EUV97: IMPROVEMENTS TO EUV IRRADIANCE MODELING IN THE SOFT X-RAYS AND FUV*

W. KENT TOBISKA
Telos/JPL, MS 264-723,4800 Oak Grove Dr., Pasadena, CA 91109, U.S.A.

F. G. EPARVIER
CIRES, University of Colorado, Campus Box 216, Boulder CO 80309, U.S.A.

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Abstract. EUV97 is a solar EUV empirical model that incorporates revised soft X-ray fluxes from the SOLRAD-11 satellite (1976–1979) and uses Lα recently recalibrated to the UARS satellite (1991–present) SOLSTICE Lα. The soft X-ray data have been revised from the original flux values using Mewe's spectral fits to the data. The recalibrated AE-E and SME Lα datasets use UARS Lα for absolute flux values to provide two solar cycles of Lα irradiance extending back to 1977. Lα is used by EUV97 as a proxy for chromospheric EUV irradiances. The EUV97 empirical solar model takes its heritage from the EUV91 model based on a multiple linear regression technique that fits soft X-ray and EUV irradiances to 10.7 cm flux for transition region and coronal emissions or to Lα and He I 10830 Å EW for chromospheric emissions.

1. Introduction

Full-disk solar extreme ultraviolet (EUV) irradiances between 1 and 121.6 nm are the fundamental energy input for the terrestrial thermosphere. They are also the primary photoionization source creating the ionosphere. Investigations of the upper atmosphere use modeled photoabsorption and energy transfer processes that require the input of these irradiances. Therefore, daily, well-calibrated full-disk irradiances in the EUV solar spectrum are a fundamental parameter for upper atmosphere and ionosphere studies. When spectral irradiance measurements are unavailable, empirical irradiance models based on ground- and space-based proxies are used as a substitute.

EUV emissions map from specific source layers in the solar atmosphere to particular levels of unit optical depth in the terrestrial atmosphere. This fact is the basis for the effort to obtain EUV irradiances on solar cycle time scales so as to understand global climate change as well as atmospheric density change that is related to low Earth-orbiting spacecraft. As an example, there may now be significant anthropogenic changes occurring in the upper atmosphere as a result of CO_2 and CH_4 that are convectively transported from lower atmosphere layers. The densities and distribution of these minor species are currently measured as they migrate upwards. Yet, their effect upon the upper atmosphere over long time scales is understood only if all other parameters are well characterized in global

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circulation models. The solar-induced perturbations to the upper atmosphere must first be quantified to determine the extent of human-induced changes. Also, solar EUV-induced thermospheric density changes produce variable drag upon spacecraft such as the Hubble Space Telescope, space shuttle, and space station thus requiring accurate EUV measurements or reliably modeled/predicted values for orbit operations.

When describing the characteristics of EUV irradiances, one notes that the absolute amount of EUV radiation is significantly smaller than the UV and visible irradiance levels. EUV emission lines often rise above the blackbody spectrum and the continua emission. This non-LTE radiation comes from higher temperature regions of the solar atmosphere including the chromosphere, transition region, and cool corona. The strength of their emission derives from the magnetic activity of the Sun. While the Sun varies on all time scales, the magnitude of variability differs by wavelength and EUV solar cycle variability is much greater than the rest of the spectrum. Long-term (11-year solar cycle) variability is related to the number of active regions and plage areas on the viewable solar disk which form in response to the 22-year magnetic field pole reversal cycle of the Sun. Intermediate-term (3 to 6 months) variations are modulated by 27-day solar rotation and result from the emergence and decay of specific active regions on the solar disk. Soft X-ray irradiance (1–30 nm) is dominated by coronal emission lines which may vary several orders of magnitude (1–10 nm) or less (10–30 nm) during long- and intermediate-term periods. Timothy (1977), Schmidtke (1984), Lean (1987, 1991), Rottman (1987, 1988), Simon and Tobiska (1991), Donnelly (1993), and Tobiska (1993) have detailed or reviewed solar EUV variability on these time scales.

