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

Level 1 ESP Science Data Product README
06/13/2024

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Introduction

The SDO EVE ESP Level 1 data files are created by 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. ESP Level 1 data products are generated using software and algorithms created at the Univ. of Southern California Space Sciences Center in Los Angeles, CA. For a high-level introduction to the EVE instrumentation, please visit the following website: https://lasp.colorado.edu/home/eve/science/instrument/.

These Level 1 products are defined to contain 4-Hz integrations from the Extreme ultraviolet Spectro-Photometer (ESP) and began in 2010 day 120 and are continuing. This version change includes updated long-term degradation corrections. This release of EVE ESP Level 1 data products replaces all previous versions.

While we have made significant effort towards verification and validation, if you have any questions or encounter any issues with the data, please do not hesitate to inform us about them.

For access and data product issues please contact Don Woodraska, (don.woodraska at lasp.colorado.edu).

For science issues please contact Andrew Jones, (arjones 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.

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.

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.

ESP Overview

The Extreme Ultraviolet Spectro-Photometer (ESP) utilizes a transmission grating, thin film filters, and multiple silicon photodiodes to measure solar irradiance in five discrete wavelength bands. These bands include first-order diffraction measurements of 33.3-40.04 nm, 27.16-33.8 nm, 22.28-28.78 nm, 16.64-21.5 nm, as well as zero-order measurements obtained by four photodiodes in a quad configuration, ranging from 0.1 to 7 nm. Additionally, a fully-obscured "dark" photodiode is used as part of a correction for background signal related to high energy particles. Under normal operation, ESP provides these measurements with a time resolution of 0.25 seconds.

However, ESP channel 1 with a band of 33.3–40.04 nm demonstrates significant non-solar behavior related to the increased instability of the detector's shunt resistance. Therefore, we do not recommend using this band's data for short-time evaluation of solar irradiance.

Table 1. ESP Channels Names and Wavelength Ranges

ESP Channel Number	Description	Wavelength Range	Data Product Names
1	36 nm Irradiance	33.3-40.04 nm	CH_36
2	26 nm Irradiance	22.28---28.78 nm	CH_26
3	Dark Diode	N/A	CH_D
4	Quad Diode #0	0.1---7.0 nm *QD = name for sum of four quad diodes*	Q_0
5	Quad Diode #1		Q_1
6	Quad Diode #2		Q_2
7	Quad Diode #3		Q_3
8	18 nm Irradiance	16.64---21.5 nm	CH_18
9	30 nm Irradiance	27.16---33.8 nm	CH_30

More information about the ESP instrument, measurements, and calibration can be found in the Didkovsky, et al. (2012).

This paper presents an overview of the instrument design and calibration process. Equations 17 and 18 in the paper describe how to calculate the location of the solar X-ray center intensity using the quad diode signals from ESP channels 4-7. As the quad diode measures X-rays in the 0.1-7.0 nm range, the calculated intensity location is not the actual center of the sun, but instead represents the weighted location of active regions on the solar disk. This information can be useful for identifying the location of a solar flare.

Figure 1 ESP drawings from Didkovsky, et al. (2012).

