

**NASA  
Reference  
Publication  
1199**

1988

Nimbus 7 Solar Backscatter  
Ultraviolet (SBUV) Spectral  
Scan Solar Irradiance and  
Earth Radiance Product  
User's Guide

Barry M. Schlesinger  
and Richard P. Cebula  
*ST Systems Corporation (STX)  
Hyattsville, Maryland*

Donald F. Heath  
and Albert J. Fleig  
*Goddard Space Flight Center  
Greenbelt, Maryland*



National Aeronautics  
and Space Administration

Scientific and Technical  
Information Division

## ACKNOWLEDGEMENTS

The SUNC and EARTH tapes described in this User's Guide were prepared by the Ozone Processing Team of NASA/Goddard Space Flight Center. Please acknowledge the Ozone Processing Team as the source of the data whenever reporting on results obtained using data from these tapes. The members of the Ozone Processing Team contributing to this effort were Albert J. Fleig (manager), P. K. Bhartia, Richard P. Cebula, Donald F. Heath, K. F. Klenk, R. D. McPeters, Hongwoo Park, and Barry M. Schlesinger.

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## INTRODUCTION

The Solar Backscatter Ultraviolet (SBUV) experiment was launched aboard the Nimbus-7 satellite on 24 October 1978. Its principal function has been to measure albedos at 12 selected wavelengths from 255.5 nm to 339.8 nm for the purpose of deriving atmospheric ozone. From time to time, the instrument has also been operated in a spectral scan mode, in which it measures solar irradiance and Earth radiance, scanning the spectrum from 160 nm to 400 nm in 0.2-nm steps, with a 1.1-nm half-width triangular bandpass. This document describes the archived tape products containing the results of the measurements in spectral scan mode. The results of spectral scan measurements of the solar irradiance from 160 nm to 400 nm are on continuous scan solar flux (SUNC) tapes. Data from spectral scan measurements of the Earth radiance from 200 nm to 400 nm are on continuous scan Earth Radiance (EARTH) tapes.

The solar irradiance data are of extremely high precision, except at the shortest wavelengths. The scan-to-scan repeatability ranges from better than 0.5 percent between 320 nm and 400 nm to 1 percent around 280 nm, 2 percent around 210 nm, and 4 percent near 175 nm, with the scatter increasing to shorter wavelengths. The repeatability of the Earth radiance values depends upon both wavelength and solar zenith angle, ranging from 2 to 3 percent at longer wavelengths and low solar zenith angles to 10 percent at shorter wavelengths and high solar zenith angles. The data have been corrected for all known changes in instrument sensitivity. The residual uncertainty in solar irradiance and Earth radiance individually is 0.8 percent per year. Because the SBUV experiment is designed principally to measure albedos, the EARTH tapes also contain the solar irradiance for each day on which the Earth radiance was measured in continuous scan mode to facilitate the calculation of the albedo, the ratio of backscattered irradiance to scattered radiance. All optical elements except one are common to both the solar irradiance and the Earth radiance measuring systems; the instrumental uncertainty in the albedo is therefore smaller than that in the radiances and irradiances individually, less than 0.5 percent per year.

### 1.1 Outline of Document

This guide is intended to assist users of the Nimbus-7 SBUV SUNC and EARTH tapes. It is designed to accompany the first 6 years of these tapes. There is one tape of each kind for each year.

This first section contains a description of the experiment and the workings of the continuous scan mode of measurement, an outline of the contents of the tape, and a summary of the uncertainties in the data on the tape. Section 2 describes in detail how radiances and irradiances have been derived from the raw counts, how changes in the instrument sensitivity have been accounted for, and what uncertainties remain in the final data product. Section 3 discusses quality control: conditions which lead to data rejection, fill values, and/or data flags. Details of the operating schedule and data coverage appear in Section 4. Section 5 describes how the tapes are produced. A detailed description of the tape structure and formats appears in Section 6. An inventory of tapes and discussion of how they can be obtained appear in the Appendixes.

### 1.2 Experiment

A detailed description of the experiment can be found in the User's Guide to the SBUV/TOMS RUT data sets (Fleig *et al.*, 1983). The summary below is adapted from that discussion.

The SBUV instrument aboard the Nimbus-7 satellite is designed to measure total ozone and its distribution with height in the atmosphere, by measuring the ratio of backscattered ultraviolet Earth radiance to incident solar irradiance (Fleig *et al.*, 1982). To measure the ultraviolet Earth radiance and solar irradiance, the SBUV experiment contains a double monochromator and a filter photometer. About 10 percent of the light from the monochromator is diverted to a reference photodiode instead of going to the photomultiplier used for solar irradiance and Earth radiance measurements. The photometer is included to monitor the UV reflectivity in the field of view for a 3-nm-wide wavelength band centered at 343 nm. The monochromator can operate in either of two modes. In step scan mode, it measures radiation in twelve 1.1-nm ultraviolet (UV) wavelength bands that were selected because they could be used to retrieve total atmospheric ozone and

its altitude distribution. In a single scan, each band is measured in turn. In continuous scan mode, the monochromator scans the spectrum continuously over a nominal wavelength range of 160 nm to 400 nm at intervals of 0.2 nm. The SUNC and EARTH tapes contain only information that was acquired in continuous scan mode.

An orbit-by-orbit inventory for the first 2 years of SBUV step scan and continuous scan data is available from the National Space Sciences Data Center (NSSDC) (NASA, 1983). According to this inventory, no regular ON/OFF schedule was followed in the first 7 months of instrument operation. Originally, the instrument was intended to be ON 3 days and OFF 1 day. In the beginning, however, the instrument was ON continuously for 17 days before the first turn-off. The schedule did not become regular until May 23, 1979 (day 148 of 1979). The instrument schedule followed a more or less regular pattern of 3 days ON and 1 day OFF until August 1983, after which the instrument was ON nearly every day. Continuous scan Earth radiance measurements were made every 24 days. More details on the schedule appear in Section 4.

### 1.3 Tape Contents

The data on both tapes have been derived from the raw Nimbus-7 SBUV data on the Raw Unit Tape-SBUV (RUT-S) tapes (Fleig *et al.*, 1983; NASA, 1983). The SUNC tape contains corrected solar irradiance data; the EARTH tape contains corrected Earth radiance data.

Each SUNC tape contains the following types of data records:

- a) The first record of each file contains the calibrated post-launch wavelength for each of the 1200 continuous scan samples.
- b) The second and third records contain screening limits used for the current file.
- c) Individual scan continuous scan solar flux for each of 1200 wavelengths (from 160 nm to 400 nm at 0.2-nm intervals), also 96 photometer solar flux measurements, at 343.3 nm, each coinciding with 2.5 nm of solar flux scan measurement, and reference diode data.
- d) Orbital mean irradiances and number of samples, whenever solar flux is measured for more than one orbit per day.
- e) Daily mean irradiances, standard deviations, minimum and maximum irradiances, and number of samples.
- f) Daily 5-nm average flux (centered at 162.5, 165.0, 167.5, etc.).
- g) Trailer record for each file, containing quality control information.

Each tape contains data for one satellite data year. Satellite data years begin the first Sunday in November, except for the first year, which begins 31 October 1978. Data are grouped by Bartels period, with one file for each Bartels period. Bartels periods are 27 days, corresponding approximately to the apparent rotation period for solar features as seen from the Earth. The first Bartels period for which SBUV solar irradiance measurements were made, and for which data are on the tapes, was #1986, which began 4 November 1978. When a Bartels period includes days in consecutive satellite data years, data for the entire period are included on the tape for the year in which it ends. Individual scans of each orbit are grouped into their proper day according to the Greenwich Mean Time (GMT) day of the first good sample of the orbit, as determined from the orbital header record on the RUT tape of origin. The tape is described in greater detail in Section 6.3.1.

The structure of the EARTH tape is the same as that of the SUNC tape: one tape per satellite data year, one file per Bartels period. Each EARTH tape contains the following types of data records:

- a) The first record of each file contains calibrated post-launch wavelengths for the 1200 samples.

- b) *Individual scan continuous scan daytime Earth radiance* for each of 1200 wavelengths (from 160 nm to 400 nm at 0.2-nm intervals), and 96 photometer measurements at 343.3 nm. Only the words for 200-400 nm contain Earth radiance values; the others contain fill. Each photometer measurement is an average over the time equivalent to 12.5 scan positions (2.5 nm).
- c) Daily average solar flux for the day of Earth radiance measurements. If solar flux data are unavailable or of poor quality, solar flux for the last day with satisfactory solar flux before the current day is used.
- d) Trailer record for each Bartels period (file) containing quality control information.

A description in greater detail appears in Section 6.3.2. For the solar flux for a day to be included on the EARTH tape, 1184 out of 1200 wavelengths must have nonfill values for at least one scan.

## 1.4 Summary of Uncertainties

Although every effort has been made to produce a data set that reflects only the changes in the incoming solar irradiance and backscattered Earth radiance, instrument behavior has proven too complex to permit derivation of a simple, physically based model that will account perfectly for every instrumental effect. This problem is especially important when using these data sets to investigate possible changes with time of the solar UV irradiance. Before interpreting the results derived from these tapes, users should understand the following aspects of the data sets.