Since full-disk solar irradiance measurements from the soft X-rays to Lα are only possible above the atmosphere, they were first made photographically, and then later by photometric detectors, on short duration rocket flights starting in 1946. Early EUV rocket measurements provided estimates of absolute fluxes during specific solar conditions and have been reviewed (Tousey, 1961; Timothy, 1977; Schmidtke, 1984; Lean, 1987, 1991; Rottman, 1988; Tobiska, 1993). Satellite survey observations across the EUV spectrum were conducted during the 1960s and 1970s by the Orbiting Solar Observatories (OSO-1, -3, -4, and -6) (Neupert, Behring, and Lindsay, 1964; Chapman and Neupert, 1974; Timothy and Timothy, 1970; Woodgate *et al.*, 1973), the AEROS-A (Schmidtke *et al.*, 1977), the Atmospheric Explorers (AE-C and E) (Hinteregger, Bedo, and Manson, 1973; Hinteregger, 1985), and the SOLRAD-11 (Kreplin and Horan, 1992). In particular, the revised AE-E solar irradiance data (Hinteregger, Fukui, and Gilson, 1981; Torr and Torr, 1985) have provided several reference spectra for atmospheric modeling that are representative of solar minimum and maximum conditions during cycle 21.

Following the end of the AE-E measurements in December 1980, there have not been daily solar EUV irradiance measurements. Donnelly (1987) refers to this lack of solar EUV spectral irradiance measurements as the 'solar EUV hole'.

The few solar EUV spectral irradiance observations during this period include approximately 20 days during the *San Marco* 5 satellite mission (Schmidtke, Seidl, and Wita, 1985; Schmidtke *et al.*, 1992; Schmidtke, Doll, and Wita, 1993) and four sounding rocket measurements (Woods and Rottman, 1990). There have also been broad bandpass, integrated EUV flux measurements from *Pioneer Venus* (Brace, Hoegy, and Theis, 1988), *Prognoz* 7 (Kazachevskaya, Ivanov-Kholodny, and Gonyukh, 1985; Ivanov-Kholodny and Kazachevskaya, 1981; Kazachevskaya and Lomovsky, 1992), *Phobos* 1 and 2 (Kazachevskaya *et al.*, 1991; Kazachevskaya and Lomovsky, 1992), and sounding rocket measurements (Ogawa *et al.*, 1990).

Lacking regular space-based measurements and given the limited nature of generalized reference spectra, empirical EUV solar irradiance models have been developed to meet the need for daily, full-disk irradiance values. The SERF1 (Hinteregger, 1985; Donnelly 1988), the Nusinov (Nusinov, 1984, 1992; Bruevich and Nusinov, 1984), SERF2 (Tobiska and Barth, 1990; Tobiska, 1990), EUVAC (Richards, Fennelly, and Torr, 1994), and SERF3 (Donnelly, 1996, private communication) models were each derived from the AE-E dataset. SERF2 additionally used rocket observations for its derivation. Following a comparison between SERF1 and SERF2 (Lean, 1990), SERF2 was revised into the EUV91 model (Tobiska, 1991). Additional work on EUV91 (Tobiska *et al.*, 1993; Tobiska, 1994, 1995) has led to this model, designated EUV97, which improves the estimation of soft X-ray (1–5 nm) and Lα (121.6 nm) absolute magnitude and irradiance variability.

2. Soft X-Ray Fluxes from SOLRAD-11

One of the few satellite datasets of the soft X-ray fluxes between 1 and 6 nm is that from the SOLRAD-11 mission (March 1976 to October 1979). Three ionization chamber instruments made observations of the Sun at 0.1–0.8, 0.8–2.0, and 4.4–6.0 nm during the rising phase of solar cycle 21. Kreplin and Horan (1992) describe in detail the daily-averaged, full-disk fluxes in which flares have been removed. Tobiska (1994) showed that the SOLRAD-11 measurements yielded soft X-ray photon fluxes in the 1.8–5.0 nm range that were about 27 times greater than the SERF1 model. SERF1 soft X-rays in this range were derived from sounding rocket measurements during solar minimum and the rising phase of cycle 21.