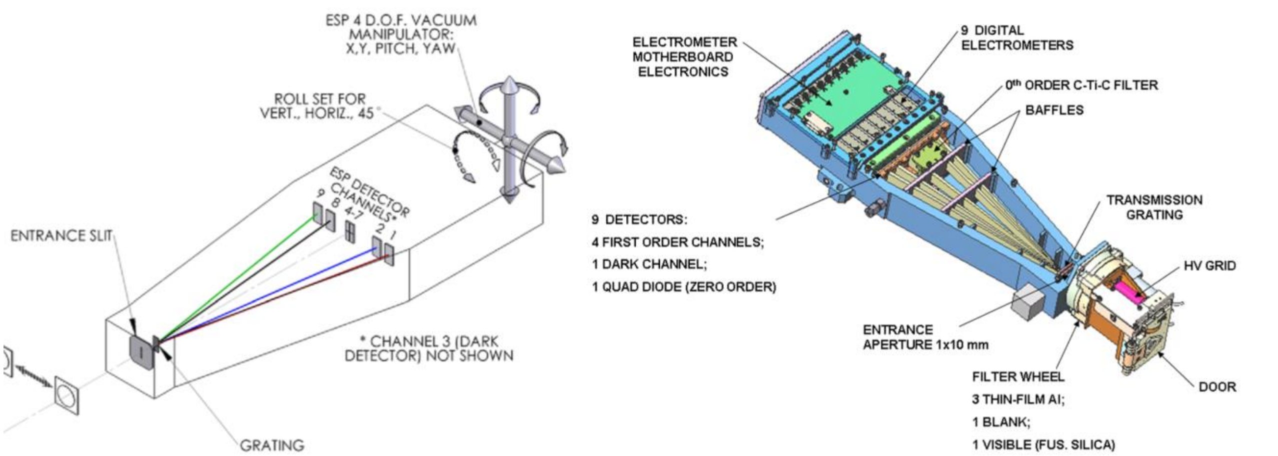
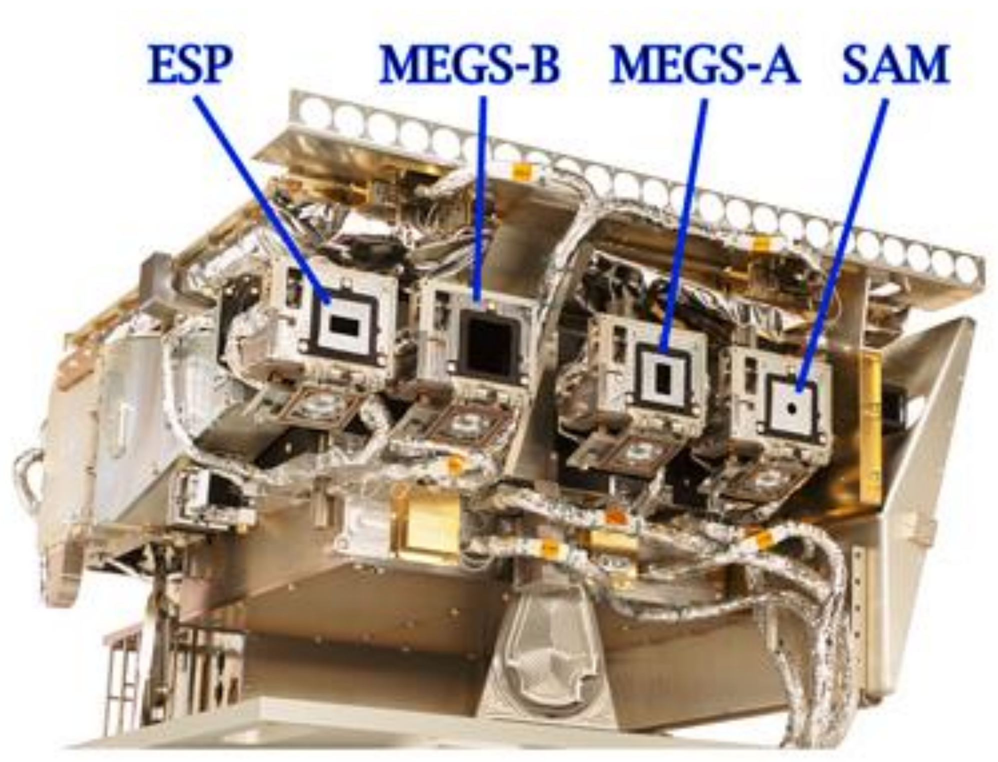


Figure 2 EVE science channels with ESP grating dispersion vertically, along the solar north-south direction.



Routine data products contain only the measurements from the primary filter position. The primary filter is exposed to sunlight nearly all day and the secondary filter is exposed for 70 seconds per day. The other filters are exposed for only a few minutes once each week. The secondary filter is used for measuring relative changes (degradation) in the primary filter. The fused silica filter does not allow science measurements of EUV and soft X-rays. The fused silica window is used to track visible light scatter. The blank, or dark, position blocks all sunlight.

Level 1 ESP Science Products

The ESP Level 1 irradiance data is fully calibrated and corrected for particle background, visible light leakage, degradation in sensitivity, and spacecraft location (corrected to 1-AU). Absolute calibrations are conducted once a year using a suborbital sounding rocket payload. The first suborbital flight after the launch of SDO was on May 3, 2010, followed by flights on March 23, 2011, June 23, 2012, October 21, 2013, June 1, 2016, and June 18, 2018. Daily on-orbit calibrations are performed to track changes in detector dark current and filter condition (including degradation) as well as electrometer gain. Each data file covers a time span of 24 hours with a 4 measurements/second cadence. Level 1 data is typically available within approximately 1 day of acquisition.