- a) The irradiance signal short of 170 nm is very weak, and the signal is consequently extremely noisy, with the scatter between adjacent wavelength positions ranging from about 5 percent near 170 nm to 20 percent near 160 nm. Smaller changes seen in the data may therefore not be significant. For the Earth radiance data, the count to physical radiance units conversion between 200 nm and 220 nm is not based on direct calibration data from longer wavelengths. No radiance values short of 200 nm appear on the tape. The radiometric calibration of both radiances and irradiances is discussed in greater detail in Section 2.2.
- b) The raw data exhibit a wavelength-dependent drift over the long term, which is believed to be linked to changes in the instrument optics. The model that was used to remove this effect does not appear to describe completely the long-term wavelength dependence of the instrument behavior; some of the changes with time in the archived data sets may still be instrumental in origin. The size of the uncertainty ranges from 0.1 percent per year for 290 nm to 400 nm, to 0.5 percent per year for 220 nm to 290 nm, to 2 percent per year short of 220 nm. At wavelengths shorter than 200 nm, the functional form chosen to represent changes in the optics with time does not appear to represent the wavelength dependence of the changes well. The uncertainties in the instrument optics characterization are discussed in greater detail in Section 2.5. The significance of these uncertainties is that the user must consider the possibility of instrument related changes when using these tapes to investigate long-term variations in solar irradiance or Earth radiance.
- c) The models used to characterize the changes in the instrument optics and the degradation of the diffuser plate have a  $2\sigma$  statistical uncertainty that would correspond to a change of approximately 0.8 percent per year over the 6 years. Derived upper limits on systematic change in the diffuser sensitivity are smaller.
- d) Changes in the optics and diffuser sensitivity were derived explicitly at only 31 of the 1200 wavelengths; changes at other wavelengths were derived by interpolation in wavelength. Uncertainty in the fit may lead to uncertainty in the yearly change of from 0.1 percent near wavelengths used for the derivation to as much as 0.3 percent per year midway between. The importance of the use of this approximation to the instrument change is that it may produce wavelength-dependent changes with time that do not reflect actual solar change. The characterization of instrumental changes and the uncertainties therein are described in Sections 2.4 and 2.5.

- e) The wavelength corresponding to a given grating position changes with time. No correction for this change has been made to the archived tapes. This wavelength drift can produce a change of 0.3 percent per year in the wings of strong lines and a change of 0.1 percent per year elsewhere. Wavelength calibration is described in Section 2.1.
- f) All measurements are normalized to a five-wavelength average, centered at 391.3 nm. This normalization is equivalent to assuming that the solar flux at these wavelengths does not change with time. Examination of published measurements of the solar constant suggests a possible error of 0.03 percent per year over the long term and up to 0.5 percent over periods of a week.
- g) There is evidence for a possible change in the photomultiplier gain between ground calibration and the first instrument measurements. As a result, the absolute value of the irradiance may be at least 2.7 percent low. This effect would be wavelength independent. Additional detail appears in Section 2.4.
- h) To eliminate bad data points, such as those that might arise from hardware or data transmission problems, all data points that differ by more than 5 standard deviations from the mean of the previous Bartels period are rejected. For scattered days, this criterion may result in the rejection of valid data wavelengths where solar variations are strongest, at short wavelengths and at the center of the magnesium line. On the other hand, some erroneous data points may be accepted if the deviations from proper values are smaller than the  $5\sigma$  screening criterion.



## DERIVATION OF RADIANCES AND IRRADIANCES

Heath *et al.* (in preparation) and Cebula *et al.* (1987) provide a detailed discussion of the instrument calibration. The discussion in this section, based in part on early drafts of those papers, describes those aspects of the calibration results needed for use of the continuous scan tapes.

### 2.1 Wavelength Calibration

To provide for inflight wavelength calibration, a low-pressure mercury-argon lamp was flown aboard Nimbus-7. Wavelength calibration measurements have normally been made about twice per week. The wavelength scale adopted was based upon measurements of six mercury lines and two solar lines during weeks 250-262 of the flight of Nimbus-7; 11 August to 5 November 1983. The mercury lines measured were those at 184.9 nm, 253.7 nm, 296.8 nm, 334.2 nm, 289.4 nm, and 365.1 nm; the solar lines used were the Ca II H and K lines at 393.3 nm and 396.8 nm.

The following fit was derived:

$$\lambda_0 = 160.23 + 0.19985n \quad (1)$$

where  $\lambda_0$  is the wavelength in nanometers, and  $n$  is the continuous scan grating position number which runs from 1 to 1200. The calibrated wavelengths are written as the first record of each file. The departure from a linear fit is extremely small; a quadratic fit gave wavelengths that differed by no more than 0.002 nm from the linear fit at any grating position. The  $1\sigma$  statistical uncertainty is less than 0.02 nm at any grating position.

Analysis of measurements of the first four mercury lines listed above has revealed a nearly linear shift in the wavelength scale with time. The derived shift is given by

$$\lambda - \lambda_0 = 1.392 \times 10^{-7} (\lambda_0 - 209)(d - d_0) \quad (2)$$

where  $\lambda_0$  is the wavelength in nanometers for the base period,  $d_0$  is the central day of the base period, and  $\lambda$  is the actual wavelength on day  $d$ . For wavelengths shorter than 209 nm, the wavelength corresponding to a given grating position increases with time, while for longer wavelengths, it decreases with time. The largest change is at 400 nm, about 0.05 nm over the 5 years. The measurements also show evidence of random jitter, about 0.01 nm in amplitude, more pronounced at the longer wavelengths. The wavelengths written on the tapes at the start of each file, corresponding to individual grating positions, are those for the 1983 base period. Because drift and jitter are present, some care is required when comparing irradiances on different days. In regions of the spectrum where the irradiance changes rapidly with wavelength, such as the wings of strong lines, changes in the wavelength corresponding to a given scan position may produce spurious changes in the irradiance. When the wavelength corresponding to a given grating position changes, the solar irradiance will be that at the new grating position. This irradiance will, in general, differ from the irradiance at the wavelength originally corresponding to that scan position. The drift in wavelength of the scan position will, consequently, give rise to a spurious apparent change with time in the solar irradiance. When investigating long-term changes at any wavelength with this data set, the effect of wavelength drift must be considered and, if necessary, a correction made for it. The effect of jitter is most likely to be a problem when comparing spectra of two different days in the region of a line. Figure 2.1 illustrates the effects of changes in the wavelength corresponding to a given scan position. The upper panel shows the average irradiance from 392 nm to 395 nm, in the vicinity of the Ca II K line, over 5 days at the beginning of the flight of Nimbus-7: 8, 9, 10, 12, and 14 November 1978. The solid line shows the actual derived solar irradiance at each grating position plotted at the wavelength that is listed on the tape for that grating position, a wavelength based on a period nearly 4 years later. The dashed line shows an estimate of the actual irradiance at those wavelengths for November 1978. It is derived by calculating the wavelength corresponding to each grating position for November 1978, and then deriving the irradiance at the wavelengths on the tape through interpolation. In November 1978, each grating position corresponds to a longer wavelength than that shown on the tape. Consequently, when the irradiance is plotted as a function of wavelength,

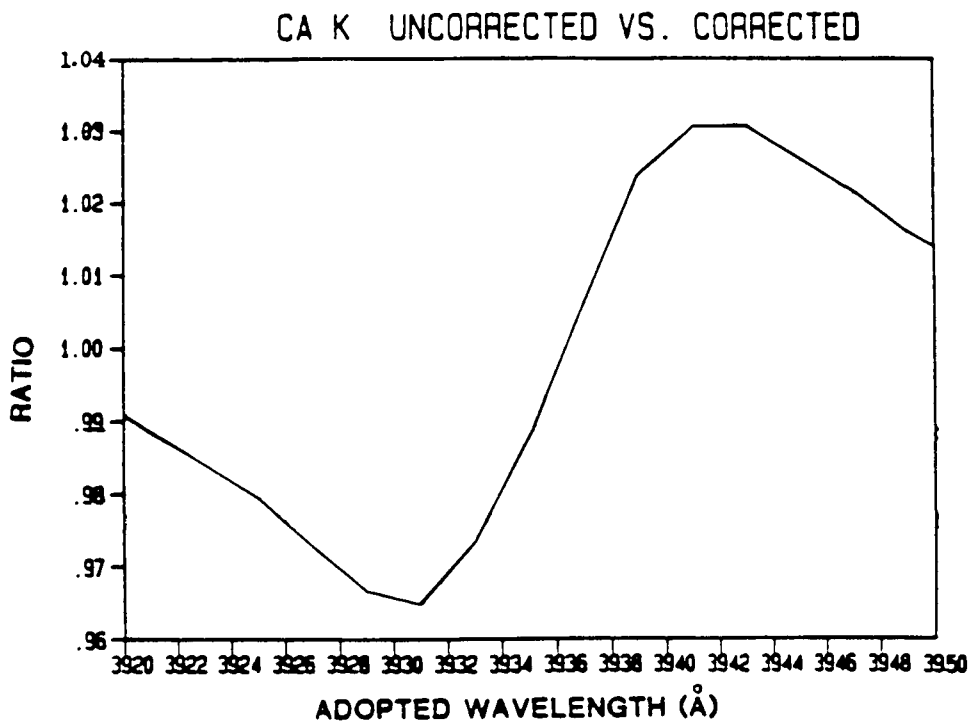
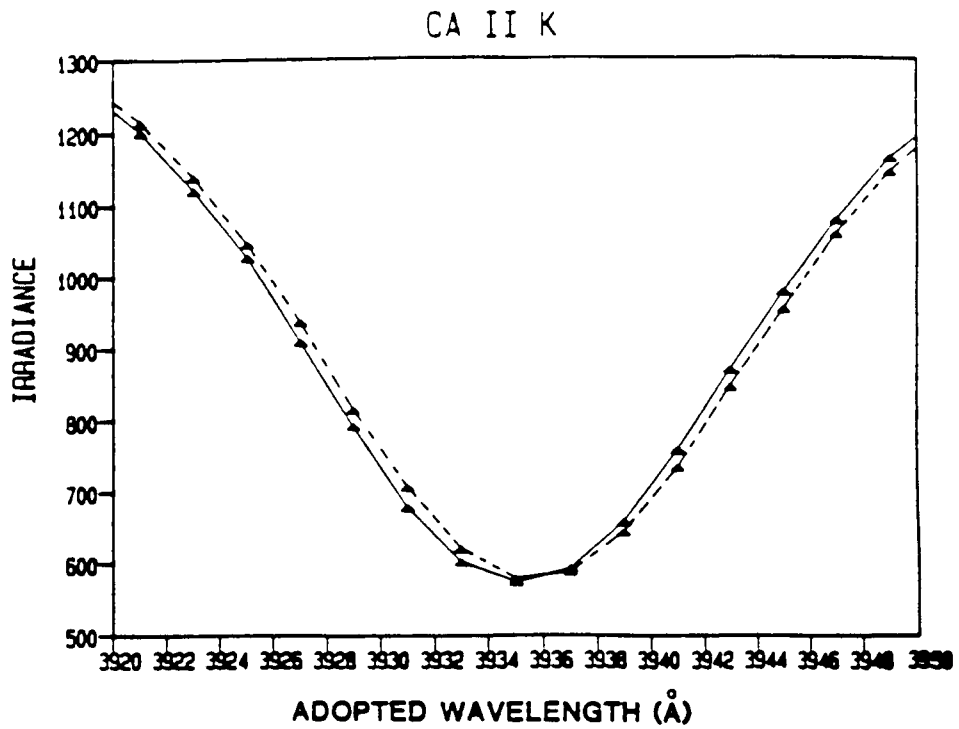