This discrepancy between SERF1 and the published SOLRAD-11 data motivated a re-evaluation of the SOLRAD-11 original calibration. In the original calibration, a grey-body solar spectra of 2×10^6 K for the 0.1–0.8 and 0.8–2.0 nm channels and 5×10^5 K for the 4.4–6.0 nm channel was assumed. Following the original calibration, improved models of the solar spectrum became available. Eparvier and Bornmann (1996) removed the original grey-body spectral assumption from the SOLRAD-11 data and replaced it with two-temperature synthetic spectra using a Mewe spectral algorithm (see *Yohkoh* IDL® package using MEWE_SPEC.PRO by J. R. Lemen). The two temperatures were allowed to be free parameters in the

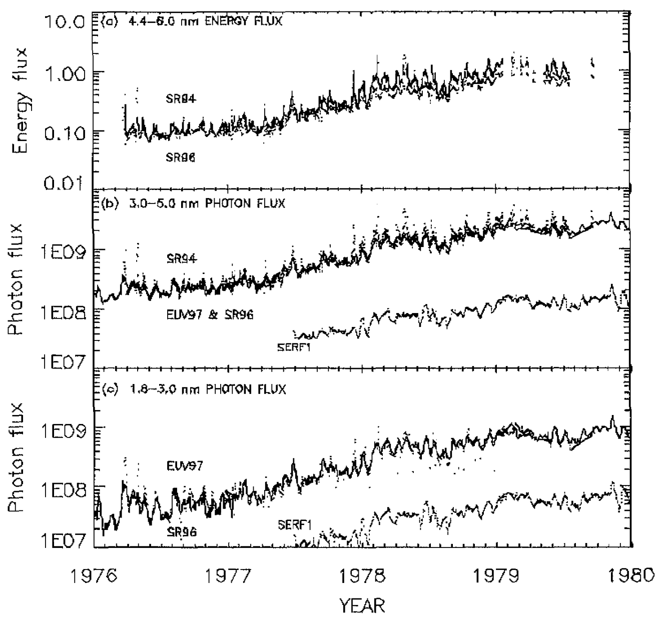

Figure 1. (a) Comparison of Kreplin and Horan SOLRAD-11 (SR92) energy flux (erg cm^{-2} s^{-1}) with the Tobiska digitization (SR94) and the Eparvier and Bornmann recalibration (SR96) for the 4.4–6.0 nm range; (b) comparison between SR94, SR96, and empirically modeled (EUV97) photon fluxes (photons cm^{-2} s^{-1}) to the SERF1 model in the 3.0–5.0 nm range; and (c) comparison between SR96 and EUV97 photon fluxes to SERF1 in the 1.8–3.0 nm range during the rising period of solar cycle 21.

simultaneous fitting of the measurements from all three channels for each day. The two-temperature daily fits yielded revised spectral and absolute flux in the 0.1–6.0 nm range at lower intensities than the originally published fluxes.

A new comparison of the photon flux in the 1.8–3.0 nm range shows that the SOLRAD-11 soft X-rays (mean of the ratios) average 13 times larger than the SERF1 model for the dataset. The comparison for the 3.0–5.0 nm range shows SOLRAD-11 to be 16 times larger than SERF1. Figure 1 shows the original SOLRAD-11 (SR92) energy flux compared with the Tobiska digitization of the dataset (SR94) and the Eparvier and Bornmann revised fluxes (SR96) in the 4.4–6.0 nm range. The figure also compares the SR94, SR96, and empirically modeled EUV97 photon fluxes to the SERF1 model in the 3.0–5.0 nm and 1.8–3.0 nm ranges. EUV97 uses the Eparvier and Bornmann values in the derivation of the model's multiple linear regression coefficients. The modeled values range within 2% of the data values. These comparisons are quantitatively summarized in Table I.