Differences from Previous Versions

This version change has several updated applied. The long-term degradation on the quad diode in version 7 has overcorrections and version 8 is now preventing that. The changes in the quad diode degradation are less than 5%.

The dark current removal from the solar irradiance measurements is improved. In version 7 dark current is subtracted based on the dark measurement on each day (or the previous day). This leads to jumps from day to day related to noisy in the dark measurements from filter position 1. Version 8 improves this in two ways. The first is by measuring dark as a function of temperature using special post-eclipse measurements of dark as the temperature increases when returning to sunlight. The temperature dependence of the quad diodes is becoming stronger over time, but the other diodes show little time dependent changes. A new measurement of the temperature trends occurs once during each eclipse season (2 times each year). When the dark current temperature trends are applied to the solar irradiance during quiet solar conditions this tends to flatten in the irradiance observed after each eclipse. The other improvement to the dark correction is in the quad diode 0. The quad diode 0 electrometer offset changed suddenly in 2019 and became less than zero. The ESP quad diode 0 dark currently is no longer directly measurable the same way as the other diodes (in filter position 1). The dark current is inferred using the fused silica window and leveraging the previous correlations to the other quad diodes. The fused silica measurements allow the dark for quad diode 0 to be determined, since the relative change can be tracked using any of the other 3 quad diodes. The quad diode 0 has continued to change in unpredictable ways, and this method allows it to be corrected within approximately 1-2 DN (data numbers or counts per integration).

Additional product improvements have increased the number of header keywords (including partial SOLARNET compliance), and additional comments.

File Naming Convention

Level 1 ESP products follow this naming convention `esp_L1_YYYYDDD_vvv.fit` where:

`esp` designates this as an EVE ESP product
`L1` designates this as a level 1 product
`YYYY` is the year
`DDD` is the day of year (001-366)
`vvv` is the version number (007)

The version number is only updated after significant software changes or major calibration updates, such as the incorporation of each suborbital rocket calibration flight. Users are expected to mention this version number when referencing EVE data in scientific papers.

Level 1 HDU

The EVE level 1 ESP product contains one null HDU (#0 is provide for compatibility with other FITS software) and another HDU containing the data (extname is ESP_L1). The contents are reported in Table 2.

Note about variable names. There are multiple conventions for the names of the channels and this table show the equivalence between naming conventions.

Table 1 Diode naming conventions

Channel #	Level 1 name	Level 2 name	Description
Ch5	Q0 (QD)	Q0 (QD)	NE quadrant 0.1-7 nm
Ch6	Q1 (QD)	Q1 (QD)	NW quadrant 0.1-7 nm
Ch4	Q2 (QD)	Q2 (QD)	SE quadrant 0.1-7 nm
Ch7	Q3 (QD)	Q3 (QD)	SW quadrant 0.1-7 nm
Ch8	CH_18	171	16.64-21.5 nm (includes Fe IX 17.1 nm)

Ch2	CH_26	256	22.28-28.78 nm (includes He II 25.6 nm)
Ch9	CH_30	304	27.16-33.8 nm (includes He II 30.4 nm)
Ch1	CH_36	366	33.3-40.04 nm (includes Fe XVI 36.0 and Mg IX 36.8 nm)*
Ch3	CH_D	Dark	Dark diode receives no sun light