Figure 2.1 Effect of wavelength scale changes. (top) *solid line* - November 1978 irradiance as a function of calibration wavelengths; *dashed line* - estimated November 1978 irradiance as a function of actual wavelength (bottom) ratio of irradiance as function of calibration wavelength to irradiance as function of actual wavelength.

and the wavelength assigned to a grating position is that on the tape, features appear at wavelengths that are too short. The lower panel shows the effect of a slight relative shift in the wavelength scale, giving the ratio of the uncorrected to the corrected irradiances. There is a relative minimum of about 0.097 on the short side of the line and a relative maximum of 1.03 on the long side of line center, both at wavelengths where the change of irradiance with wavelength is steepest. If this pattern is seen in the vicinity of a line when the ratio of data from two different days is calculated, the effect of wavelength drift should be suspected. Drift is nearly certain to produce such a pattern when the data compared are widely separated in time; for neighboring days, jitter may produce such an effect on a smaller scale. The Ca II K line presents an extreme case of this effect, as it is a region of the spectrum where the irradiance changes most rapidly with wavelength and where the wavelength drift is at maximum.

## 2.2 Radiometric Calibration

Table 2.1 lists the radiometric calibration standards used, the wavelength range for which each source was used, and the estimated accuracy. These sources were National Bureau of Standards (NBS) spectral irradiance standards. They were calibrated at NBS both before and after their use for SBUV instrument calibration. Additional details on the prelaunch calibration are in Fleig *et al.* (1983).

As can be seen from Table 2.1, the Ar lamp calibration source used for wavelengths short of 200 nm is less precise than the sources used for calibration at longer wavelengths. Consequently, the irradiances at the shorter wavelengths are not as reliable as those at longer wavelengths.

Radiance calibration required measurement at NBS of the diffuse reflectance of a BaSO<sub>4</sub> diffuser illuminated by the irradiance standard. A calibration of this diffuser below 220 nm was not available. For the region 200-220 nm, radiances were, therefore, calculated using an extrapolation of the calibration. For wavelengths below 200 nm, where the terrestrial radiance is weak, the EARTH tape contains only fill values.

The signal measured by SBUV varies by over 5 orders of magnitude. The wide instrumental dynamic range required for such measurements was achieved by employing different gain ranges with the electronic amplifiers. The gain ratios between different ranges were determined from inflight data: they are, 52.42 between ranges 1 and 2 and 80.50 between ranges 2 and 3. Over 5 years there is no evidence for any change in these ratios; the upper limit is 0.3 percent. The linearity within gain ranges was investigated by comparing the photomultiplier to reference diode ratio for a range of signal levels in a given gain range. Since the reference photodiode has a gain of unity, the output to input ratio is not signal dependent, and it can be used as a standard with which the photomultiplier can be compared. No evidence was found for departures from linearity, with an upper limit of 20 percent.

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Table 2.1

Standards for the Calibration

<u>Wavelength Range (nm)</u>	<u>Standard</u>	<u>Accuracy</u>
160-200	Ar mini-arc lamp	+ 10%
200-250	Deuterium arc lamp	+ 6%
250-400	Quartz-halogen	+2.6% at 250 nm +1.7% at 350 nm +1.4% at 450 nm

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Prelaunch calibration values were not available for the reference diode. No calibration has been applied to derive values on the tape; a conversion factor of unity was used. The reference diode values on the CSCAN tape are therefore raw counts and not physical values.

## 2.3 Geometrical Corrections

The direction of the incoming solar radiation changes as the satellite moves in its orbit. As the angle of incidence on the diffuser departs from normal, the amount of radiation striking a unit area of the detector for a given incoming solar irradiance changes. Because the diffuser is not a perfect Lambertian scatterer, it was necessary to determine its reflectivity as a function of angle of incidence and angle of observation through direct measurements. The angular response of the instrument for solar flux measurement was measured prior to launch; in-orbit measurements also were made. The relative angular response of the instrument can be represented by the following analytic function (called the goniometric function):

$$F_1(\alpha, \beta) = b_0 + b_1\alpha + b_2\beta + b_3\alpha^2 + b_4\alpha\beta + b_5\beta^2 + b_6\alpha^3 + b_7\alpha^2\beta + b_8\alpha\beta^2 + b_9\beta^3 \quad (3)$$

where  $\alpha$  is the solar elevation angle, and  $\beta$  is the angle between the Sun-Earth vector and the satellite orbital plane. The values of the coefficients are given in Table 2.2.

No goniometric correction need be applied to derive the terrestrial radiances on the EARTH tape, as the diffuser is not deployed when they are measured.

The solar irradiance incident at the Earth varies not only as the Sun changes but also as the distance between the Earth and sun varies over the year. The irradiances have been reduced to the value that would have been measured at 1 a. u. by multiplying by the square of the Earth-Sun distance in astronomical units. The following approximation to the Earth-Sun distance  $r$  is used:

$$r = 1 - 0.0167 \cos 2\pi(d - 3.4)/365.25 \quad (4)$$

Table 2.2

### Goniometric Function Coefficients

$$F_1(\alpha, \beta) = b_0 + b_1\alpha + b_2\beta + b_3\alpha^2 + b_4\alpha\beta + b_5\beta^2 + b_6\alpha^3 + b_7\alpha^2\beta + b_8\alpha\beta^2 + b_9\beta^3$$

<u>Coefficient</u>	<u>Value</u>
b <sub>0</sub>	1.0026
b <sub>1</sub>	-1.5593 x 10 <sup>-2</sup>
b <sub>2</sub>	1.1334 x 10 <sup>-3</sup>
b <sub>3</sub>	6.0358 x 10 <sup>-4</sup>
b <sub>4</sub>	-2.6769 x 10 <sup>-5</sup>
b <sub>5</sub>	5.7401 x 10 <sup>-5</sup>
b <sub>6</sub>	-6.3707 x 10 <sup>-6</sup>
b <sub>7</sub>	-3.8590 x 10 <sup>-7</sup>
b <sub>8</sub>	-4.2615 x 10 <sup>-6</sup>
b <sub>9</sub>	-4.7925 x 10 <sup>-6</sup>

where  $d$  is the day number in the year, running from 1 to 365 (or 366). Terrestrial radiance is also corrected to the value that would be obtained if the Sun were at a distance of 1 a. u.

## 2.4 Instrument Changes

Two sources of change in the instrument sensitivity as a function of time are known. There is clear evidence that the gain of the photomultiplier (PMT) varies with time. Exposure to sunlight causes materials that were deposited on the diffuser plate at the time of launch to become opaque, producing a decrease with time of the diffuser reflectivity. In addition to these known sources of sensitivity change, there is evidence for additional changes with other origins, as in the instrument optics. These additional changes will be characterized as secular degradation.

As discussed in Section 1.2, some of the incident light was diverted to a reference diode of gain unity. The goal was to provide a means of calibrating the changes in the gain in the PMT. However, studies of the PMT and reference diode signals yielded evidence for changes over the long term in the reference diode sensitivity. With no direct measurement available for monitoring the PMT, and with no clear physical model for the variations, the approach chosen was to assume that the Sun is constant at the longest wavelengths measured. This approach, in effect, corrects for all wavelength independent changes of the instrument with time, not only for PMT gain changes; thus, the secular term includes any wavelength-dependent changes with time. At the wavelengths used for PMT calibration, most of the radiation is coming from the photosphere, the region of the solar atmosphere from which the visible continuum originates. Available observations of the variations of the solar constant may, therefore, be used to estimate the likely variations of the Sun near 400 nm and to estimate the possible error introduced by this assumption. The size of this error will be discussed in Section 2.5.

