README file for Level 3 version 2 release (02/17/11)

Files in this directory 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.

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.

EVE Overview

EVE spectrographs measured the solar extreme ultraviolet (EUV) radiation spectrum from 6-105 nm with a resolution of approximately 0.1 nm and a cadence of 10 seconds from geosynchronous orbit. A series of photometers are used to also provide broadband measurements at a 4 Hz cadence.

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, p. 3, doi: 10.1007/s11207-009-9487-6, Jan. 2010.
http://lasp.colorado.edu/eve/docs/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, doi: 10.1007/s11207-010-9520-9, Feb. 2010.
http://lasp.colorado.edu/eve/docs/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, p. 182, doi: 10.1007/s11207-009-9485-8, Dec. 2009.

Daily activities are performed to maintain calibration; otherwise EVE has nearly continuous solar observing capability.

Data Availability/Gaps

CCD bakeouts may occur 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 2.

For the MEGS-P (H I Lyman-alpha) measurement, the data are filtered out to exclude periods of high background particle noise. This results in some days earlier in the mission that have missing Lyman-alpha.

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

Product Overview

The following sections describe the level 3 data products available in the version 2 release.

Level 3 Products

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 from the diodes, the extracted bands, and selected lines. Data are filtered to remove calibration and other non-nominal science measurements, and then a simple average is calculated.

Level 3 products are available for each day that contains measurements for that day. However, a set of mission-merged files is also created which are likely to be more useful for long-term studies. There are 3 sets of mission-merged files.

The first file contains the high-resolution spectra at the same wavelength sampling as level 2 (0.02 nm). The next mission-merged product contains the same spectra, but integrated to 0.1 nm (1-angstrom) bins. The last mission-merged product contains the spectra integrated to 1.0 nm bins. The diodes, lines, and bands are available in all mission-merged products.

Level 3 spectra are the merged spectral measurements from the two spectrographs, A and B. The A detector is designed to measure from 6-17 nm, and 16-38 nm using two filters, while the B detector is designed to measure 35-105 nm. Level 2 processing stitches these pieces to form one spectrum. These are averaged to create the level 3 daily spectrum. In version 2, the MEGS-B region is only included from 37-65 nm. A future version may include the longer wavelength data. All irradiances are adjusted to 1-AU.

Lines are calculated in level 2 by integrating from low to high bounds, and the 4 Hz photometer data are averaged down to the same time scale as the spectrum. No continuum is subtracted from the line irradiances.

Version 2 Data Notes:

Missing or corrupted data is replaced using the "fill" value of -1.0. Fill values should be discarded since these are not science measurements.

MEGS-B is included in this product release for wavelengths spanning 37-65 nm. We have elected to release these Version 2 products without the longer wavelengths since the shorter part is fairly well understood. The longer wavelength portion of MEGS-B not yet ready to support scientific studies, like the other channels. The investigation into MEGS-B is ongoing.

MEGS-B has a reduced-exposure operation where the detector is exposed for 3 hours each day, and additionally for another 5 minutes each hour. This began on August 16, 2010 (day 228).

MEGS-B is also used to support flare campaign operations. Each flare campaign lasts 24 hours and starts at 16:00 UT. The flare campaigns to date are summarized below.

Dates	NOAA flare classifications
2010/291-292 (Oct 18-19)	C2.5, C1.2, B7.3, C1.3, C1.1, B2.6, B5.1, B5.8
2011/021-022 (Jan 21-22)	C2.2, C1.1, C1.3, B3.2, B1.7, B1.5, B1.4, C2.4, B3.7, B4.3
2011/045-047 (Feb 14-16) extended 48-hours	C7.0, M2.2, C6.6, C2.7, C2.7, X2.2, C4.8, C4.8, C6.6, C2.0, M1.0, C2.2, C5.9, C2.1, M1.1, C9.9, C3.2, M1.6, C7.7

The spectrum 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 Lyman-alpha diode measurement is susceptible to low energy particles. Our initial attempt to remove the low energy particle noise using the dark diode needs refinement. Rather than exclude this measurement, we filter it based on those periods of increased particle noise. Therefore, the MEGS-P Lyman-alpha measurement is sometimes very complete, and sometimes only available from about 6-12 UT each day. The Lyman-alpha measurement uses the same filter mechanism as MEGS-B, so it is also operating with the same reduced-exposure scenario.

Except for flare campaign days, MEGS-P measures the sun for about 20% of a day.