Table I
Comparisons of soft X-ray fluxes

Datasets	References for the datasets	Wavelength range	Mean of the ratios
SR94/SR92	Tobiska (1994); Kreplin and Horan (1992)	4.4–6.0 nm	0.98
SR96/SR92	Eparvier and Bornmann (1996); Kreplin and Horan (1992)	4.4–6.0 nm	0.76
SR94/SERF1	Tobiska (1994); Hinteregger (1985)	3.0–5.0 nm	20.2
SR96/SERF1	Eparvier and Bornmann (1996); Hinteregger (1985)	3.0–5.0 nm	16.4
EUV97/SERF1	this work; Hinteregger (1985)	3.0–5.0 nm	16.6
SR96/SERF1	Eparvier and Bornmann (1996); Hinteregger (1985)	1.8–3.0 nm	13.1
EUV97/SERF1	this work; Hinteregger (1985)	1.8–3.0 nm	13.3

3. Lα during Two Solar Cycles

In the EUV97 model, similar to EUV91, solar Lα photon flux is used as a proxy for estimating the chromospheric component of EUV emission. Substantial improvements have recently been made in determining the absolute Lα irradiance values over solar cycle time scales. Using the UARS/SOLSTICE solar Lα (Rottman, Woods, and Sparn, 1993; Woods, Rottman, and Ucker, 1993; Woods *et al.*, 1996) and the Pioneer Venus Orbiter UV spectrometer (PVOUVS, 1979–1992) upwind sky background interplanetary Lα (Ajello *et al.*, 1987; Pryor *et al.*, 1992; Ajello *et al.*, 1994), Tobiska, Pryor, and Ajello (1997) have produced a preliminary, composite Lα dataset spanning two full solar cycles. Making use of a close relationship between Lα sky background line center (e.g., PVOUVS data) and solar full-disk line integrated intensity variations (e.g., SME and UARS/SOLSTICE data) over solar cycle time scales (Ajello *et al.*, 1987), AE-E and SME data were rescaled to new absolute values from the SOLSTICE-PVOUVS relationship. After scaling is applied, the resulting composite Lα flux for two full solar cycles is determined and shown in Figure 2. Woods and Rottman (1997) have independently derived a similar long-term solar Lα using the UARS, SME, and AE-E datasets. EUV97 uses the Tobiska, Pryor, and Ajello two-solar-cycle Lα irradiance values.

4. Derivation of EUV97

The EUV97 model uses the identical multiple linear regression technique as the EUV91 model (Tobiska, 1991). Solar Lα and He I 10 830 Å EW data are used as independent model parameters for solar chromospheric irradiances while 10.7 cm radio emission ($F_{10.7}$) daily and 81-day running mean values are used as independent model parameters for solar transition region and coronal irradiances. The model, as formulated in Equation (1), produces daily-averaged, full-disk photon

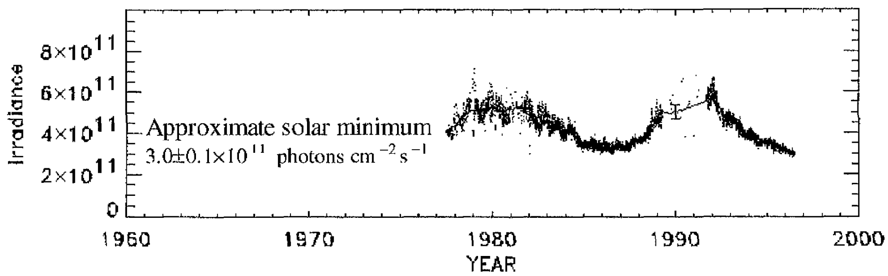

Figure 2. Two-solar-cycle composite Lα (Tobiska, Pryor, and Ajello, 1997). Irradiance is in units of photons cm^{-2} s^{-1}. The $\pm 1\sigma$ error bar (scatter indicator) is derived from the He I 10 830 Å EW fit to the composite Lα (solid line).