The correction for wavelength-independent degradation to provide a constant irradiance near 400 nm was derived from data to which the goniometric correction and the diffuser correction, but not the secular correction, had been applied. A five-wavelength average was used to reduce noise. For the wavelengths immediately shortward of 400 nm, a number of days, especially in early 1981 and 1982, have no data available. If they were used, a large gap would appear in the correction function. Moving shortward, wavelengths where the data are again more nearly complete are in the Ca II H&K doublet, where the assumption of solar constancy may not be valid. The longest wavelengths shortward of the Ca II doublet are the five wavelength bins centered at 391.3 nm. They are located near a local irradiance maximum, away from major absorption features; intrinsic solar variability should be at a relative minimum. Consequently, the average of these five wavelengths was chosen to represent wavelength-independent change. To derive the final combined PMT plus wavelength-independent instrument change characterization, a 7-day binomial weight running average was applied to the five-wavelength goniometric and diffuser corrected means; the result was then normalized to unity by dividing out by the first 7-day average. Figure 2.2 shows the unnormalized characterization function. To apply this correction, the radiance and irradiance values for each scan at each wavelength are divided by this function. This correction is applied only to the monochromator measurements of solar irradiance and terrestrial radiance; it is not applied to the photometer and reference diode values.

Changes in the PMT gain between ground calibration and the first days of solar flux measurements are also likely to have occurred. Between the time the instrument was turned on and the day of the first solar flux measurements, Earth radiance measurements were taken using the PMT and reference diode. Those using the PMT show a decline; those using the reference diode are nearly constant. If, as appears likely, the relative change over these 6 days is due nearly entirely to a change in the photomultiplier gain, a decrease in gain of 2.7 percent over the period is derived. To obtain absolute solar fluxes, the values on the SUNC tape must be increased by this amount. It is also possible that the PMT gain changed between the time of ground calibration and the time the instrument was first turned on, so that even values with the 2.7 percent correction may be low. This possibility should be kept in mind when comparing the absolute irradiances on the SUNC tape with solar flux measurements from other sources.

Because there is no onboard calibration source, the instrumental changes due to diffuser degradation and to changes in the optical system must be modeled. Diffuser degradation is believed to occur after material deposited on the plate at the early stages of the mission becomes opaque as a result of exposure to sunlight. The following differential equation represents this process:

$$dR/R = -r dE \quad (5)$$

where R is the reflectivity of the diffuser plate, E is the time the diffuser plate has been exposed to sunlight, and r is a proportionality constant that is assumed not to vary with time. This equation has an exponential solution; thus, the diffuser model yields an exponential decay with exposure. The origin of the change of the optics has not been identified; by analogy with the diffuser, the secular term has been represented by an exponential decay with total elapsed time.

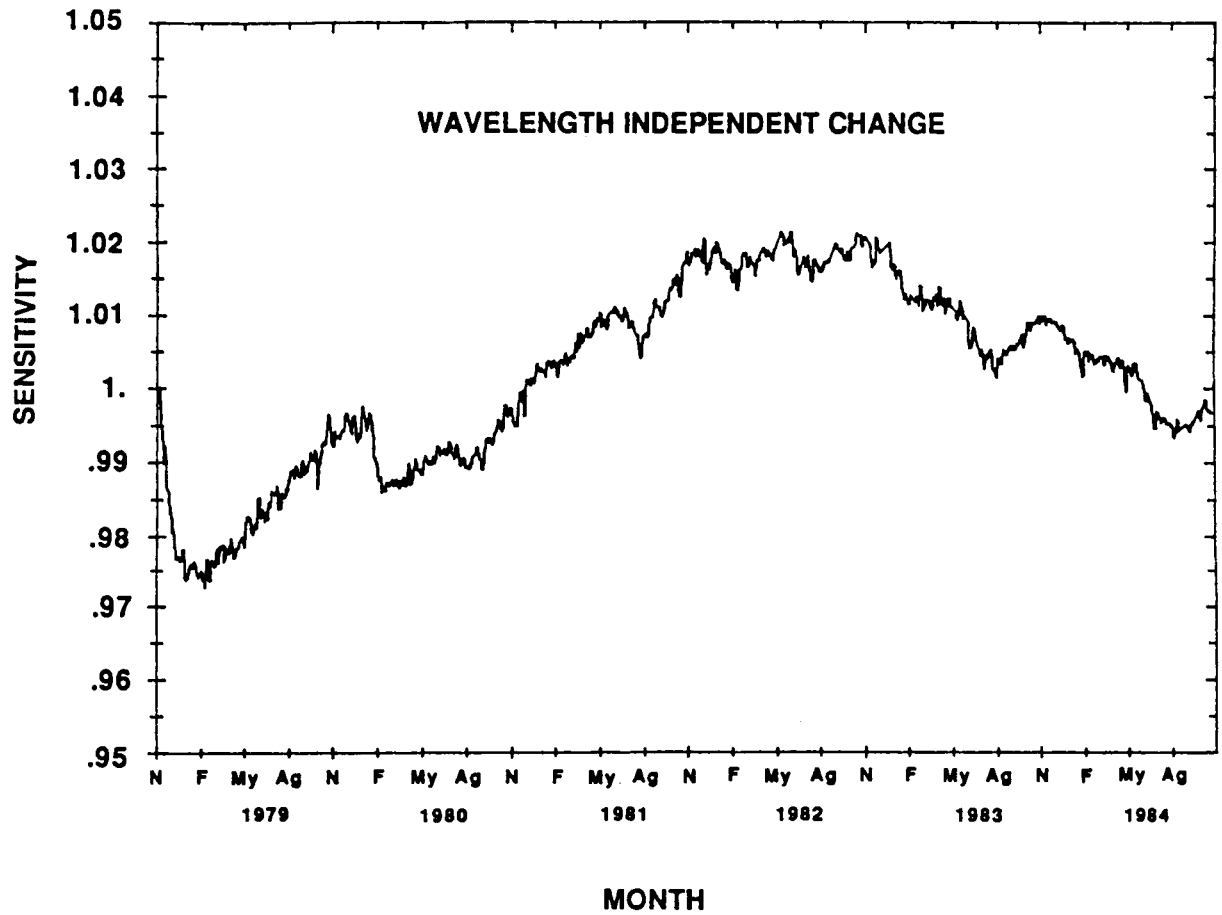


Figure 2.2 Time dependence of wavelength-independent change in instrument sensitivity.

A calculation of the actual diffuser degradation at each wavelength was required for the ozone processing. In the interest of consistency, it was decided to calculate the diffuser degradation for the solar flux processing before dividing out the 400 nm signal, thus producing an actual diffuser degradation at each wavelength, not one relative to 400 nm.

Exposure time and elapsed time are linearly related over much of the lifetime of the experiment. Figure 2.3 shows the relation over the first 6 years. Only when the exposure rate changes between once per day and once per orbit is there a clear distinction. Periods of frequent exposure take up only about 15 percent of the 6-year data period. If the diffuser degradation and secular term were derived from the full 6 years of data, the rate of increase of total exposure would be proportional to time over most of the period, and it would be difficult to distinguish the rate of exposure-dependent decay from the rate of time-dependent decay. Therefore, the rates of decay were derived by considering only the interval of time 14 July 1980-18 September 1981, which contained roughly comparable intervals of high exposure rate and low exposure rate, during which dependence on exposure was distinct from dependence on time.

Changes in the instrumental signal during the period used to derive the decay rates arise not only from instrumental changes but also from actual changes in the solar irradiance. If only instrumental terms were used in modeling the instrument behavior, the solar change would be absorbed into one of the decay rates. The solar change was modeled using the ratio of the average irradiance at three wavelengths near the core of the Mg II 280 nm doublet, 279.8, 280.0, and 280.2 nm, to the average over 276.6, 276.8, 283.2, and 283.4 nm. The denominator wavelengths are equidistant from the line on either side of center and provide an estimate for the continuum at line center. Scaling this ratio has been shown to provide a good estimate for solar variations in the UV at least as far as 200 nm (Heath and Schlesinger, 1986). This model has been used only to derive the diffuser and secular corrections; it has not been applied to the raw data in the SUNC tape production.

The functional form chosen to derive instrument changes is

$$F(t) = F_0 \exp[-rE(t)] \exp(-st) \exp[-\gamma(t)] \quad (6)$$

where  $F(t)$  is the irradiance corrected for PMT changes,  $F_0$  is the measured irradiance at  $t=0$ , when the instrument was turned on immediately after launch,  $E(t)$  is the accumulated diffuser exposure at time  $t$ ,  $r$  and  $s$  measure the rate of diffuser and secular decay, respectively, and  $\gamma(t)$  is the model of actual solar flux changes. Use of the logarithmic form of the equation permitted a linear fit calculation. For mathematical compatibility with the other terms, the actual linear scale of the solar flux change was replaced by an exponential. Because the solar variations are small, the difference between exponential and linear scaling is also small, for example, a modeled change of 6 percent in the linear model would be 6.2 percent in the exponential. The actual fit equation then becomes

$$\log F(t) = \log F_0 - rE(t) - st - \gamma(t). \quad (7)$$

Equation (7) was fit to time series to derive values of  $r$  and  $s$  at 36 separate wavelengths. To derive values of  $r$  and  $s$  at other wavelengths, smoothed splines were fit to the values of  $r$  and  $s$  at 31 of these wavelengths. Wavelengths that are in the core or wings of strong lines were excluded. Figure 2.4 shows the fit to  $r(\lambda)$ . Asterisks represent the actual  $r$  values derived using equation (7) for the fit period; the solid line is the spline. Figure 2.5 is a similar plot for the  $s$  values. Because there is some random error in the calculation of the  $r$  and  $s$  values, the splines were not constrained to go through every point; rather a smoothed fit was used.