Daily File Naming Convention:

Level 3 daily products follow this naming convention
`EVE_L3_YYYYDDD_HH_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)
`HH` is the UT hour of day (00-23)
`vvv` is the version number (002)
`rr` is the revision number (01-99)

Each Level 3 data file spans one UT day.

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.

Mission-Merged File Naming Convention:

Level 3 mission-merged products follow three naming conventions:
`EVE_L3_merged_YYYYDDD_vvv.fit`
`EVE_L3_merged_1a_YYYYDDD_vvv.fit`
`EVE_L3_merged_1nm_YYYYDDD_vvv.fit` where:
`EVE` designates this as an EVE product
`L3_merged` designates this as a level 3 product containing data from the whole mission
`YYYYDDD` is the year and day of year the file was created
`vvv` is the version number (002)

Each Level 3 mission-merged data file spans the entire normal mission starting on 2010 day 120. Each day, the previous mission-merged files are deleted and new ones are created with different dates (YYYYDDD). The latest version/revision data for each day are used to create the new files, so there is no revision number associated with the mission-merged files.

Level 3 Spectra Products:

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., 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/`

For IDL, we use mrdfits.pro.
`http://idlastro.gsfc.nasa.gov/mrdfits.html`
`http://idlastro.gsfc.nasa.gov/fitsio.html`

An example of using mrdfits directly follows:

```
IDL> data1=mrdfits('EVE_L3_2010120_002_01.fit',1,hdr,/unsigned)
```

This reads HDU #1 and returns an array of structures called "data1" with header keywords in a string array called "hdr". Note that HDU #0 is reserved for image data, so it is NULL. With this approach, each of the HDUs can be successively read from the FITS file.

Alternatively, we provide an IDL function called read_generic_fits.pro that is available from the EVE web site to read all of the HDUs in the EVE FITS files. It iterates over the HDUs for you and builds a structure containing all of the HDU data. It is really a wrapper for the mrdfits.pro functions. This may be more useful for users that wish to read all of the data with one function call.

```
IDL> d=read_generic_fits('EVE_L3_2010120_002_01.fit')
% Compiled module: READ_GENERIC_FITS.
% Compiled module: STRSPLIT.
% Compiled module: REVERSE.
% Compiled module: FITS_INFO.
% Compiled module: SXPAR.
% Compiled module: GETTOK.
% Compiled module: STRN.
% Compiled module: VALID_NUM.
% Compiled module: MRDFITS.
% Compiled module: FXMOVE.
% Compiled module: MRD_HREAD.
% Compiled module: FXPAR.
% Compiled module: MATCH.
% Compiled module: MRD_STRUCT.
% Compiled module: IS_IEEE_BIG.
% Compiled module: MRD_SKIP.
% Compiled module: FXADDPAR.
% Compiled module: IEEE_TO_HOST.
IDL> help,d
D               STRUCT    = -> <Anonymous> Array[1]
IDL> help,d,/str
```

```
** Structure <e22adb8>, 14 tags, length=80288, data length=80278, refs=1:
   PRIMARY          INT              0
   PRIMARY_HEAD     STRING    Array[5]
   SPECTRUMMETA     STRUCT    -> <Anonymous> Array[5200]
   SPECTRUMMETA_HEADER
                    STRING    Array[25]
   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]
   DATA             STRUCT    -> <Anonymous> Array[1]
   DATA_HEADER      STRING    Array[87]
```

The primary data unit is null for the level 3 daily file, but there is a standard 5 line header that is returned in PRIMARY_HEAD. The next substructure contains metadata for the spectrum (SPECTRUMMETA) with an array of strings created from the header. The next several structures are also metadata (LINESMETA, BANDSMETA, DIODEMETA, QUADMETA). The data is in the DATA substructure. The DATA also has associated keywords that are returned in the DATA_HEADER string array.