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

Table 2 Descriptions for the ESP_L1 HDU

Column Name	DataType	Units	Description
Q0	Float		Fractional signal in Q0
Q1	Float		Fractional signal in Q1
Q2	Float		Fractional signal in Q2
Q3	Float		Fractional signal in Q3
QD	Float		Irradiance in W/m^2 from the quad diode 0.1-7 nm
CH_18	Float		Irradiance in W/m^2 from Ch8/CH_18/171
CH_26	Float		Irradiance in W/m^2 from Ch2/CH_26/256
CH_30	Float		Irradiance in W/m^2 from Ch9/CH_30/304
CH_36	Float		Irradiance in W/m^2 from Ch1/CH_366/36
CH_D	Float		Counts per quarter second from Ch3/CH_D/Dark diode
Q_0_PREC	Float		Relative precision in Q_0 diode
Q_1_PREC	Float		Relative precision in Q_1 diode
Q_2_PREC	Float		Relative precision in Q_2 diode
Q_3_PREC	Float		Relative precision in Q_3 diode
QD_PREC	Float		Relative precision in quad diode QD
CH_18_PREC	Float		Relative precision in CH_18
CH_26_PREC	Float		Relative precision in CH_26
CH_30_PREC	Float		Relative precision in CH_30
CH_36_PREC	Float		Relative precision in CH_36
CH_D_PREC	Float		Relative precision in Dark diode
FILTER	Float		The filter mechanism position 0-5. 1=Dark position 2-4=Science positions (primary, daily, weekly) 5=Scattered light position 0=in-between positions. 3 was primary science until 2018 day 109, then 4 became primary science.
CH_TEMP	Float		The ESP detector temperature in degrees C.
YEAR	Int		4-digit year
DOY	Int		3-digit UT day of year where Jan 1=001
SOD	Double		Seconds of the UT day at the center of the integration
EFF_QD	Float		Effective counts in the quad diode, includes degradation correction
EFF_CH_26	Float		Effective counts in CH_26, includes degradation correction
EFF_CH_18	Float		Effective counts in CH_18, includes degradation correction
EFF_CH_30	Float		Effective counts in CH_30, includes degradation correction
EFF_COUNTS	Float		Effective counts in CH_36, includes degradation correction
QD_F3_DEGRAD	Float		Degradation in filter 3 for the quad diode

L1C_FLAGS	Byte		Level 1 Critical Flags when set force the irradiance to be the -1 fill value. Bitwise definitions are not mutually exclusive 0=Good 1=Off-point from sun center (bit 1) 2=Voltage reference circuit enabled (bit 2) 4=Roll maneuver in-progress (bit 3) 8=Eclipse (bit 4) 16=ESP data transfer invalid to FPGA (bit 5) 32=Non-primary science filter (bit 6) 64=Lunar transit (bit 7)
L1NC_FLAGS	Byte		Level 1 Non-Critical Flags 0=Good 1=Eclipse penumbra possibly affecting 30.4nm 2=Lunar transit imminent or recently occurred, possible impact

The ESP central (zero order) diode is a quadrant diode that provides information not only about irradiance but also about the center of brightness for the 0.1-7 nm bandpass. The Q0-Q3 variables provide the relative quadrant contributions to the whole signal, which can be used as a measure of the distribution of irradiance. During flare periods, the difference between flare and pre-flare measurements can be used to determine the flare position.

It is important to note that ESP is not centered with the guide telescope, so the central order is not perfectly split. This non-centering could impact positioning information more on one side than the other, especially for dim flares. Additionally, the ESP slit is 10 times taller in the cross-dispersion (East-West) direction than in the dispersion direction (North-South).

Data Processing

All data products described in this document are generated at LASP and are publicly available on the EVE website as Level 1 ESP products. However, we advise users to consider their data requirements carefully when downloading data files. While Level 1 ESP products are free for public use, downloading the entire dataset may not be the best solution for most users. Level 2b EVL products at a 1-minute cadence may be sufficient for some users, and this is already aligned in time with other EVE measurements.

FITS Definition and Software

The EVE Level 1 ESP products are stored in the scientific format called FITS as binary tables. FITS was first introduced in 1979 and is one of the oldest scientific data formats. FITS 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. https://ui.adsabs.harvard.edu/abs/1981A&AS...44..363W
>
> 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/full/1995A%26AS..113..159C

Additional detailed documentation is available online, for example;.
https://heasarc.gsfc.nasa.gov/docs/software.html
https://fits.gsfc.nasa.gov/fits_documentation.html

The LASP has provided an IDL function called "eve_read_whole_fits.pro" that enables easy reading of any EVE data product in FITS format. This file includes all the necessary software from the GSFC IDL astronomy library. Users who have a newer version of the IDL astronomy library can use "mrdfits" directly. The read_whole_fits.pro file may be downloaded from the EVE web site at
https://lasp.colorado.edu/eve/data_access/eve_data/software/eve_read_whole_fits.pro

For IDL, users may also use mrdfits.pro available at:
https://idlastro.gsfc.nasa.gov/mrdfits.html

User Guide and Examples in IDL

Level 2 data products are stored in FITS format and may be read by a variety of software. In the following examples we use the LASP provided IDL function called eve_read_whole_fits.pro (based on an older version of mrdfits.pro) which allows easy reading of any EVE data product that is in FITS format.

