SORCE-XPS Release Notes for Version 12 Level 3 Data Product and Version 12.1 for Level 4 Data Product

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SORCE XUV Photometer System (XPS) data Version 12 (V12) appears in three locations:

1. On the LISIRD website: http://lasp.colorado.edu/lisird/sorce/)
2. On the SORCE website: http://lasp.colorado.edu/home/sorce/data/
3. On the NASA DAAC: https://disc.gsfc.nasa.gov/datasets/SOR3XPSD_012/summary

An IDL reader for the L3 ASCII formatted data present on the SORCE web site is available at:
http://lasp.colorado.edu/data/sorce/file_readers/read_lasp_ascii_file.pro

An IDL reader for the L4 NetCDF formatted data present on the SORCE web site is available at:
http://lasp.colorado.edu/data/sorce/file_readers/read_netcdf.pro

Key References for SORCE XPS and its Science Data Processing algorithms are:

Woods, T. N., G. Rottman, and R. Vest, XUV Photometer System (XPS): Overview and calibrations, *Solar Physics*, **230**, 345-374, 2005a.

Woods, T. N., and G. Rottman, XUV Photometer System (XPS): Solar variations during the SORCE mission, *Solar Physics*, **230**, 375-387, 2005b.

Woods, T. N., P. C. Chamberlin, W. K. Peterson, R. R. Meier, P. G. Richards, D. J. Strickland, G. Lu, L. Qian, S. C. Solomon, B. A. Iijima, A. J. Mannucci, and B. T. Tsurutani, XUV Photometer System (XPS): Improved irradiance algorithm using CHIANTI spectral models, *Solar Physics*, **249**, 235-267, doi 10.1007/s11207-008-9196-6, 2008.

1. SORCE XPS Data Products

The XPS Level 3 and Level 4 data products are the science-quality data products made available to the public. These are observations of the solar X-ray UltraViolet (XUV) irradiance from the Solar Radiation and Climate Experiment (SORCE) as described by Woods et al. (2005a) and Woods and Rottman (2005b).

A small change to the L4 products has been included in V12.1. Each L4 product now contains both MODELFLUX_MEDIAN and MODELFLUX_MEAN arrays, replacing the MODELFLUX field in V12. All other lower level products up to and including L3 remain unchanged and remain at V12.

The following two tables list the variables in those XPS data products. Level 3 is the daily average solar irradiance for the XUV photometers in their broad bands. Changes for the Level 3 processing are described in Section 2. Level 4 is the spectral XUV irradiance in 0.1 nm intervals as model estimates based on the XPS XUV observations used as the solar variability proxy. Changes for the Level 4 processing are described in Section 3

Table 1. SORCE XPS Level 3 Data Product Variables.

Variable	Description	Type	Range
NOMINAL_DATE_ YYYYMMDD	Date as Year-Month-Day number	double	20030302 – 20200225
NOMINAL_DATE_JDN	Date as Julian Day	double	2452700 – 2458904
AVG_MEASUREMENT_ DATE_JDN	Julian Day average for all measurements	double	2452700 – 2458904
STD_DEV_MEASUREMENT_ DATE	Standard deviation of measured date	float	0 – 0.46
DIODE_NUMBER	XPS Diode Number	int	1 – 11
MIN_WAVELENGTH	Bandpass minimum wavelength (nm)	double	0.1 – 121
MAX_WAVELENGTH	Bandpass maximum wavelength (nm)	double	7 – 122
MEDIAN_IRRADIANCE	Irradiance median over the day (W/m^2)	double	1.2E-5 – 8.23E-3
MEAN_IRRADIANCE	Irradiance mean over the day (W/m^2)	double	1.73E-6 – 8.37E-3
ABSOLUTE_UNCERTAINTY	Irradiance uncertainty (relative in %)	float	0.13 – 342
MEASUREMENT_PRECISION	Measurement precision (relative in %)	float	0.007 – 341
CALCULATION_PRECISION	Standard deviation of daily average (in %)	float	0.002 – 9.8
DEGRADATION_MODEL	Index of degradation of model	int	0 – 1
DEGRADATION_VERSION	Version number of degradation model	int	3 – 3
NUMBER_OF_POINTS	Number of data points in daily average	int	2 – 1835

Table 2. SORCE XPS Level 4 Data Product Variables.

