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

Level 4 Science Data Product README
06/13/2024

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Introduction

The Laboratory for Atmospheric and Space Physics in Boulder, Colorado created Level 4 data files for the NASA Solar Dynamics Observatory (SDO) Extreme Ultraviolet Variability Experiment (EVE). The Science Processing and Operations Center (SPOC) is responsible for maintaining access to all EVE products. To learn more about the EVE instrumentation, visit this link: https://lasp.colorado.edu/home/eve/science/instrument/.

The level 4 spectra products consist of a model spectrum at a 1-minute cadence, with each product containing 1,440 spectra covering one UTC day. The model spectra are derived from the ESP quadrant diode irradiance and the isothermal plasma temperature from the GOES X-ray channel ratios. These measurements drive a model with components for quiet sun, active region, and flare spectrum contributions. A similar technique was used for TIMED-SEE and SORCE XPS level 4 products that utilized XPS soft x-ray measurements that are analogous to the ESP quadrant diode measurements.

This release of EVE data products replaces all previous versions, and every effort has been made for verification and validation. If you have any questions or encounter any problems with the data, please do not hesitate to inform us.

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

This model is based on the paper from 2008.

Woods, T. N., and 11 co-authors, XUV Photometer System (XPS): Improved irradiance algorithm using CHIANTI spectral models, Solar Physics, 249, https://doi.org/10.1007/s11207-008-9196-6, 2008.

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 4 Science Products

Level 4 spectra are models of irradiance based on broadband diode measurements at 1-AU.

The level 4 data products are available as one file per day at the highest wavelength sampling of 0.02 nm.

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

Naming Convention

Level 4 products follow this naming convention

`EVE_L4_YYYYDDD_vvv_rr.fit` where:

- `EVE` designates this as an SDO EVE product
- `L4` designates this as a level 4 product
- `YYYY` is the year
- `DDD` is the day of year (001-366)
- `vvv` is the version number (008)
- `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.

Level 4 One-minute Averaged Data

Each daily file spans one UT day. The EVE level 4 files contain 1 FITS header data unit that contains data (spectrum). The first HDU#0 is null for compatibility with other FITS software.

Spectrum HDU

The Spectrum data unit consists of one array that represents the center wavelengths of each spectral bin. This array contains 5300 elements, starting from 0.01 nm and extending to 105.99 nm. It should be noted that this range is beyond the measurement capability of EVE and corresponds to one dimension of the spectra variable. The other dimension of the spectra variable corresponds to time, which is available in the variable SOD (seconds of UTC day). SOD represents the center of the 1-minute time interval (30, 90, 150, and so on).

Table 1 SpectrumMeta Description

Column Name	Type	Description
SOD	Float	Center of time window in UTC seconds for this day.
WAVELENGTH	Float	Wavelength in nm is the center value of each irradiance bin in the spectra.
SPECTRA	Float	Irradiance spectra with one dimension of time and the other of wavelength.

User Guide and Examples in IDL

The level 4 data products are stored in FITS format and can be read using a variety of software. For more information, please refer to the documentation section on the following website: https://lasp.colorado.edu/eve/data_access/index.html.

LASP has provided an IDL function called eve_read_whole_fits.pro, which allows for easy reading of any EVE data product that is in FITS format. This software can be downloaded from the EVE website. https://lasp.colorado.edu/eve/data_access/eve_data/software/eve_read_whole_fits.pro

Reading a level 4 spectrum file

We will use the function eve_read_whole_fits in the following examples.

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

```
IDL> eveL4 = eve_read_whole_fits( 'EVE_L4_2021001_008_01.fit' )
```

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

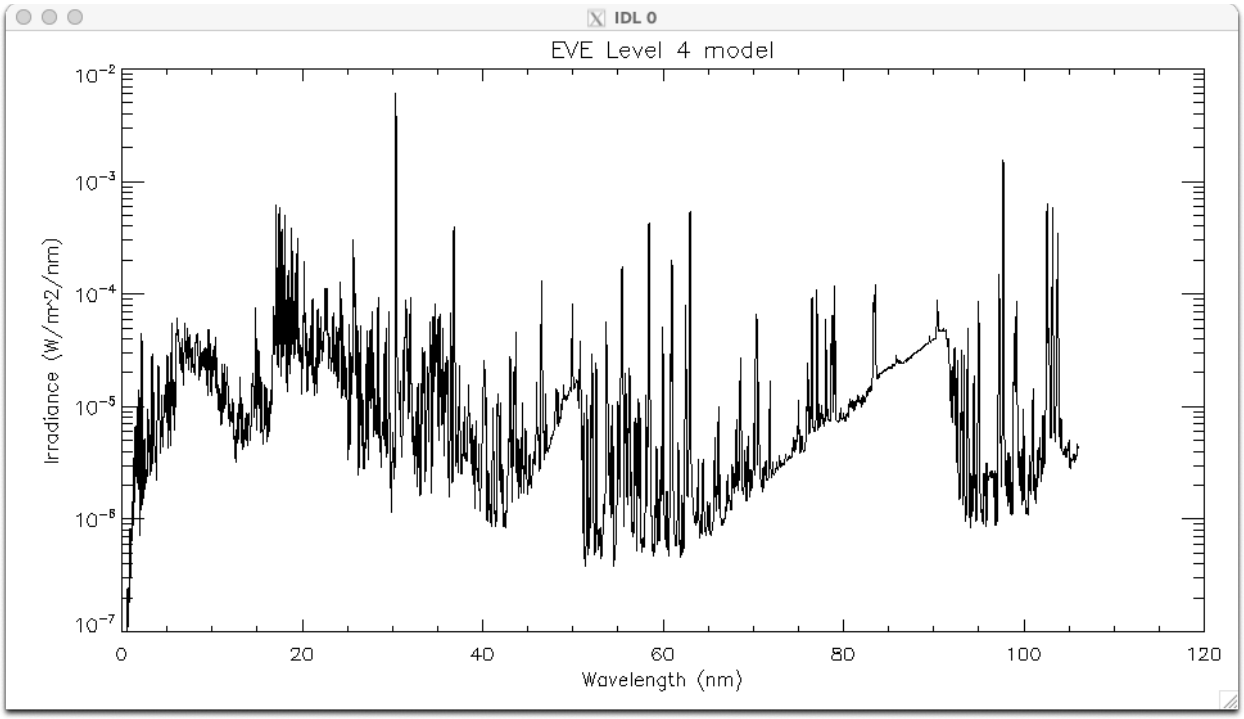
```
IDL> help, eveL4, /struct
** Structure <1f07928>, 4 tags, length=30577080, data length=30577076, refs=1:
   PRIMARY         LONG                 0
   PRIMARY_HEAD    STRING    Array[10]
   SPECTRUM        STRUCT    -> <Anonymous> Array[1]
   SPECTRUM_HEADER STRING    Array[47]

IDL> help, eveL4.spectrum, /struct
** Structure <1e106c8>, 3 tags, length=30576160, data length=30576160, refs=2:
   SOD             FLOAT     Array[1440]
   WAVELENGTH      DOUBLE    Array[5300]
   SPECTRA         FLOAT     Array[1440, 5300]
```