Reading a Level 1 ESP File and Plotting a Time Series

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

```
IDL> eve = eve_read_whole_fits( 'esp_L1_2014051_008.fit.gz' )
```

To see a list of the structure tag names, run the IDL help command:

```
IDL> help,eve
** Structure <17b0c48>, 4 tags, length=46987528, data length=43532764, refs=1:
   PRIMARY         LONG                 0
   PRIMARY_HEAD    STRING    Array[5]
   ESP_L1          STRUCT    -> <Anonymous> Array[345476]
   ESP_L1_HEADER   STRING    Array[169]

IDL> help,eve.esp_l1,/str
** Structure <2de7c58>, 32 tags, length=136, data length=126, refs=2:
   Q_0             FLOAT          0.328611
   Q_1             FLOAT          0.194605
   Q_2             FLOAT          0.306484
   Q_3             FLOAT          0.170300
   QD              FLOAT       0.000776387
   CH_18           FLOAT        0.00113106
   CH_26           FLOAT       0.000611877
   CH_30           FLOAT        0.00109199
   CH_36           FLOAT       0.000584215
   CH_D            FLOAT           49.0000
   Q_0_PREC        FLOAT       0.000924029
   Q_1_PREC        FLOAT       0.000765754
   Q_2_PREC        FLOAT       0.000959737
   Q_3_PREC        FLOAT       0.000781490
   QD_PREC         FLOAT        0.00172396
   CH_18_PREC      FLOAT       1.27688e-06
   CH_26_PREC      FLOAT       2.52097e-06
   CH_30_PREC      FLOAT       4.99869e-06
```

```
   CH_36_PREC      FLOAT       0.000166109
   CH_D_PREC       FLOAT          0.504097
   FILTER          INT              3
   CH_TEMP         FLOAT           21.3333
   YEAR            INT           2014
   DOY             LONG                 51
   SOD             DOUBLE           30.815466
   EFF_QD          FLOAT           4518.40
   EFF_CH_26       FLOAT           1297.61
   EFF_CH_18       FLOAT           4124.05
   EFF_CH_30       FLOAT           1733.35
   L1C_FLAGS       BYTE         0
   L1NC_FLAGS      BYTE         0
   TAI_SECONDS     DOUBLE       1.7715457e+09

IDL> for i=0,168 do print,eve.esp_l1_header[i]
XTENSION= 'BINTABLE'           /Binary table written by MWRFITS v1.11
BITPIX  =                    8 /Required value
NAXIS   =                    2 /Required value
NAXIS1  =                  126 /Number of bytes per row
NAXIS2  =               345476 /Number of rows
PCOUNT  =                    0 /Normally 0 (no varying arrays)
GCOUNT  =                    1 /Required value
TFIELDS =                   32 /Number of columns in table
COMMENT
COMMENT  *** End of mandatory fields ***
COMMENT
PROJECT = ' NASA Living with a Star'
MISSION = '                     SDO' // Solar Dynamics Observatory
CREATOR = '        SDO_EVE_pipeline' //
TELESCOP= '                 SDO/EVE' // Extreme ultraviolet Variability Experiment
INSTRUME= '                 EVE_ESP' // EUV SpectroPhotometer
LEVEL   = '                       1' // ESP Level 1
ORIGIN  = '            SDO/EVE SPOC' // LASP, University of Colorado, Boulder
EXTNAME = 'ESP_L1'                   // EUV SpectroPhotometer Level 1 product
DATE    = '2024-04-15T19:01:53.006Z' // UTC file creation time
TAI_OBS =           1771545665.815  // TAI time at start of obs
DATE_OBS= '2014-02-20T00:00:30.815Z' // UTC at start of obs