The diffuser correction thus derived was applied to all solar irradiance values, but not to the Earth radiance values. The secular correction for changes in instrument sensitivity relative to 391.3 nm was applied to both radiance and irradiance values.

## 2.5 Model Uncertainties

In spite of exhaustive investigations into the instrument behavior (Cebula *et al.*, 1987), it has not been possible to model the changes with time perfectly, for reasons that have been discussed earlier in Section 2. Consequently, some of the changes with time seen in the data may not represent changes with time in the solar irradiance or Earth radiance but may arise from instrument properties that have not been fully represented by the model.

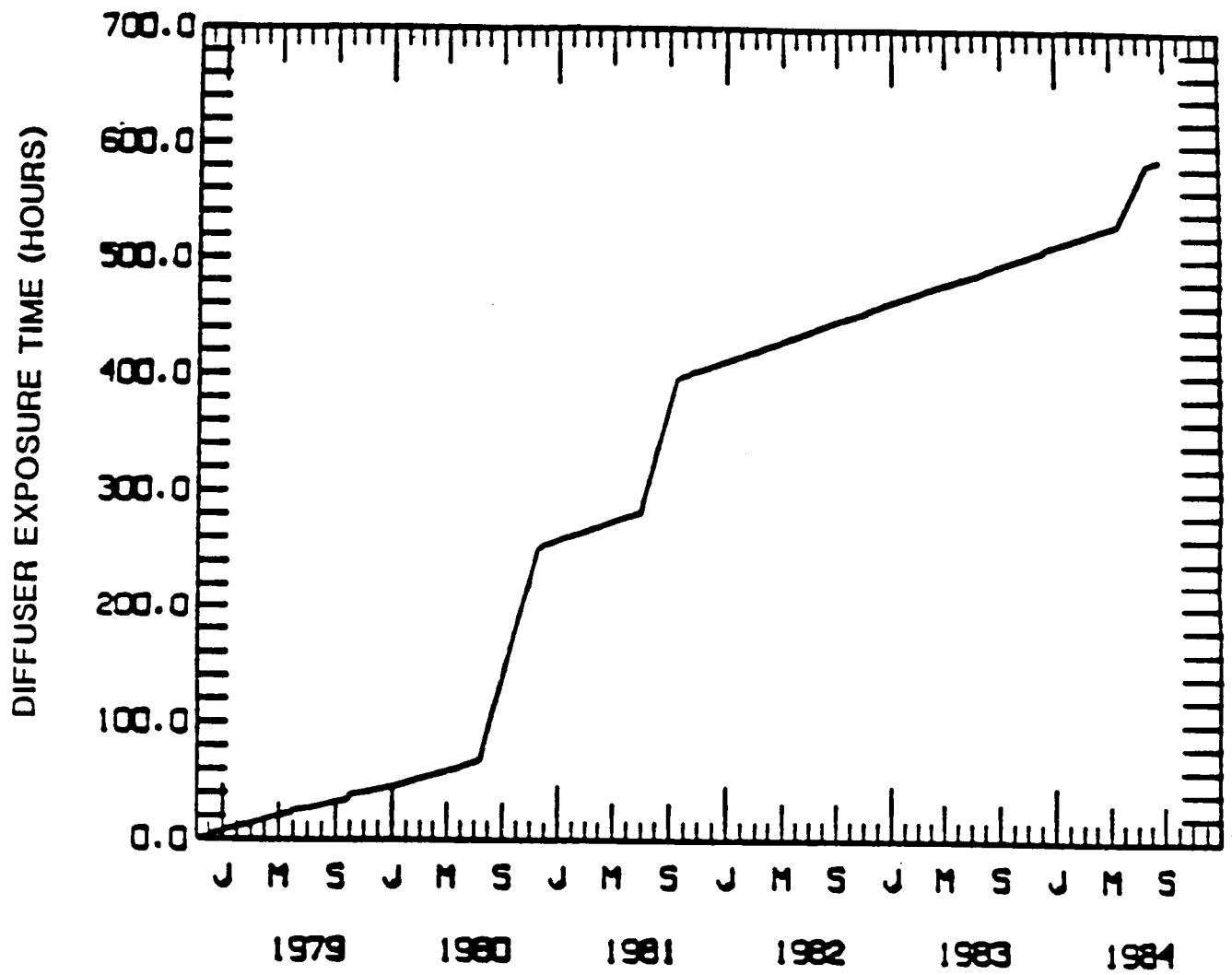


Figure 2.3 Accumulation of diffuser exposure time as a function of clock time.



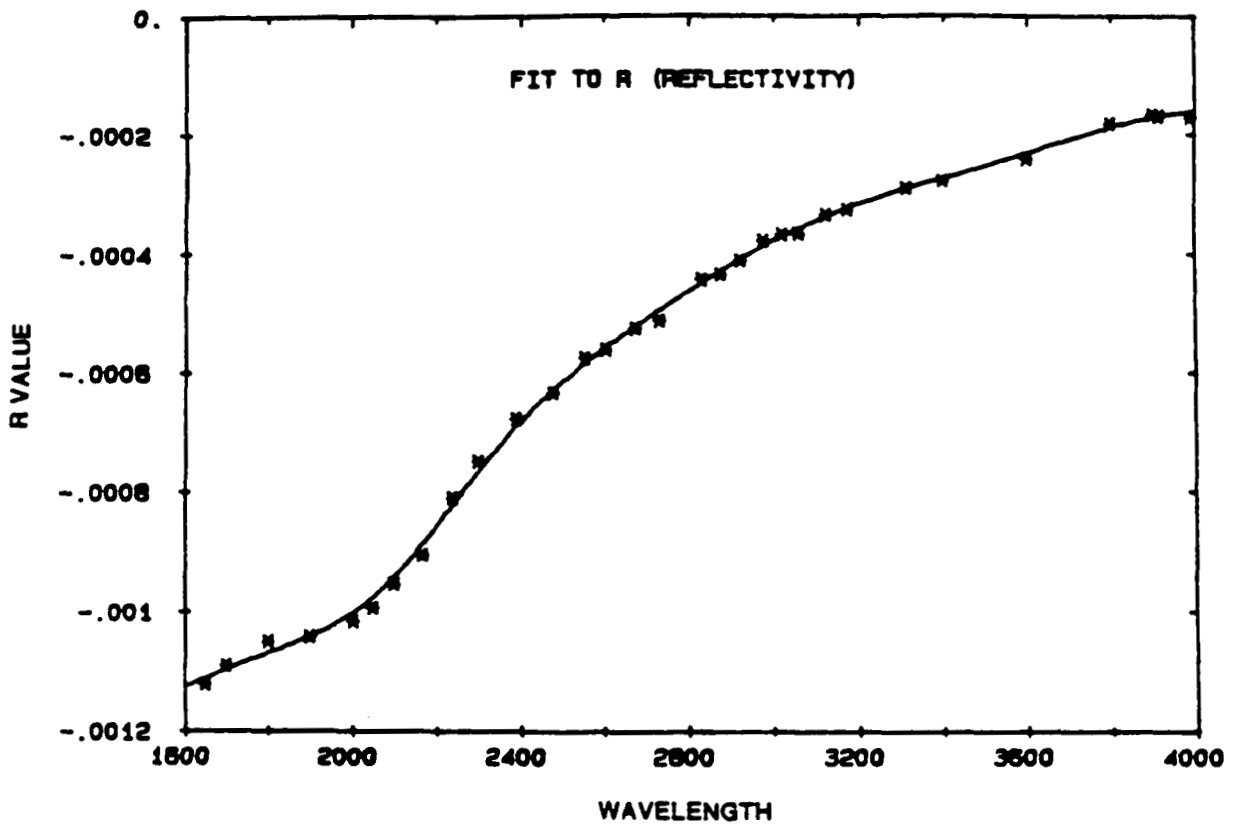


Figure 2.4 Fit to reflectivity parameter as function of wavelength.