fluxes at 1 AU for 39 wavelength groups and discrete lines or for 809 discrete lines between 1.8 and 104.9 nm:

$$\Phi(\lambda, k, t) = \sum_{k=1}^{2} \left\{ a_0(\lambda, k) + \sum_{i=1}^{4} (a_i(\lambda, k) F_i(t)) \right\} . \quad (1)$$

Photon flux, $\Phi(\lambda, k, t)$, is a function of wavelength, λ, key, k (chromospheric, $k = 1$; transition region/coronal, $k = 2$), and daily-average time, t. $F_i(t)$ is the independent model parameter, or proxy, used to generate the flux values (Lα, $i = 1$; He I 10 830, $i = 2$; $F_{10.7}$ daily, $i = 3$; $F_{10.7}$ 81-day, $i = 4$). The model coefficients are $a_0 \ldots a_4$.

In addition to the datasets used in the EUV91 model derivation (OSO-1, -3, -4, -6, AEROS-A, AE-E, and six rocket datasets), the EUV97 model replaces the Hinteregger 1.8–5.0 nm soft X-rays with the SOLRAD-11 data described in Section 2 and shown in Figure 1. EUV97 also uses the revised Lα described in Section 3 and shown in Figure 2 as one of the two chromospheric proxies instead of the SME Lα values used in EUV91.

In the model's lookup table of daily proxies, the He I 10 830 Å EW data are converted to the same units as Lα. This is useful if Lα is not measured on a given date. The He I–Lα relationship is derived in EUV91, modified by the UARS-based recalibration of SME Lα described in Section 3 ($\times$1.295), and shown in Equation (2). Daily modeled fluxes are available in EUV97 from February 14, 1947 to May 2, 1996.

$$F_{\mathrm{L}\alpha} = \{3.78 \times 10^9 F_{\mathrm{He\,I}} + 8.40 \times 10^{10}\} \times 1.295 . \quad (2)$$

Predicted daily flux values can be generated from May 3, 1996 through December 31, 2003 using the best estimate predicted $F_{10.7}$ which peaks in August 2000 (solar cycle 23) with a maximum of 216 (K. Schatten, 1995, private communication). Chromospheric proxies are generated by the relationship between $F_{10.7}$ and

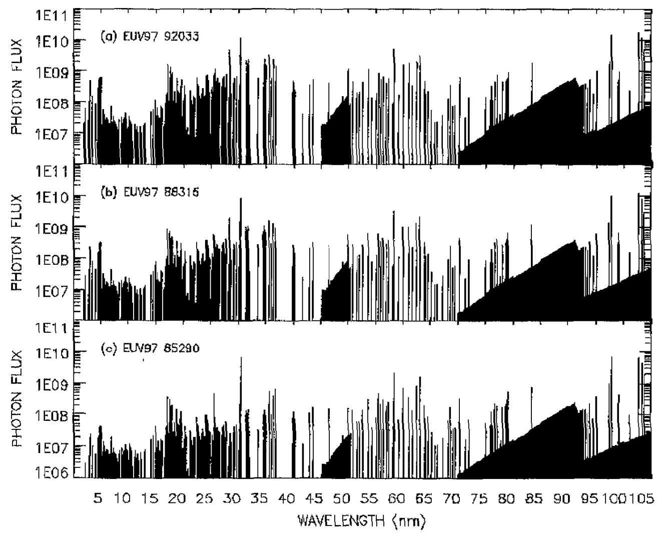

Figure 3. EUV97 fluxes for (a) high solar activity with $F_{10.7} = 280$, (b) moderate solar activity with $F_{10.7} = 148$, and (c) low solar activity with $F_{10.7} = 76$. Wavelength grid is the same as SC#21REFW and photon flux is in units of photons cm^{-2} s^{-1} $\Delta\lambda^{-1}$.