T_OBS   = '2014-02-20T12:00:30.000Z' // UTC at center of obs
EXPTIME =                    0.250  // seconds per integration
TIME    =                   30.815  // UTC seconds of day at start of obs
SOLARNET= 0.5                        // Partially SOLARNET-compliant
OBS_HDU =                     1     // This HDU contains observational data
DATE-BEG= '2014-02-20T00:00:30.815Z' // Date of start of observation
CADENCE = 0.25                       // seconds
VERSION =                      008  // major code/cal version
REVISION=                      001  // reprocess number
FILENAME= 'esp_L1_2014051_008.fit'
COMMENT
COMMENT  *** Column names ***
COMMENT
TTYPE1  = 'Q_0     '           / quad diode 0 NE, fraction of 0.1-7 nm
TUNIT1  = 'NA' / dimensionless
TTYPE2  = 'Q_1     '           / quad diode 1 NW, fraction of 0.1-7 nm
TUNIT2  = 'NA' / dimensionless
TTYPE3  = 'Q_2     '           / quad diode 2 SE, fraction of 0.1-7 nm
TUNIT3  = 'NA' / dimensionless
TTYPE4  = 'Q_3     '           / quad diode 3 SW, fraction of 0.1-7 nm
TUNIT4  = 'NA' / dimensionless
TTYPE5  = 'QD      '           / quad diode, irradiance in 0.1-7 nm
TUNIT5  = 'W m^-2' / Watts per square meter
TTYPE6  = 'CH_18   '           / irradiance in 16.64-21.5 nm, Fe IX 17.1 nm
TUNIT6  = 'W m^-2' / Watts per square meter
TTYPE7  = 'CH_26   '           / irradiance in 22.28-28.78 nm, He II 25.6 nm
TUNIT7  = 'W m^-2' / Watts per square meter
```

```
TTYPE8  = 'CH_30   '           / irradiance in 27.16-33.8 nm, He II 30.4 nm
TUNIT8  = 'W m^-2' / Watts per square meter
TTYPE9  = 'CH_36   '           / irradiance in 33.3-40.04 nm, Fe XVI 36.1 nm
TUNIT9  = 'W m^-2' / Watts per square meter
TTYPE10 = 'CH_D    '           / dark diode
TUNIT10 = 'c' / counts per integration
TTYPE11 = 'Q_0_PREC'           / precision of quad diode 0, 0.1-7 nm
TUNIT11 = 'NA' / dimensionless, fractional
TTYPE12 = 'Q_1_PREC'           / precision of quad diode 1, 0.1-7 nm
TUNIT12 = 'NA' / dimensionless, fractional
TTYPE13 = 'Q_2_PREC'           / precision of quad diode 2, 0.1-7 nm
TUNIT13 = 'NA' / dimensionless, fractional
TTYPE14 = 'Q_3_PREC'           / precision of quad diode 3, 0.1-7 nm
TUNIT14 = 'NA' / dimensionless, fractional
TTYPE15 = 'QD_PREC '           / precision in quad diode
TUNIT15 = 'NA' / dimensioness, fractional
TTYPE16 = 'CH_18_PREC'         / precision in 16.64-21.5 nm
TUNIT16 = 'NA' / dimensionless, fractional
TTYPE17 = 'CH_26_PREC'         / precision in 22.28-28.78 nm
TUNIT17 = 'NA' / dimensionless, fractional
TTYPE18 = 'CH_30_PREC'         / precision in 27.16-33.8 nm
TUNIT18 = 'NA' / dimensionless, fractional
TTYPE19 = 'CH_36_PREC'         / dimensionless in 33.3-40.04 nm
TUNIT19 = 'NA' / dimensionless, fractional
TTYPE20 = 'CH_D_PREC'          / relative precision in dark diode
TUNIT20 = 'NA' / dimensionless, fractional
TTYPE21 = 'FILTER  '           / 1=dark, 2-4=science, 5=FS, 0=unknown
TUNIT21 = 'NA' / dimensionless filter position
TTYPE22 = 'CH_TEMP '           / ESP detector temperature
TUNIT22 = 'C' / degrees Celsius
TTYPE23 = 'YEAR    '           / year
TUNIT23 = 'years' /
TTYPE24 = 'DOY     '           / day of year, range 001-366