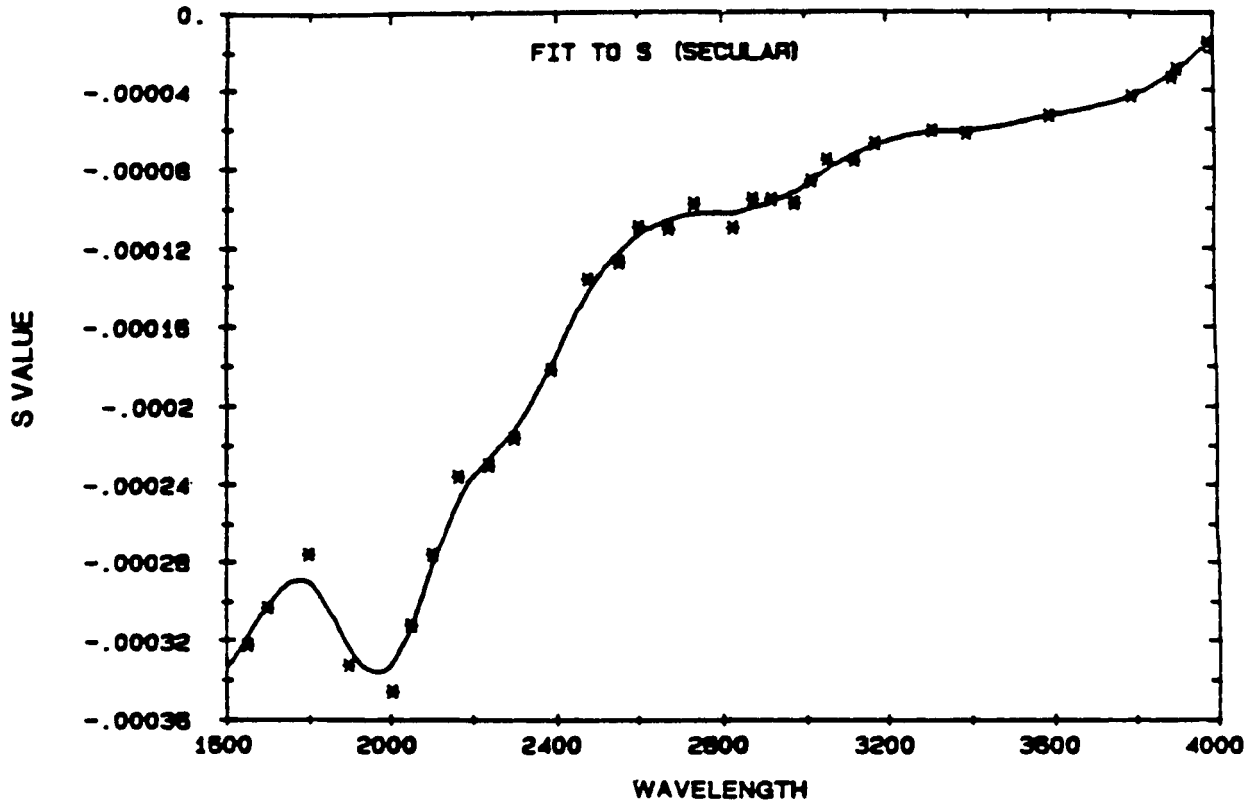


Figure 2.5 Fit to secular change parameter as function of wavelength.

The model makes several assumptions in deriving the changes with time of the instrument sensitivity:

- That the diffuser degrades only when exposed to the Sun and therefore the diffuser degradation can be modeled by an exponential decay with exposure
- That the wavelength-dependent change with time (s-term) can be modeled by an exponential decay with time in the measured irradiances, using an s-factor that is constant with time
- That the Sun does not vary at 391 nm
- That the goniometric function (Section 2.2) does not change with time

Failure to derive the correct r or s value and departures of the degradation from the model dependence on exposure and time will lead to long-term drifts in the SUNC tape solar flux relative to the actual solar flux.

How well the derived r and s values model the instrument output for the fitting period can be obtained from the formal errors of the fit. This formal statistical error also shows the size of the uncertainty that might be introduced by variations in r and s over the 14-month period used to derive them. An additional error might be introduced if the value of r and s that described instrument changes at a particular time varied over the long term. During the sixth year, there was a period of approximately 2 months during which for 2 out of every 4 days, the diffuser was exposed once an orbit rather than once a day, permitting derivation of r and s values independent of each other and of those derived from the 1980-1981 fit period. The sixth year's r and s values can be compared with those for the earlier fit period to determine if changes have occurred. In the case of the diffuser reflectivity parameter r, there is an independent method for estimating changes. On a small number of selected days, step scan Earth radiance has been measured with the diffuser plate deployed. Comparing these measurements with those made on surrounding days when the diffuser was not deployed provides a measure of diffuser attenuation. These studies give an upper limit to the change in r between the two fit periods. The derived upper limits are smaller than the difference in r from the separate fits. Longward of 210 nm, this upper limit corresponds to an uncertainty of approximately 3 percent over the 6 years in the signal change due to diffuser degradation.

Evaluation of the likelihood of a change in s can be made if the solar and instrument effects on the archived data set can be estimated. If changes predicted by the Mg 280 nm-based solar model are removed from the 6-year change in solar irradiance, the residual change will consist only of components due to differences between the solar and instrumental model and the actual behavior of the Sun and the instrument. The effect of the possible change in s can be estimated in the following way. Let  $s_0$  be the value of s derived from the fit for the 1980-1981 period, the value used to produce the data on the SUNC and EARTH tapes. Let  $s_1$  be the value of s derived from the period of increased diffuser deployment in the sixth year. Assume that  $s=s_0$  from launch until the middle of the 1980-1981 fit period, varies linearly from  $s_0$  to  $s_1$  until the middle of the sixth year fit period, and that  $s=s_1$  from then on. The difference between the values derived using this varying s and the value on the archived tape can then be compared with the changes with time on the archival tape.

Figure 2.6 shows the comparison. The solid squares represent the ratios of the residual irradiance at the end of the sixth year -- the irradiance from which the model solar and instrumental changes have been removed -- to that soon after the start of measurements. They are plotted at the wavelengths for which values of s were calculated by fitting. The open squares show the ratio of irradiance produced using the time dependence for s described above to that derived using constant s. The triangles show the magnitude of the change due only to  $2\sigma$  statistical errors in the fit to d and s for the first fit period.

The figure shows clearly that the departure of the irradiances on the tape from the constant s values is significantly larger than the formal statistical errors. In the region from 200 nm to 300 nm this departure is comparable in both magnitude and wavelength dependence with that predicted to result from a change in s. Figure 2.7 shows the time dependence of residual irradiance from the model of the average of five wavelength positions centered at 232.4 nm. Note that the irradiance is relatively unchanged for the early years, but begins to decline in the later years, exactly the pattern that would be expected if the value of s required to model the optics was changing with time. Because data are available for only two fit periods, these results do not prove that the appropriate value of s changed. They do show that it is likely that the  $\exp(-st)$  model with constant s does not precisely represent the effect of changes in the instrument values on measured irradiance.

## CHANGE IN FLUX 1978-1984

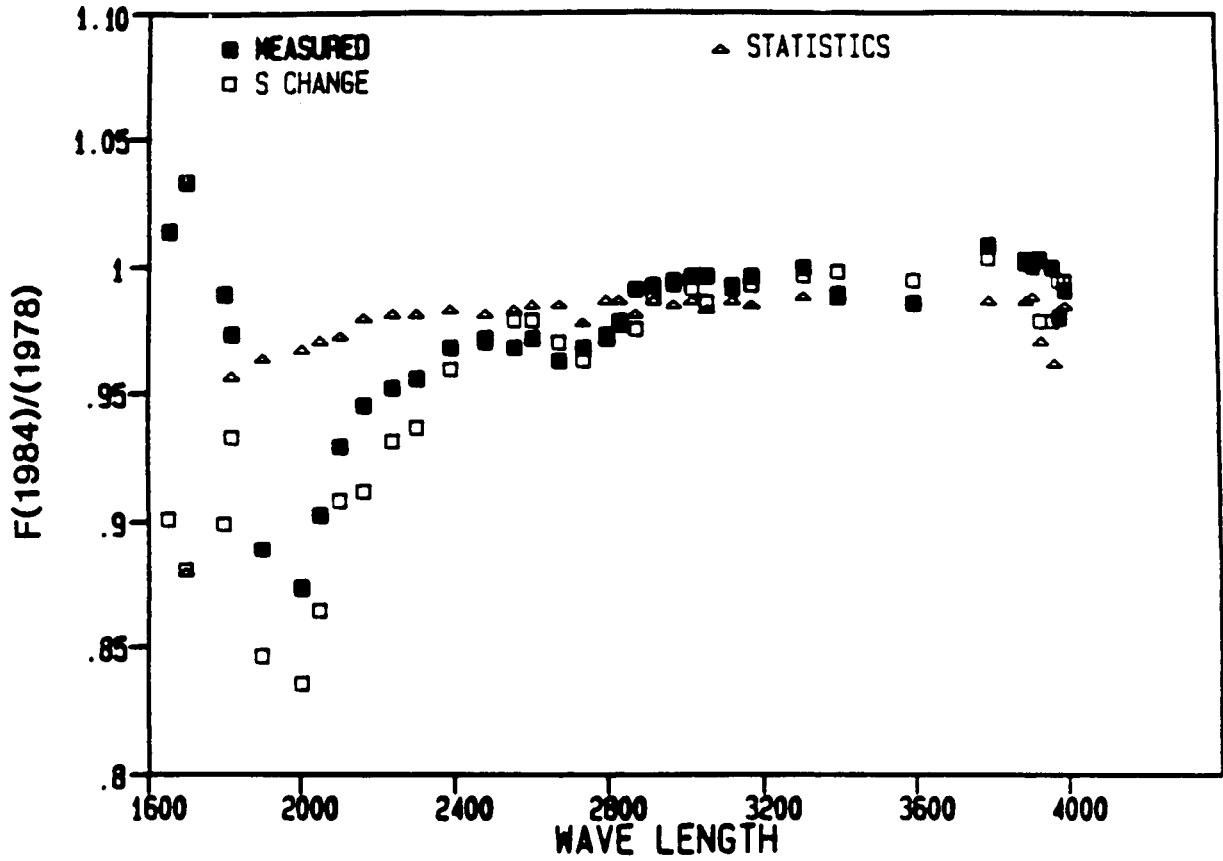


Figure 2.6 Change in irradiance not predicted by solar model. *Solid squares* - measured ratio of irradiance (solar change removed) in 1984 to that in 1978; *open squares* - calculated effect of change in s; *triangles* - statistical uncertainty of instrument characterization.