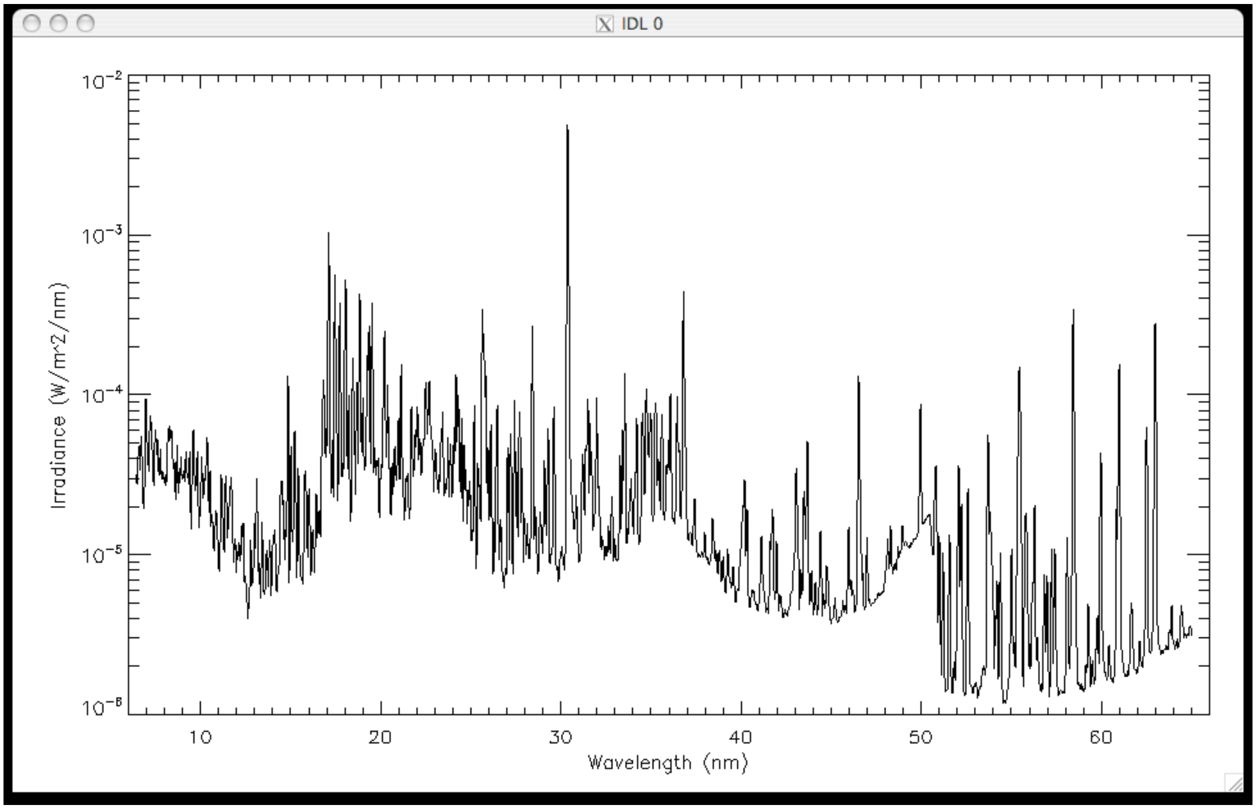
The SPECTRUMMETA array of structures contains 5200 elements, with one of the structure tags corresponding to the wavelength.

```
IDL> help,d.spectrummeta,/str
** Structure <e20e788>, 1 tags, length=4, data length=4, refs=2:
   WAVELENGTH      FLOAT           3.01000


IDL> help,d.linesmeta,/str
** Structure <e22f358>, 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    '              '

IDL> print,d.linesmeta.name
Fe XVIII Fe VIII  Fe XX    Fe IX    Fe X     Fe XI    Fe XII
Fe XIII  Fe XIV   He II    Fe XV    He II    Fe XVI   Fe XVI
Mg IX    Ne VII   Si XII   O III    O IV     He I     O III
Mg X     O V      O II     Ne VIII  O IV     H I      C III
H I      O VI

IDL> print,d.linesmeta.wave_center
      9.39260      13.1240      13.2850      17.1070
      17.7243      18.0407      19.5120      20.2044
      21.1331      25.6317      28.4150      30.3783
      33.5410      36.0758      36.8076      46.5221
      49.9406      52.5795      55.4370      58.4334
```

```
      59.9598      62.4943      62.9730      71.8535
      77.0409      79.0199      97.2537      97.7030
      102.572      103.190


IDL> help,d.bandsmeta,/str
** Structure <e1fa638>, 2 tags, length=32, data length=32, refs=2:
   NAME            STRING    'AIA_A94      '
   TYPE            STRING    'AIA '

IDL> print,d.bandsmeta.name
AIA_A94       AIA_A131      AIA_A171      AIA_A193
AIA_A211      AIA_A304      AIA_A335      GOES-14 EUV-A
GOES-14 EUV-B MA171         MA257         MA304
MA366         E7-37         E37-45        MEGS-A1
MEGS-A2       MEGS-B short  MEGS-B both   MEGS-B long


IDL> help,d.diodemeta,/str
** Structure <e2300c8>, 2 tags, length=32, data length=32, refs=2:
   NAME            STRING    'ESPQ     '
   TYPE            STRING    'ESP   '

IDL> print,d.diodemeta.name
ESPQ      ESP171    ESP257    ESP304    ESP366    MEGSP1216


IDL> help,d.quadmeta,/str
** Structure <e211338>, 2 tags, length=32, data length=32, refs=2:
   NAME            STRING    'Q0'
   TYPE            STRING    'ESP'

IDL> print,d.quadmeta.name
Q0 Q1 Q2 Q3


IDL> help,d.data,/str
** Structure <e229ae8>, 16 tags, length=52680, data length=52676, refs=2:
   YYYYDOY         LONG           2010120
   CAPTURE         ULONG            86290
   MEGSA_VALID     ULONG             8570
   MEGSB_VALID     ULONG             8557
   SP_IRRADIANCE   FLOAT     Array[5200]
   SP_STDEV        FLOAT     Array[5200]
   SP_FLAGS        UINT      Array[5200]
   LINE_IRRADIANCE DOUBLE    Array[30]
   LINE_STDEV      FLOAT     Array[30]
   LINE_FLAGS      UINT      Array[30]
   BAND_IRRADIANCE FLOAT     Array[20]
   BAND_STDEV      FLOAT     Array[20]
   DIODE_IRRADIANCE
                   FLOAT     Array[6]
   DIODE_STDEV     FLOAT     Array[6]
   QUAD_FRACTION   FLOAT     Array[4]
   QUAD_STDEV      FLOAT     Array[4]
```