Variable	Description	Type	Range
DATE	Date as Year and Day-of-Year (YYYYDDD)	long	2003061 – 2020056
TIME	Time as seconds of day (s)	float	1 – 86399
XPS_QS	Scale factor for Quiet-Sun model for XPS	float	1.00 – 1.00
XPS_AR	Scale factor for Active Region model for XPS	float	0.00 – 0.25
XPS_FLARE	Scale factor for Flare model for XPS	float	0.00 – 2389.
GOES_QS	Scale factor for Quiet-Sun model for GOES	float	1.00 – 1.00
GOES_AR	Scale factor for Active Region model for GOES	float	0.00 – 0.085
GOES_FLARE	Scale factor for Flare model for GOES	float	0.00 – 97.
FMTEMP	Flare model temperature (in log(K))	float	6.3 – 7.3
FMINDEX	Flare model array index	float	10 – 15
FMWEIGHT	Flare model weight for interpolation	float	0.00 – 1.00
ERR_ABS	Irradiance uncertainty (relative in %)	float	0.39 – 6
ERR_MEAS	Measurement precision (relative in %)	float	0.003 – 6
MODELFLUX_MEAN	Mean model irradiance (W/m^2)	float array*	2E-10 – 3E-2
MODELFLUX_MEDIAN	Median model irradiance (W/m^2)	float array*	2E-10 – 3E-2

* Array size for 1nm daily average products is 40 elements, with a wavelength range of 1nm-

40nm in 1nm increments. For the 0.1nm daily products, 400 elements are included with a wavelength range of 0.05 nm to 39.95 nm with 0.1 nm steps.

2. Level 3 Changes Since XPS Version 11

2.1 Dark Signal Calibration

Prior to the XPS filter wheel anomaly, the dark signal was measured every five minutes when the dark (blocked) filter was in place for each photodiode. After the XPS filter wheel anomaly, a model of the dark signal as a function of temperature and time was derived based on photodiode measurements when SORCE was not observing the Sun (e.g. eclipse side of the orbit). An example for the dark trend for diode #1 is shown in Figure 1.

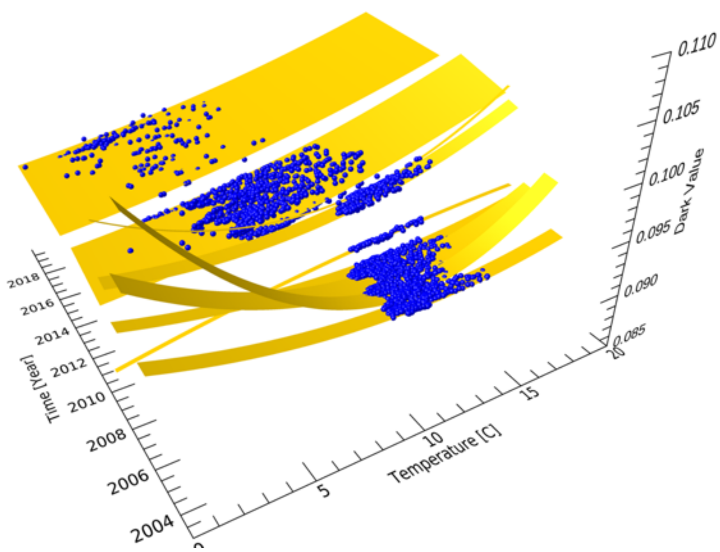

Figure 1. Example of dark signal trending for XPS diode #1. The dark model has piecewise fits with linear trending in time and quadratic fit in temperature for each time period.

