyman-alpha diode has started to show a linear drift over time relative to SOLSTICE, and while this trend is removed, there is no independent high-quality lyman-alpha measurement for verifying the calibration into the future. The LASP composite Lyman-alpha time series will soon be using the MEGS-P measurement, since SOLSTICE data is no longer available.

## 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.

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, so the number of measurements used to create the daily average varies from day to day. The Lyman-alpha measurement uses the same filter mechanism as MEGS-B, so it can only observe the sun at the same time as MEGS-B.

Due to random large particle hits, the Lyman-alpha measurement is filtered using a 10-second Kalman smoothing technique. Additional filtering was implemented for version 3 where data are pre-filtered using a median technique. Unfortunately, the Lyman-alpha measurement is very noisy, and therefore most useful after averaging to a daily value.