To plot the daily average spectrum at 1-AU from the file, this IDL command could be used. The plot is shown below.

```
IDL> plot,d.spectrummeta.wavelength,d.data.sp_irradiance, $
      yr=[1e-6,.01],/ylog,xr=[6,66],xs=1,xtitle='Wavelength (nm)', $
      ytitle='Irradiance (W/m^2/nm)'
```



Level 3 Mission-Merged Products:

These products are read the same way as the Level 3 daily products.

Reading the data directly with mrdfits is one option.

```
IDL> data1=mrdfits('EVE_L3_merged_2011054_002.fit', 1, hdr)
```

Another is to read the whole file with read_generic_fits.pro. The mrdfits library of tools will still need to be in the IDL path.

```
IDL> d=read_generic_fits('EVE_L3_merged_2011054_002.fit')
% Compiled module: READ_GENERIC_FITS.
% Compiled module: STRSPLIT.
% Compiled module: REVERSE.
% Compiled module: FITS_INFO.
% Compiled module: SXPAR.
% Compiled module: GETTOK.
% Compiled module: STRN.
% Compiled module: VALID_NUM.
% Compiled module: MRDFITS.
% Compiled module: FXMOVE.
% Compiled module: MRD_HREAD.
% Compiled module: FXPAR.
% Compiled module: MATCH.
% Compiled module: MRD_STRUCT.
```