2.2. Visible-Light Signal Calibration

Similar to the dark signal calibrations, the visible-light signal was measured every five minutes for normal operations prior to the XPS filter wheel anomaly and then just once a week for the calibration experiment after the filter wheel anomaly. A model of the visible-light correction is also made over the mission using those calibration experiments that measure the fused silica window transmission trends as shown in Figure 2. The transmission trend model has interpolation between the daily-averaged transmission measurements prior to December 2004 (filter wheel anomaly) and piecewise linear fits starting in 2005. The window transmission is applied to the diode signals obtained when a window was in place to yield the visible-light signal to be subtracted from the diode total signal. Example of the visible-light signal is shown in Figure 3.

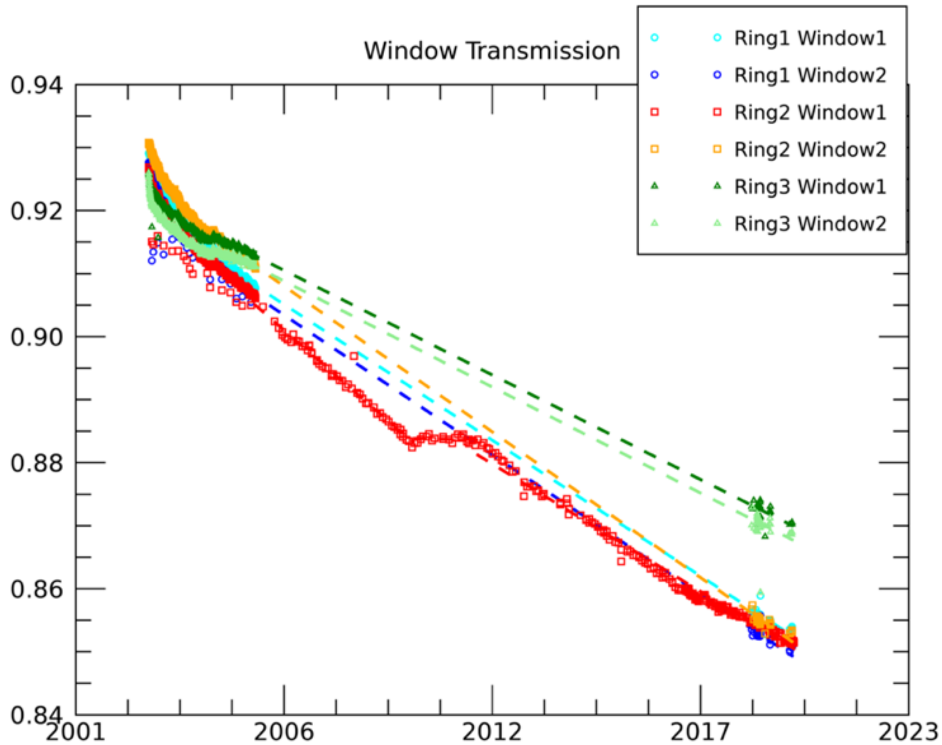

Figure 2. Transmission of the XPS visible-light calibration windows. There are a total of six windows. The transmission measurements for all windows were made frequently before the filter wheel anomaly in December 2004 and also made during the last few months of the mission. The Ring-2 Window-1 transmission was measured about once a week over the entire mission period.