Lα which was derived by Barth *et al.* (1990) for the rise of solar cycle 21. These proxies have a lower correlation than the He I–Lα relationship. A derived Lα is modified by the UARS-based recalibration of SME Lα described above ($\times 1.295$) and is shown in Equation (3):

$$F_{L\alpha} = \{8.7 \times 10^8 F_{10.7} + 1.9 \times 10^{11}\} \times 1.295 . \tag{3}$$

Table II quantitatively describes the solar cycle maximum/minimum ratios and the solar cycle daily minimum values for six aeronomically important wavelengths, i.e., 3–5, 15–20, 30.4, 58.4, 85–90, and 102.6 nm, and for Lα. The coefficients used in EUV97, Equation (1), are listed in Table III by wavelength range (λ_1 to λ_2), emission source layer ($k = 1, 2$), and indexed coefficient ($a_0 \ldots a_4$). A comparison between modeled high, moderate, and low solar activity is shown in Figure 3. In the panels, the photon flux is binned on the same wavelength grid as the SC#21REFW spectrum (Torr and Torr, 1985). Flux from wavelengths shortward of 30 nm increases significantly more than longer-wavelength irradiances from low to high solar activity. Figure 4 shows modeled and predicted flux for solar cycles 21, 22, and 23 at the six wavelengths.

5. Conclusions

The solar EUV empirical model EUV97 contains major revisions from the EUV91 model in the soft X-ray (1.8–5.0 nm) and the Lα proxy (121.6 nm) wavelengths.

Table II

Solar cycle ratios and minimums for EUV97 fluxes

EUV/FUV λ (nm)	3–5	15–20	30.4	58.4	85–90	102.6	Lα
SC 21 daily maximum*	3.9×10^{9}	1.1×10^{10}	1.2×10^{10}	5.3×10^{9}	1.4×10^{10}	1.9×10^{10}	6.9×10^{11}
SC 21–22 daily minimum*	1.3×10^{8}	1.9×10^{9}	6.2×10^{9}	1.7×10^{9}	4.5×10^{9}	5.8×10^{9}	3.0×10^{11}
SC 21–22 daily max/min	31.2	5.7	1.9	3.2	3.2	3.2	2.3
SC 22 daily maximum*	3.9×10^{9}	1.1×10^{10}	1.2×10^{10}	5.3×10^{9}	1.4×10^{10}	1.9×10^{10}	6.6×10^{11}
SC 22–23 daily minimum*	1.3×10^{8}	1.9×10^{9}	6.0×10^{9}	1.5×10^{9}	4.0×10^{9}	5.2×10^{9}	2.9×10^{11}
SC 22- 23 daily max/min	30.8	5.9	1.9	3.5	3.6	3.6	2.3

*Photons cm^{-2} s^{-1} $\Delta\lambda^{-1}$.