TUNIT24 = 'days' /
TTYPE25 = 'SOD     '           / UTC seconds of day, range 0-864001
TUNIT25 = 's' / seconds
TTYPE26 = 'EFF_QD  '           / effective counts in QD
TUNIT26 = 'c' / counts/integration
TTYPE27 = 'EFF_CH_26'          / effective counts in CH_26
TUNIT27 = 'c' / counts/integration
TTYPE28 = 'EFF_CH_18'          / effective counts in CH_18
TUNIT28 = 'c' / counts/integration
TTYPE29 = 'EFF_CH_30'          / effective counts in CH_30
TUNIT29 = 'c' / counts/integration
TTYPE30 = 'L1C_FLAGS'          / Critical flags see comments
TUNIT30 = 'NA' / dimensionless
TTYPE31 = 'L1NC_FLAGS'         / Non-critical flags see comments
TUNIT31 = 'NA' / dimensionless
TTYPE32 = 'TAI_SECONDS'        / seconds elapsed from 01-01-1958
TUNIT32 = 's' / seconds
COMMENT
COMMENT  *** Column formats ***
COMMENT
TFORM1  = 'E       '           /
TFORM2  = 'E       '           /
TFORM3  = 'E       '           /
TFORM4  = 'E       '           /
TFORM5  = 'E       '           /
TFORM6  = 'E       '           /
TFORM7  = 'E       '           /
TFORM8  = 'E       '           /
TFORM9  = 'E       '           /
TFORM10 = 'E       '           /
TFORM11 = 'E       '           /
TFORM12 = 'E       '           /
```

```
TFORM13 = 'E       '           /
TFORM14 = 'E       '           /
TFORM15 = 'E       '           /
TFORM16 = 'E       '           /
TFORM17 = 'E       '           /
TFORM18 = 'E       '           /
TFORM19 = 'E       '           /
TFORM20 = 'E       '           /
TFORM21 = 'I       '           /
TFORM22 = 'E       '           /
TFORM23 = 'I       '           /
TFORM24 = 'J       '           /
TFORM25 = 'D       '           /
TFORM26 = 'E       '           /
TFORM27 = 'E       '           /
TFORM28 = 'E       '           /
TFORM29 = 'E       '           /
TFORM30 = 'B       '           /
TFORM31 = 'B       '           /
TFORM32 = 'D       '           /
COMMENT Website reference https://lasp.colorado.edu/eve
COMMENT EVE Principal Investigator T. N. Woods
COMMENT Laboratory for Atmospheric and Space Physics/CU Boulder
COMMENT 1234 Innovation Drive, Boulder, CO 80303
COMMENT
COMMENT ESP reference article doi:10.1007/s11207-009-9485-8
COMMENT
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.
COMMENT
COMMENT Quad-Diode (QD) data (0.1 - 7.0 nm) are stored in 5 columns:
COMMENT the full solar disk irradiance QD and ratios of each diode irradiance
COMMENT to the full disk solar irradiance Q_0, Q_1, Q_2, and Q_3.
COMMENT
COMMENT Non-normal observing conditions are marked in the L1c_flags
COMMENT L1c_flags are critical flags
COMMENT OFFPOINT_FROM_SUN,  bit 0 in L1c_flags, value 1
COMMENT ESP_VOLTAGE_REF,    bit 1 in L1c_flags, value 2
COMMENT ROLL_MANEUVER,      bit 2 in L1c_flags, value 4
COMMENT ECLIPSE,            bit 3 in L1c_flags, value 8
COMMENT ESP_INVALID_XFER,   bit 4 in L1c_flags, value 16
COMMENT NOT_PRIMARY_FILTER, bit 5 in L1c_flags, value 32
COMMENT LUNAR_TRANSIT,      bit 6 in L1c_flags, value 64
COMMENT
COMMENT Non-critical observing conditions are marked in the L1nc_flags
COMMENT L1nc_flags
COMMENT 0=good
COMMENT 1=eclipse penumbra, possible 30.4 nm absorbed
COMMENT 2=lunar transit imminent or recently completed
END
```