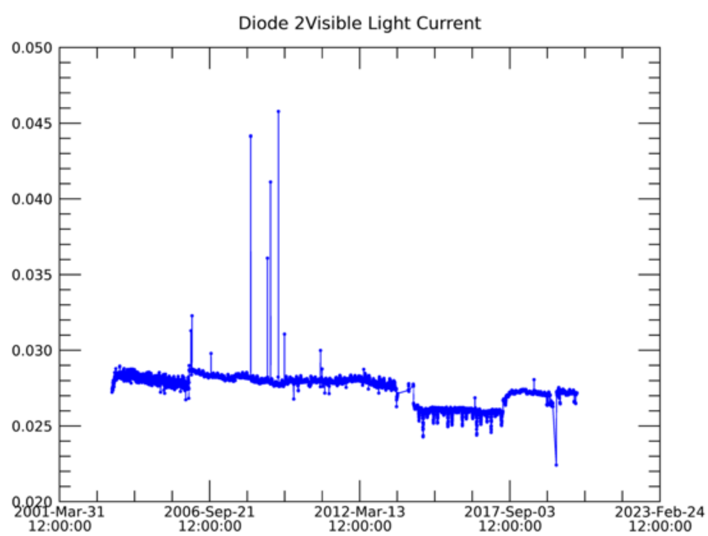

Figure 3. Example of visible-light signal trend as shown for XPS diode #2. The slow downward trend is probably related to diode degradation. The discrete jumps in the signal could be related to pin holes developing in the XUV foil filter for diode #2 and/or operational changes that caused temperature drifts.

2.3. Degradation Correction

Tracking of SORCE XPS degradation benefited from the concurrent solar XUV irradiance observations by almost identical XPS instrument on the NASA TIMED satellite (http://lasp.colorado.edu/home/see/). The primary solution for trending the SORCE XPS photometers is direct comparison of the TIMED XPS irradiance values to the SORCE XPS irradiance values.

In addition for the XPS diode #11 (Lyman-alpha 121.6 nm), there are SORCE SOLSTICE solar spectral irradiance (SSI) measurements of the H I Lyman-alpha emission line. These SOLSTICE SSI observations are calibrated with in-flight observations of stable O-B stars and redundant channel calibrations; therefore, the SOLSTICE observations are used to estimate the degradation trend for the XPS diode #11. In order to compare SORCE SOLSTICE Lyman-alpha measurements to XPS diode #11, we weight the SOLSTICE high-resolution (0.1nm resolution) L3 spectrum by the XPS responsivity function, and integrate over the XPS diode #11 bandpass. This result can then be compared against the value measured by XPS.

From these comparisons, there has been modest degradation of the SORCE XPS diodes 1 and 2 of a few percent over the SORCE mission, but there has been more significant degradation for the SORCE XPS diodes 7 and 11 as shown in Figures 4 through 7.

The Acton interference filters used for diode 11 are known to degrade in space from any hydrocarbon contaminates on the optic that can be polymerized with solar exposure and also from high-energy particle radiation affecting the multi-layer filter transmission. The XUV diodes are less sensitive to those optical degradation effects due to X-rays having very high transmission through most materials. However, hydrocarbons absorption of solar EUV radiation begins to ramp up longer than about 15 nm; this may explain why diode 7, with its bandpass extending out to 18 nm, has more degradation than diodes 1 and 2 with their bandpasses limited to shorter than 7 nm.