Plotting a spectrum

The wavelength information is stored in the eveL4.spectrum structure (from the spectrum HDU). To plot the first spectrum in the product:

```
IDL> plot, eveL4.spectrum.wavelength, eveL4.spectrum.spectra[0,*], /ylog, ystyle=1, $
    yrange=[1e-7,.01], xtitle='Wavelength (nm)', ytitle='Irradiance (W/m^2/nm)', $
    title='EVE Level 4 model'
```

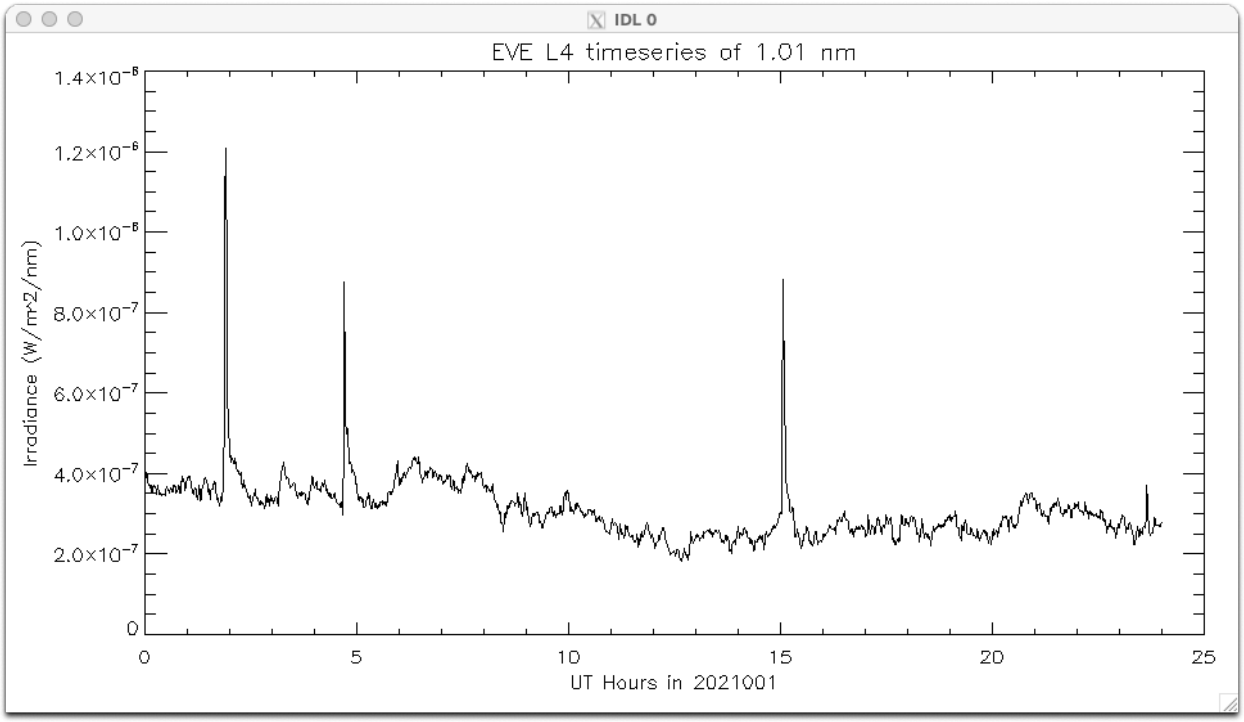


The model extends beyond the spectral range for the MEGS-A and B detectors with wavelength bin centers from 0.01-105.99 nm.

Plotting a time series

To plot a time series of wavelength bin 50 (1.01 nm):

```
IDL> plot, evel4.spectrum.sod/60./60., evel4.spectrum.spectra[*,50], $
    xtitle='UT Hours in 2021001', title='EVE L4 timeseries of 1.01 nm', $
    ytitle='Irradiance (W/m^2/nm)'
```



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. 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. 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 ESP data is almost 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 web site for the particular product and year of interest. This link is for level 4 data for 2021. Green cells indicate data is available.
https://lasp.colorado.edu/eve/data_access/eve_data/misc/eve_calendars/calendar_level4_2024.html