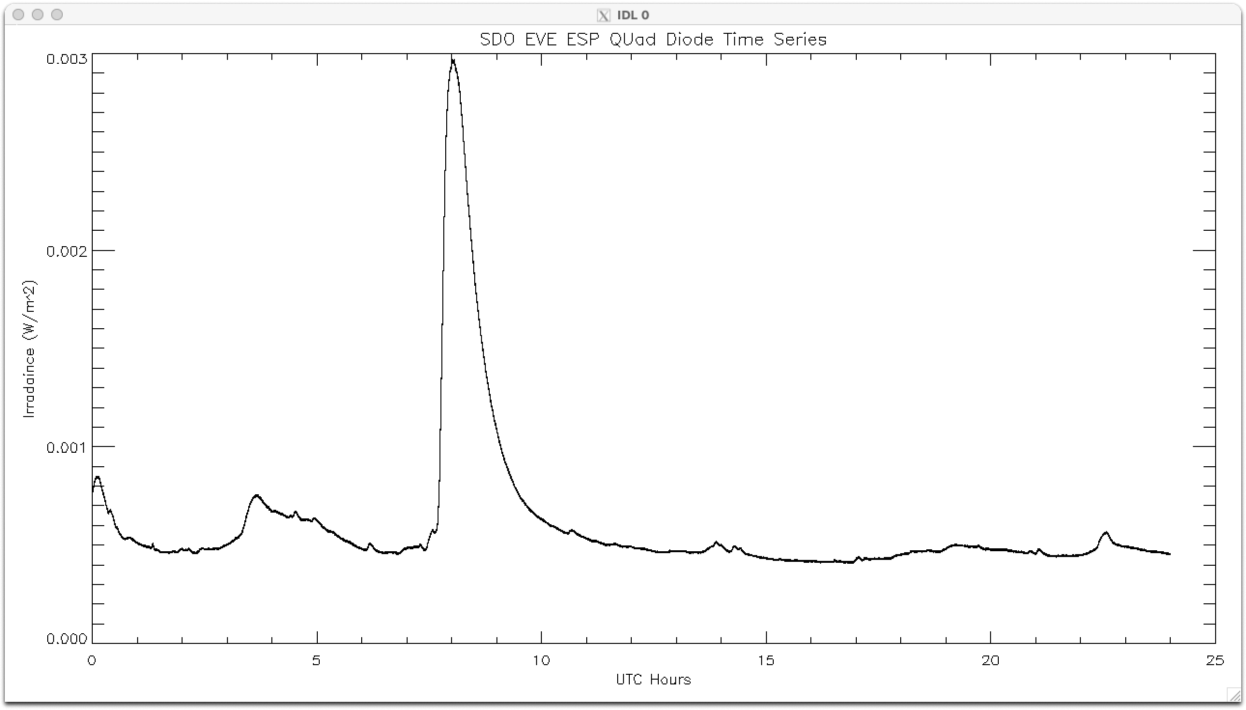
To plot a time series of the ESP quad diode irradiance showing a large flare, issue the following commands:

```
IDL> good=where(eve.esp_l1.l1c_flags eq 0 and eve.esp_l1.l1nc_flags eq 0)
IDL> plot,eve.esp_l1[gd].sod/60./60.,eve.esp_l1[gd].qd, $
   xtitle='UTC Hours in 2014051', ytitle='Irradiance (W/m^2)', $
   title='SDO EVE ESP Quad Diode Time Series'
```

Here we use the variable “good” to exclude data (about 3 minutes) where the daily calibration occurs.

This command should produce a plot similar to Figure 3.

Figure 3 Example ESP quad diode time series



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

EVE/ESP provides almost continuous solar observations, with a few exceptions. Daily calibrations require approximately 30 minutes for the entire EVE instrument, including around 2.5 minutes for the ESP portion. To ensure continuous observation, the daily calibrations for the EVE science channels are staggered. Two annual eclipse outage periods, each lasting up to 72 minutes per day, occur when the spacecraft orbit aligns with the earth and sun. Additional off-pointing maneuvers are performed, including EVE cruciform scans (9 hours), EVE FOV maps (~2 hours), and maneuvers for the other instruments and guide telescopes, around the two eclipse seasons. Infrequent activities such as lunar transits, momentum management, and station-keeping thruster firings can also interrupt observations.
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.

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 1 ESP data for 2024. Green cells indicate data are available.
https://lasp.colorado.edu/eve/data_access/evewebdata/misc/eve_calendars/calendar_level1_2024.html