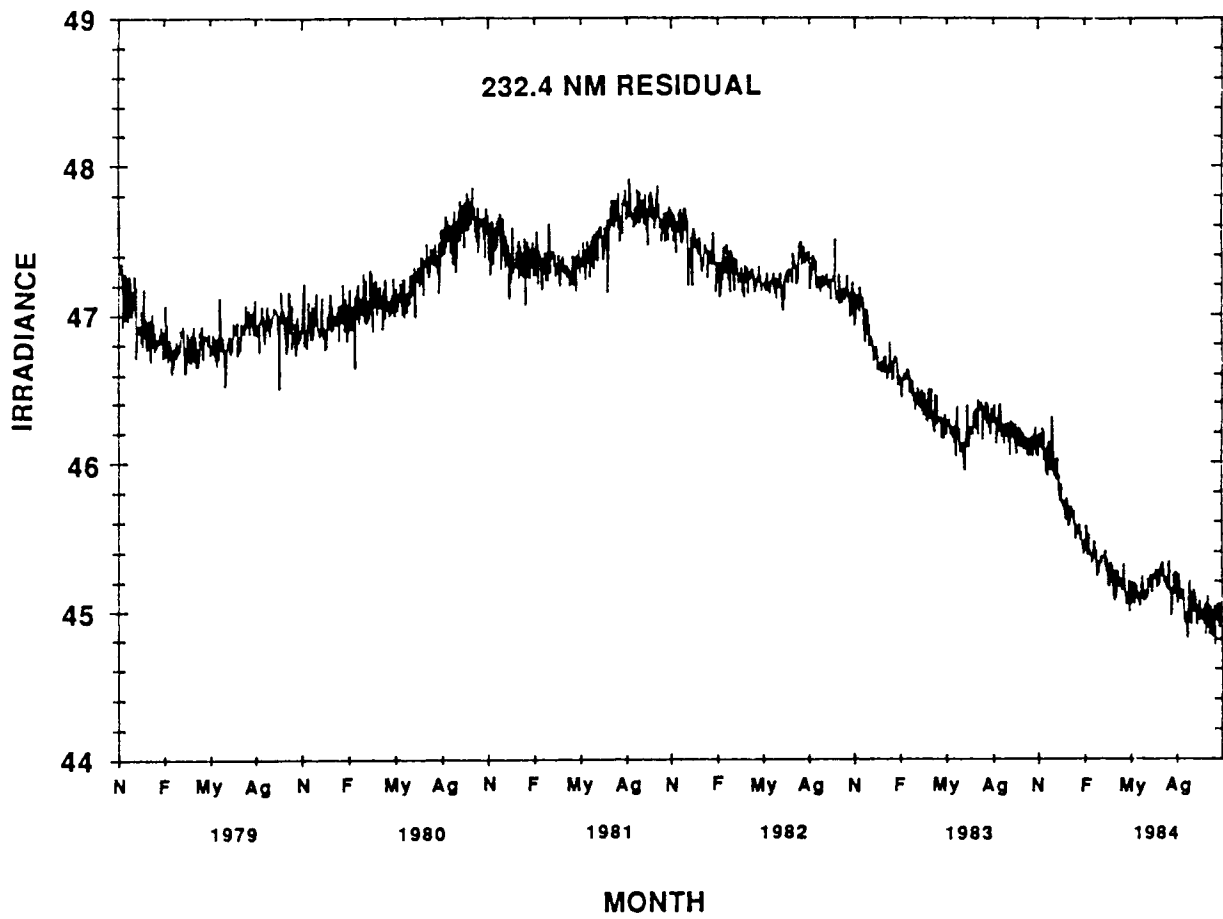


Figure 2.7 Time dependence of 232.4 nm irradiance with modeled solar variations removed.

At wavelengths short of 200 nm, a change in  $s$  value with time does not explain the changes in the residual over 6 years. The  $s$  changes predict a decline, while the residual rises. An examination of Figure 2.5 suggests a possible explanation. Short of 200 nm, the dependence of  $s$  on wavelength becomes complicated and the fit is poor. The actual instrument behavior is far more complex than that produced by the model. Users should, therefore, be particularly careful in applying the SUNC data to investigate temporal changes in the solar flux short of 200 nm; the instrument behavior has not been well accounted for. Short of 170 nm, the signal is very weak and extremely noisy.

As discussed in Section 2.4, values of  $r$  and  $s$  were derived only at a discrete set of wavelengths; values for other wavelengths were obtained by fitting a spline. Figures 2.4 and 2.5 show that, especially in the case of  $s$ , the individual wavelength points do not lie along a smooth line. This irregularity has been assumed to be random scatter, but it is possible, particularly in the case of  $s$ , that real structure may be present in the wavelength dependence. In such a case, the  $r$  and  $s$  values used in the data production would differ from those actually applicable. For wavelengths longer than 200 nm, the difference between the 6-year change derived using the spline fit values is typically on the order of half a percent, and is as large as 1 percent at some wavelengths. Moreover, if the structure is real, the uncertainty due to this source could be even larger in regions of the spectrum where the density of wavelengths used to derive  $r$  and  $s$  values is low.

Changes in the gain of the PMT and other wavelength independent changes were treated by assuming that the irradiance was constant near 400 nm. If the solar irradiance near 400 nm changes with time, an error in the irradiance will be introduced. A rough estimate of this error can be made based on measurements of the solar constant. Measurements reported by Willson (1982) using the Active Cavity Radiometer Irradiance Monitor (ACRIM), on the Solar Maximum Mission (SMM), show a possible change of 0.1 percent from early 1980 to mid 1984. Variations over shorter time scales, on the order of a week, may be as large as 0.3 percent. A simple black body approximation predicts that the changes near 400 nm should be approximately 1.5 times those in the integrated solar flux, if the changes are due to a change in temperature of the regions observed. The expected error due to assuming flux constancy near 400 nm would then be 0.2 percent over the 6-year period, or 0.03 percent per year, and 0.5 percent in short-term variations.

As noted in Section 2.1, the change with time in the wavelength corresponding to each grating position can produce spurious changes in those parts of the spectrum at the longer wavelengths where the irradiance changes rapidly with wavelength. In the vicinity of strong lines such as Ca II H and K, the magnitude of the effect may be as large as 0.3 percent per year; elsewhere, it is on the order of 0.1 percent per year.

Figure 2.8 shows the ratio of the average spectrum over the 5 days near the end of the 6 years to that for 5 days near the beginning, taken from the data on the tape. In addition to the actual changes in the solar flux, the effects of the uncertainties discussed in this section can be seen. At 170 nm, the scatter increases with decreasing wavelength. The wavelength dependence from 170 nm to 200 nm arises from the uncertainty in the optics characterization. The decrease from 300 nm to 200 nm probably includes a solar component but also shows the effect of the likely change in  $s$ . The dip at 350 nm occurs in a region between two widely spaced wavelength points used to determine  $s$  and illustrates the possible magnitude of the fitting errors. The structure around the strong Mg II 280 nm doublet, Mg I 285.3 nm, Ca II H and K lines, similar to Figure 2.1, illustrates the magnitude of the effect of wavelength drift. Any studies making use of the continuous scan tapes should make allowance or correction for these instrumental uncertainties.

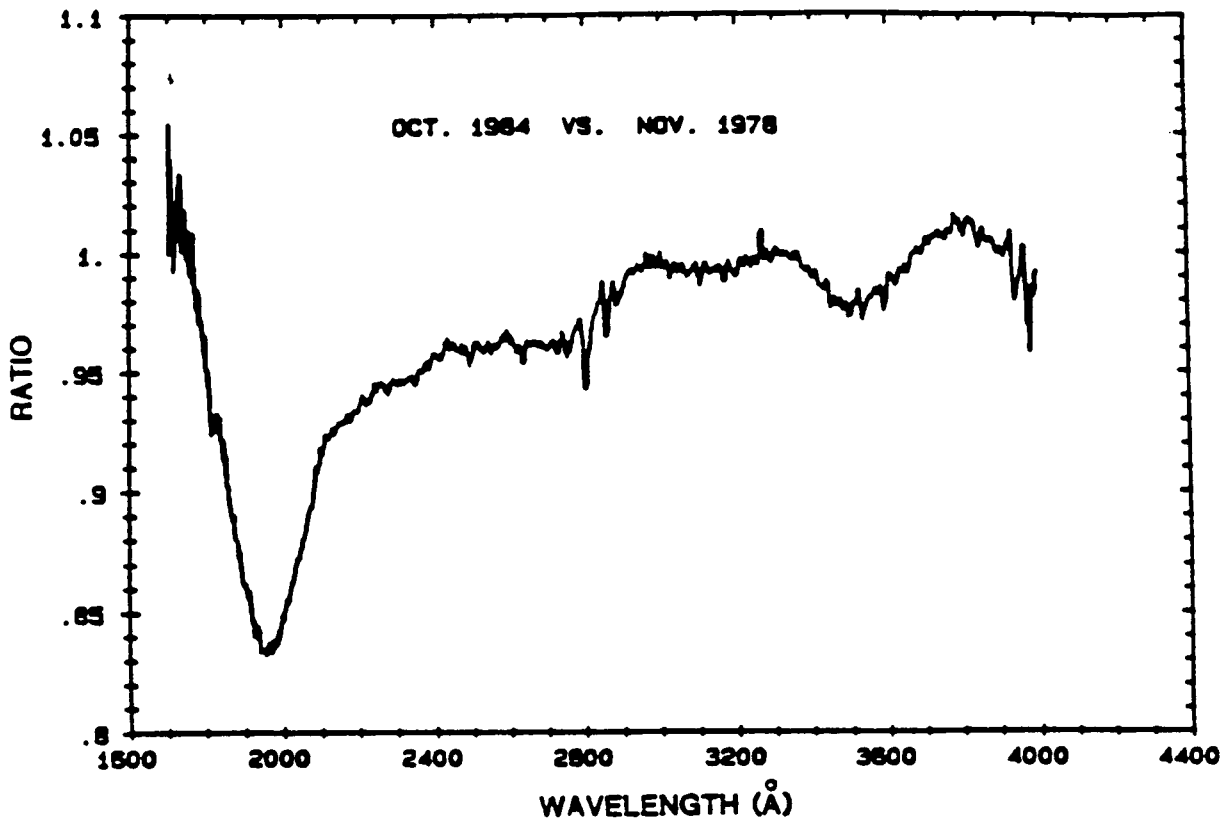


Figure 2.8 Ratio of irradiance at end of sixth year to that at start of first.