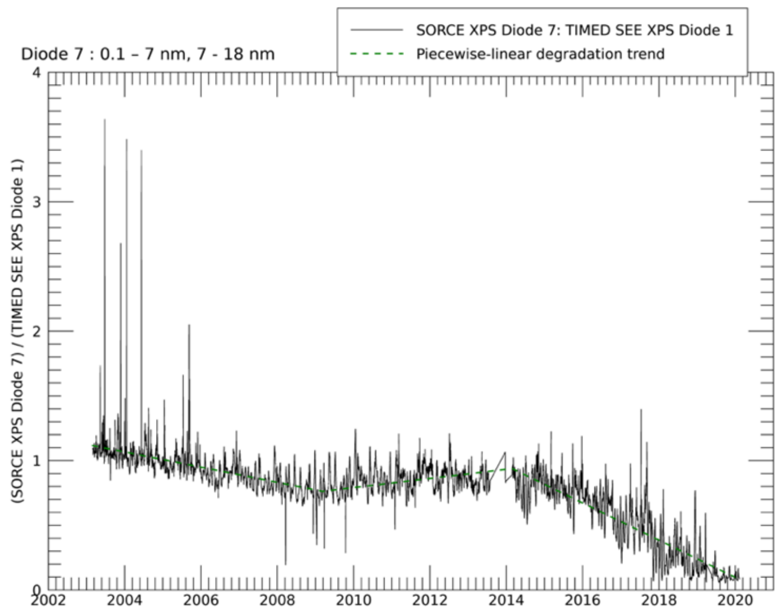

Figure 4. Degradation for SORCE XPS diode 7 is estimated with comparison to TIMED SEE XPS diode 1 with a similar spectral bandpass of 0.1-7 nm.

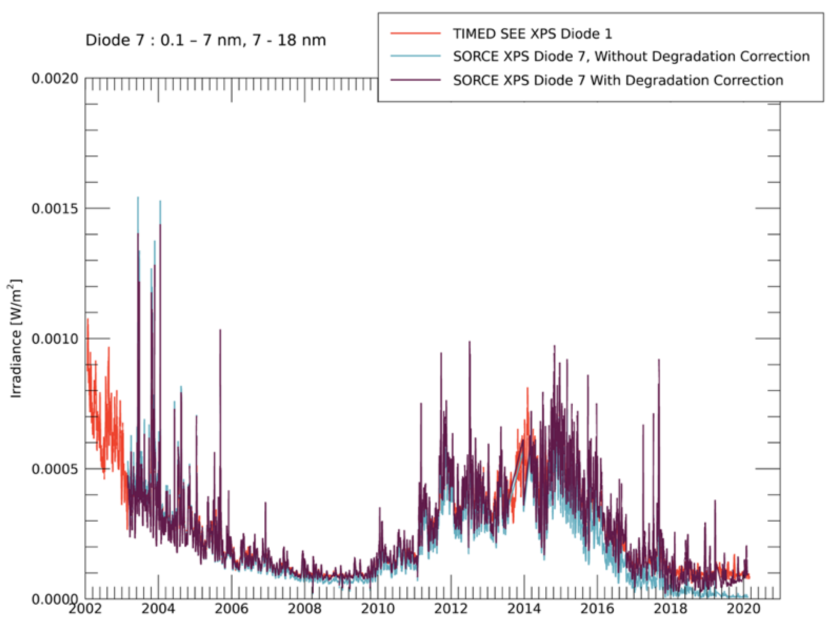

Figure 5. Uncorrected (light blue) and corrected (purple) SORCE XPS diode 7 overplotted with TIMED SEE diode 1 (red).

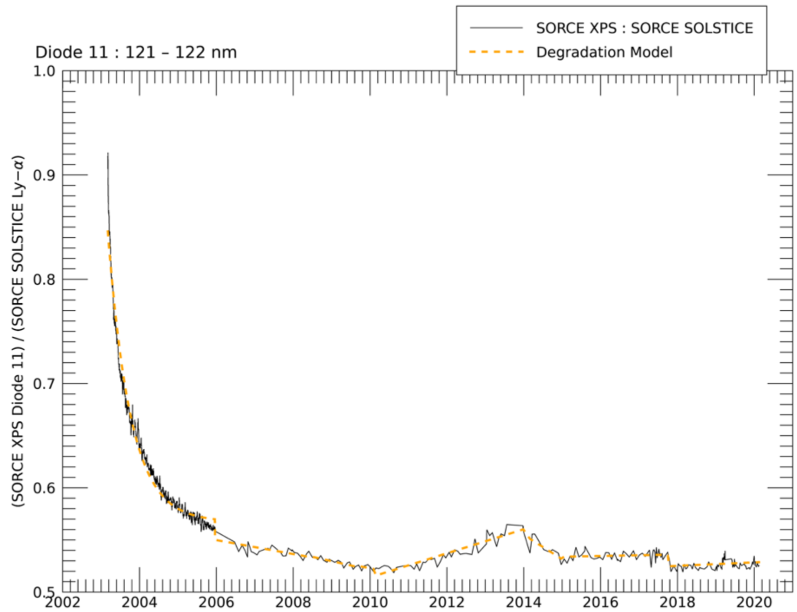

Figure 6. Degradation for SORCE XPS diode 11 is estimated with comparison to SORCE SOLSTICE Lyman-alpha irradiance at 121.5 nm.