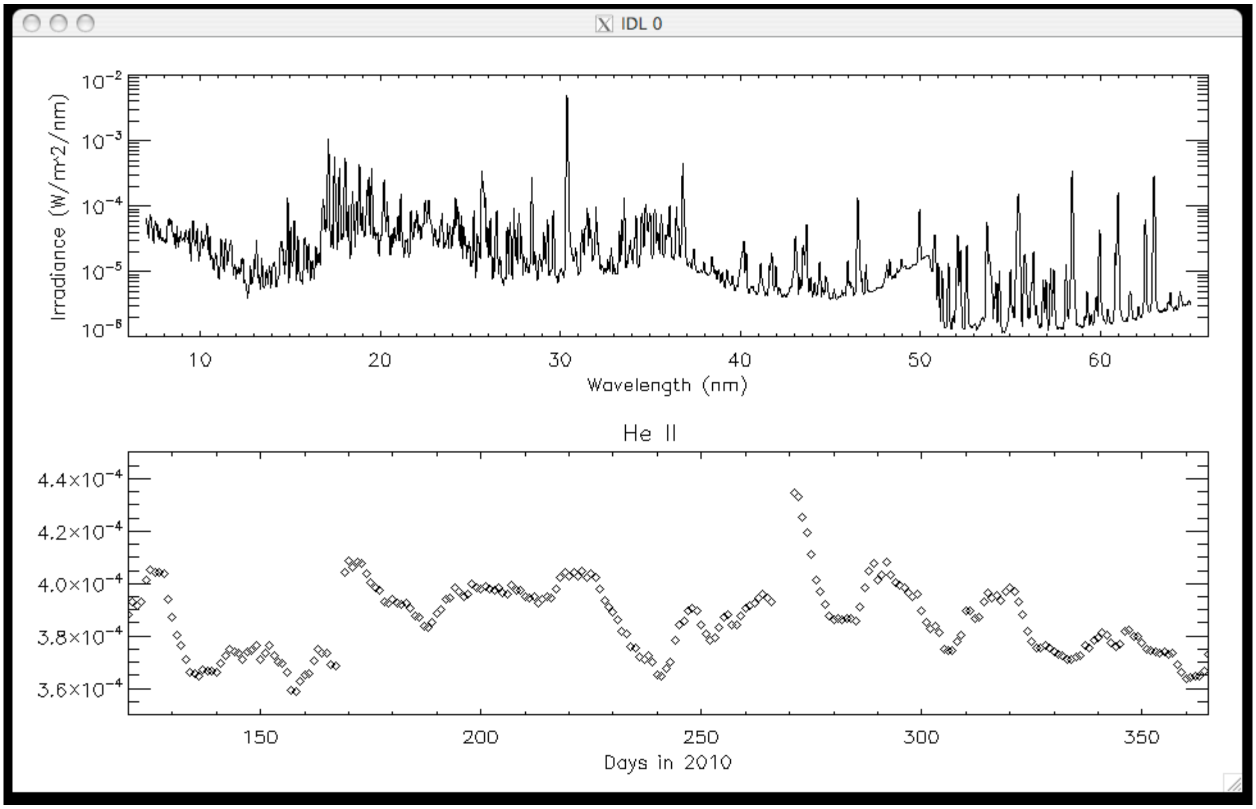
```
% Compiled module: IS_IEEE_BIG.
% Compiled module: MRD_SKIP.
% Compiled module: IEEE_TO_HOST.
% Compiled module: FXADDPAR.

IDL> help,d
D               STRUCT    = -> <Anonymous> Array[1]

IDL> help,d,/str
** Structure <1df74e88>, 12 tags, length=11983888, data length=11983882, refs=1:
   PRIMARY          INT              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]
   SPECTRUMMETA     STRUCT    -> <Anonymous> Array[1]
   SPECTRUMMETA_HEADER
                    STRING    Array[47]
   MERGEDDATA       STRUCT    -> <Anonymous> Array[298]
   MERGEDDATA_HEADER
                    STRING    Array[74]
```

Many of the substructures are identical to those described in the daily level 3 products. However, there is no QUADMETA structure. The actual science measurements are all contained in MERGEDDATA.

```
IDL> help,d.mergeddata,/str
** Structure <1dfffd08>, 11 tags, length=40060, data length=40060, refs=2:
   YYYYDOY          LONG           2010120
   CAPTURE          ULONG            86290
   SP_IRRADIANCE    FLOAT     Array[4950]
   SP_STDEV         FLOAT     Array[4950]
   DIODE_IRRADIANCE
                    FLOAT     Array[6]
   DIODE_STDEV      FLOAT     Array[6]
   BAND_IRRADIANCE  FLOAT     Array[20]
   BAND_STDEV       FLOAT     Array[20]
   LINE_IRRADIANCE  FLOAT     Array[30]
   LINE_STDEV       FLOAT     Array[30]
   AU_FACTOR        FLOAT          0.985824
```

The 1-AU correction factors for each day are reported. To remove the 1-AU correction from the irradiances, multiply the 1-AU correction factor by the irradiances. All irradiances are at 1-AU.

```
IDL> plot,d.spectrummeta.wavelength,d.mergeddata[0].sp_irradiance,/ylog, $
      yr=[1e-6,.01],xr=[6,66],xs=1,xtitle='Wavelength (nm)', $
      ytitle='Irradiance (W/m^2/nm)'
IDL> plot,d.mergeddata.yyyydoy mod 1000, d.mergeddata.line_irradiance[11], $
      ys=1,xs=1,xr=[120,365],xtitle='Days in 2010',yr=[.00035,.00045],$
      ps=4, title=d.linesmeta[11].name
```


IDL 0
Irradiance (W/m^2/nm)
Wavelength (nm)
He II
Days in 2010