Table III
EUV97 model coefficients

λ_1	λ_2	k	a_0	a_1	a_2	a_3	a_4
1.9	3.0	2	−4.08334E+08	0	0	4.24664E+06	1.98503E+06
3.0	4.9	1	0	0	0	0	0
3.0	4.9	2	−1.06994E+09	0	0	7.94298E+06	9.47885E+06
5.1	10.0	1	−2.63824E+08	−1.48160E−05	1.69344E−03	0	0
5.1	10.0	2	−2.01169E+08	0	0	3.59384E+06	2.32841E+06
10.1	14.8	1	−1.04138E+08	−6.35077E−06	6.88071E−04	0	0
10.1	14.8	2	−2.10080E+05	0	0	6.34184E+05	4.09793E+05
15.0	19.9	1	−1.74864E+08	−1.39392E−05	1.59327E−03	0	0
15.0	19.9	2	−8.50452E+08	0	0	2.15983E+07	1.39840E+07
20.0	24.9	1	−2.03915E+08	−1.62148E−05	1.85329E−03	0	0
20.0	24.9	2	−1.89626E+09	0	0	2.02855E+07	1.31572E+07
25.6	25.6	1	−3.03544E+07	−1.34653E−05	1.45856E−03	0	0
28.4	28.4	2	−1.87425E+09	0	0	1.60441E+07	9.43640E+06
25.1	30.0	1	−7.71343E+07	−1.16469E−05	1.33111E−03	0	0
25.1	30.0	2	−3.82102E+09	0	0	3.48145E+07	2.27244E+07
30.3	30.3	2	−1.05822E+09	0	0	1.00705E+07	7.17696E+06
30.4	30.4	1	2.13752E+08	−1.74742E−04	1.99727E−02	0	0
30.3	35.0	2	−4.65860E+09	0	0	4.45973E+07	2.91061E+07
36.8	36.8	2	2.87050E+08	0	0	2.79581E+06	1.72142E+06
35.6	40.0	1	−5.81546E+06	−8.67583E−07	9.91946−05	0	0
35.6	40.0	2	−1.24569E+09	0	0	1.90743E+07	1.20416E+07
40.1	43.7	1	−5.89509E+07	−9.43228E−06	1.02271E−03	0	0
40.1	43.7	2	−1.26274E+08	0	0	3.23658E+06	1.98280E+06
46.5	46.5	2	5.89122E+07	0	0	8.44715E+05	5.20445E+05
45.3	49.9	1	−1.97061E+08	−1.20655E−05	1.30719E−03	0	0
45.3	49.9	2	−9.71259E+08	0	0	1.08776E+07	7.12062E+06
50.0	55.0	1	−4.19500E+08	−3.54612E−05	3.84192E−03	0	0

Table III
(continued)

λ_1	λ_2	k	a_0	a_1	a_2	a_3	a_4
50.0	55.0	2	−4.74330E+08	0	0	4.08502E+06	2.44630E+06
55.4	55.4	1	−7.97562E+07	−1.56297E−05	1.69443E−03	0	0
58.4	58.4	1	−2.40503E+09	−1.18646E−04	1.35717E−02	0	0
55.4	60.0	1	−1.46520E+09	−9.37977E−05	1.01714E−02	0	0
61.0	61.0	2	−2.41248E+08	0	0	5.22489E+06	2.80106E+06
63.0	63.0	1	−3.35139E+08	−5.35513E−05	6.12470E−03	0	0
61.0	64.4	1	−2.40644E+08	−3.99578E−05	4.32751E−03	0	0
61.0	64.4	2	−1.76203E+08	0	0	3.64330E+06	2.32576E+06
65.0	70.0	1	−1.27309E+08	−1.18820E−05	1.28718E−03	0	0
65.0	70.0	2	4.86650E+07	0	0	3.31301E+05	1.89074E+05
70.3	70.3	1	−2.33828E+07	−1.03695E−05	1.12356E−03	0	0
70.1	75.0	1	−6.59024E+07	−7.98417E−06	8.64873E−04	0	0
76.5	76.5	1	−9.70182E+07	−9.18718E−06	9.95058E−04	0	0
77.0	77.0	2	−3.39939E+07	0	0	1.75960E+06	1.12721E+06
78.8	79.0	1	−1.44845E+08	−2.63403E−05	3.01266E−03	0	0
75.0	80.0	1	−4.03358E+08	−3.67037E−05	3.97636E−03	0	0
75.0	80.0	2	−6.05958E+07	0	0	2.87651E+06	1.84637E+06
80.1	85.0	1	−1.91143E+09	−1.17893E−04	1.27725E−02	0	0
85.1	90.0	1	−6.50213E+09	−3.18520E−04	3.64148E−02	0	0
90.1	95.0	1	−5.46244E+09	−2.81559E−04	3.21729E−02	0	0
97.7	97.7	1	−3.42946E+09	−2.98656E−04	3.23490E−02	0	0
95.1	100.0	1	−1.16091E+09	−9.34911E−05	1.01294E−02	0	0
102.6	102.6	1	−8.49329E+09	−4.15799E−04	4.75659E−02	0	0
103.2	103.2	1	−5.70932E+09	−2.89205E−04	3.13320E−02	0	0
100.1	105.0	1	−4.28991E+09	−2.33472E−04	2.52878E−02	0	0