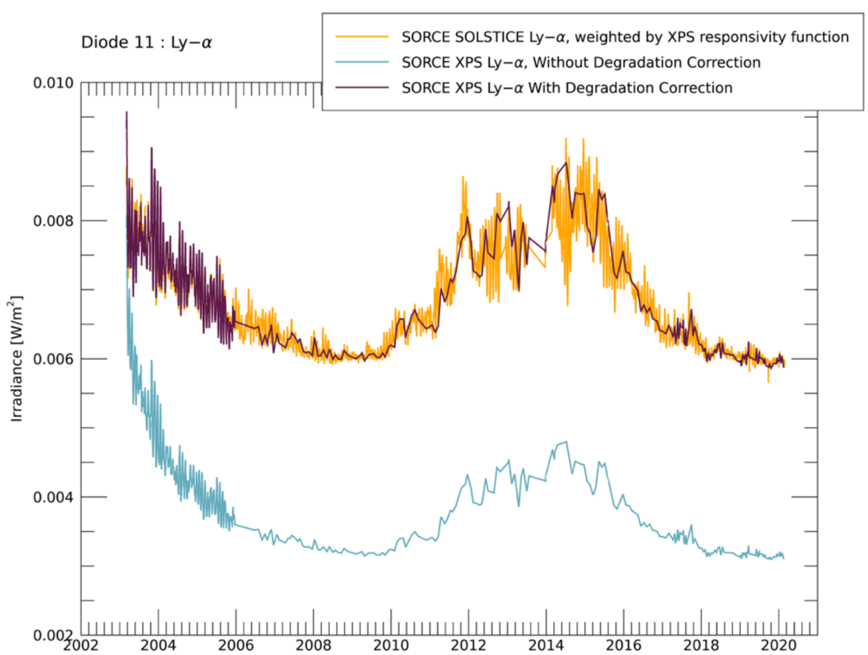

Figure 7. Uncorrected (light blue) and corrected (purple) SORCE XPS diode 11 overplotted with SORCE SOLSTICE Lyman-alpha (orange) weighted by the XPS responsivity function(red).

2.4. Degradation Estimation Measurement Equation

While the degradation rate may be related to solar exposure time, the degradation trend approach is an empirical fit over time (versus a degradation model dependent on exposure-time or wavelength). This is appropriate for simple photometers that have a broad spectral bandpass and without means to determine more detailed wavelength dependence of the degradation

For SORCE XPS diode 7, its degradation trend is represented as a piecewise series of linear fits of degradation over time as shown above in Figure 4. This approach is also used for the other diodes. The exception is for diode 11; we still use a piecewise approach but where the first period (up to the filter-wheel anomaly in late 2005) is an exponential of the form:

$$d(t) = a * b^t + c$$

where “d” represents the degradation as a function of time “t”, and “a”, “b” and “c” are the free parameters of the fit, and all subsequent periods are piecewise-linear.

3. Level 4 Change Since XPS Version 11

The XPS Level 4 product is a solar spectral model of the XUV irradiance from 0.1 nm to 40 nm in 0.1 nm bins as based on XPS broadband measurements to scale quiet-sun, active-region, and flare model reference spectra. The GOES XRS data are used to obtain the flare emission temperature for the flare reference spectrum. Version 11 used the CHIANTI reference spectra for the three components (Woods *et al., Solar Physics*, **249**, 235, 2008). Version 12 uses instead new solar reference spectra for the quiet-sun and active-region components derived from the Solar Dynamics Observatory (SDO) EUV Variability Experiment (EVE) solar spectral measurements in the XUV-EUV.