λ_1 is the starting wavelength interval in nm.
λ_2 is the ending wavelength interval in nm.
k is key for emission source layers of the solar atmosphere (1 = chromospheric and 2 = transition region/coronal).
a_0 through a_4 are the coefficients of the EUV97 model in Equation (1) where $i = 0$–4.

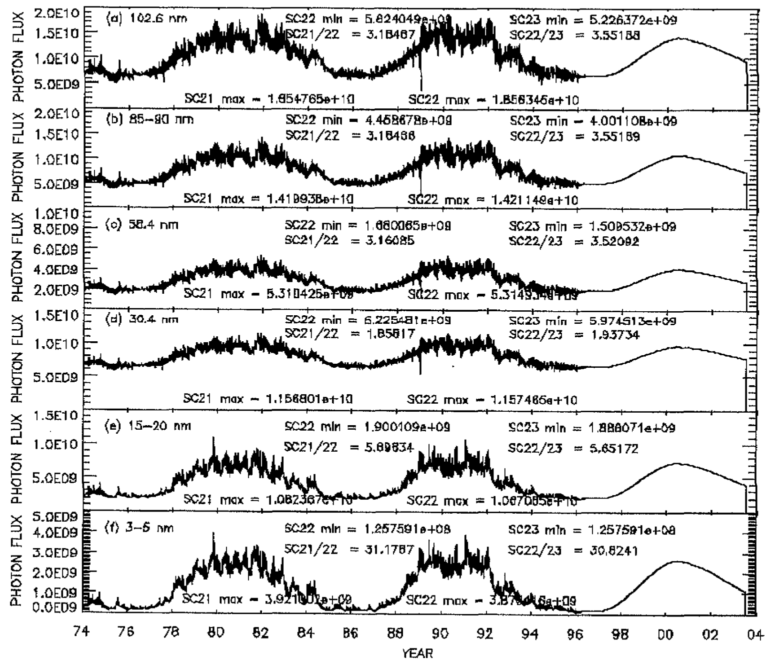

Figure 4. Six aeronomically important EUV wavelengths modeled for solar cycles 21 and 22 and predicted for solar cycle 23. Solar cycle maximum and minimum values are shown in each panel as are the max/min ratios based on daily-average values. Photon flux is in units of photons cm^{-2} s^{-1} $\Delta\lambda^{-1}$.

SOLRAD-11 data were used for the revised 1.8–5.0 nm wavelength range. Eparvier and Bornmann (1996) removed the original grey-body spectral assumption from the SOLRAD-11 data and replaced it with two-temperature synthetic spectra using a Mewe spectral algorithm. The Lα proxy is a new, preliminary dataset encompassing solar cycles 21 and 22 provided by Tobiska, Pryor, and Ajello (1997). For this dataset, AE-E and SME Lα data were rescaled to new absolute values from a derived SOLSTICE-PVOUVS relationship.

The model produces daily-averaged, full-disk photon fluxes at 1 AU for 39 wavelength groups and discrete lines or for 809 discrete lines between 1.8 and 104.9 nm. It also provides daily modeled fluxes from February 14, 1947 to May 2, 1996. Predicted daily flux values, using predicted $F_{10.7}$, can be estimated from May 3, 1996 through December 31, 2003. EUV97 is currently available as IDL® code by email from the authors.

Future improvements to this model will result from the final calibration of the UARS Lα data which will affect the absolute magnitude of this proxy. Potential rocket and satellite measurements between 0.5–1.5 nm will provide anticipated changes in that wavelength range.

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