## QUALITY CONTROL

### 3.1 Instrument Configuration

Valid results for the irradiance or radiance are produced only under appropriate instrument configurations. Whether or not conditions for valid results exist can be determined from information on the RUT tapes. If conditions are not appropriate, the values from the input unitized tapes are not transferred to the continuous scan tapes but are replaced with fill values.

Instrument conditions can be obtained from words 4 and 5 of the input tape, in the form of a series of data flags. Those conditions relevant to continuous scan production are summarized in Table 3.1; a detailed description of how they appear on the RUT tapes appears in Fleig *et al.* (1983). The flag values required correspond to the following instrument configuration:

- SBUV power enable and high voltage on (the instrument power is available for operation).
- The instrument is not in electronic or wavelength calibration mode.
- The diffuser is at SBUV (for irradiance) or stowed (for Earth radiance), not moving.
- The cam and chopper positions are synchronized for proper wavelength identification.

If the above conditions are not satisfied, a fill value of -8888. is written instead of the radiance or irradiance. In addition, if the data mode (available in word 8 of the input tape record) differs from that of the first frame of the scan, the frame is rejected and fill values of -8888. are written to the output tape.

If a frame is missing, fill values of -7777. are written to the output tape to distinguish missing values from those rejected because of instrument conditions.

Finally, the word containing the actual counts is checked. If the gain range code is other than 1, 2, or 3, or the exponential is other than 7, the -8888. fill value is written to the output tape.

Table 3.1

Conditions Marked by Data Flags

<u>Indicator Designation</u>	<u>Condition Monitored</u>
X0	Source of attitude data
X2	Diffuser moving
X3	SBUV High voltage (on/off)
X4	SBUV power enabled
X5	Mercury lamp for wavelength calibration (on/off)
X6	Electronic calibration (on/off)
X7	Diffuser at SBUV position
X8	Cam synchronized
X9	Chopper synchronized
X10	Diffuser stowed

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## 3.2 Angular Limits

Acceptable data can be obtained only for certain times of day and orientations of the instrument relative to the Sun and Earth. Only during the day can valid irradiances and radiances be measured. The division between day and night measurements has been set to be a zenith angle of 95 degrees. If the zenith angle is larger, a fill value of -8888. is written. Data with negative solar zenith angles, which may appear if the zenith angle has a fill value on the input tape, are also rejected.

The goniometric calibration of the scattering properties of the diffuser plate was limited in its angular extent. If the angle of solar incidence is outside this range, valid calibrated solar flux values cannot be obtained. In addition, for some positions of the Sun, the diffuser plate is shadowed, again leading to unreliable values. Only a limited range of diffuser coordinate elevation and azimuth angles will correspond to a configuration for which a calibration is available. The software producing the continuous scan tape will accept data only if the azimuth angle is in the range from -8 degrees to +10 degrees and the elevation angle is in the range of -3 degrees to +18 degrees. Otherwise, a fill value of -8888. is written.

## 3.3 Screening

Even for the proper instrument configuration, problems with the instrument or data transmission may lead to the presence of invalid values. A screening procedure has been devised for solar irradiance to make certain that these values are not present for individual scans and do not contribute to averages. The mean irradiance for the Bartels period, and its standard deviation, is calculated at each of the 1200 monochromator wavelengths, for all photometer measurements, and for each of the 96 reference diode measurements in a set. Every scan is weighted equally in the averaging. The results are then used to determine screening criteria for the next Bartels period. Screening limits are set to be five standard deviations above and below the mean for the previous Bartels period; however, neither limit may differ from the mean by more than a factor of 30. If a monochromator, photometer, or reference diode value is outside the appropriate screening limits, a fill value of -9999. is written to the continuous scan tape.

Screening values for the first Bartels period with SBUV measurements were determined by running the tape production software for that period without screening and then using the resulting values to screen a second run of the same period. The screening values derived from the first run and the results from the second were carefully examined to verify that this procedure actually screened out unacceptable irradiance values while passing valid ones. For later periods, screening values must be based upon at least five scans for a Bartels period. If there are fewer than five scans at a particular wavelength for a particular Bartels period, then the screening values for that particular wavelength are set to be those for the previous Bartels period.

There are a few periods during which the actual solar irradiance at selected wavelengths, in particular the Mg h and k line center and short of 190 nm, changes from one Bartels period to the next by five or more times the standard deviation of the irradiances in the earlier Bartels period. In such cases, valid data values will be rejected by the screening process. The effect appears at a significant number of wavelengths on fewer than 10 days, but the user should be aware of its presence. Relaxing the screening to the degree necessary for acceptance of these points would also have resulted in the acceptance of clearly improper values.

Because of a problem with the instrument, derived Earth radiance values sometimes go to zero for some measurements near the equator. The signal at longer wavelengths should be strong there. To eliminate such incorrect values, Earth radiance values taken at zenith angles less than 30 degrees for wavelengths longer than 300 nm must be greater than 0.001; if the value is lower, a fill value of -9999. is written to the tape instead.

## 3.4 Off-Days and the Quasi-Daily Average

Throughout much of the experiment lifetime, limitations on the power available to the satellite have forced the experiment to be run on a 3-day on, 1-day off mode. However, during a 2-year period from 1980 to 1982, continuous scan solar flux readings appeared on the fourth day even though the instrument was off. Examination of the values showed them to be invalid because of insufficient instrument warm-up time. A list of such days was compiled, and data from them were systematically eliminated when the continuous scan tapes were being produced. In order to provide a more nearly complete data set, an average was computed for those same fourth off days using data for orbits starting after 2050 GMT

on the previous day. This average, based on data late in the previous day and assigned to the off day, is called the quasi-daily average. It is computed only for those off days for which the instrument was turned on but data were later found to be invalid. Even then, no average is computed unless there are data from orbits beginning after 2050 GMT on the previous day. It is not computed if the off day would be the first day of a Bartels period. Nor is it computed for off days that are not in the every fourth day schedule.

## DATA COVERAGE

### 4.1 Continuous Scan Solar Flux (SUNC)

Continuous scan solar flux measurements were normally made once a day, at the northern terminator of one orbit. Each measurement consisted of three scans. During the early years of the satellite lifetime, SBUV was scheduled for 3 days on, 1 day off, because of overall limitations on satellite power. This schedule was not firmly established until spring 1979. By the summer of 1983, the failure of other experiments on board the satellite had reduced the power demands, and the practice of turning off SBUV every fourth day was discontinued. In addition to the days when SBUV was not operating, there were other days when no continuous scan solar flux measurements were available. Table 4.1 contains a complete list of days on which continuous scan solar flux measurements were not made.

### 4.2 Continuous Scan Earth Radiance (EARTH)

Under normal operation, Earth radiance was measured in continuous scan mode every 24 days, for the entire day. These measurements were made instead of the step scan Earth radiance measurements for ozone determination. This schedule did not take full effect until mid-1979. Consequently, there are other days on which the instrument was used to make continuous scan Earth radiance measurements. Also, when a day was scheduled to be dedicated to continuous scan Earth radiance measurement, operation in continuous scan mode may not have begun or ended precisely at midnight GMT. In such a case, there will be some measurements on the day before or after the day assigned for continuous scan Earth radiance measurements. Table 4.2 contains a list of all days on which some continuous scan Earth radiance measurements were made. Table 4.3 lists the days on which there were at least 200 scans, about half the number possible, in continuous scan Earth radiance mode. This list can be used to identify the days on which the principal mode of operation was continuous scan Earth radiance measurement.

The daily average solar flux for the day on which the continuous scan Earth radiance measurements were made normally followed the continuous scan Earth radiance for that day. However, if solar flux was incomplete or unavailable for that day, with fill values at 16 or more wavelengths, then the solar flux for a neighboring day was written to the tape. Also, because the day assigned to an orbit was the day on which the first scan of an orbit began, if continuous scan Earth radiance measurements began before midnight GMT, data for all orbits beginning before midnight would be assigned to the previous day and followed by a separate daily average solar flux record. The remainder of the scans for the scheduled continuous scan Earth radiance day and the corresponding solar flux record would follow.

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Table 4.1

Days Without Continuous Scan Solar Flux

YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY
1978	315	1978	319	1978	320	1978	321	1978	322	1978	325
1978	334	1978	337	1978	344	1978	345	1978	349	1978	357
1979	004	1979	008	1979	011	1979	016	1979	017	1979	020
1979	032	1979	037	1979	040	1979	044	1979	049	1979	052
1979	064	1979	068	1979	070	1979	075	1979	076	1979	080
1979	095	1979	102	1979	104	1979	105	1979	112	1979	114
1979	116	1979	120	1979	124	1979	125	1979	128	1979	132
1979	143	1979	144	1979	148	1979	149	1979	152	1979	156
1979	160	1979	164	1979	168	1979	171	1979	172	1979	176
1979	180	1979	181	1979	184	1979	187	1979	188	1979	192
1979	199	1979	200	1979	204	1979	205	1979	208	1979	212
1979	219	1979	220	1979	224	1979	228	1979	232	1979	233
1979	240	1979	244	1979	247	1979	248	1979	249	1979	252
1979	254	1979	256	1979	257	1979	260	1979	264	1979	268
1979	275	1979	276	1979	280	1979	282	1979	284	1979	288
1979	293	1979	294	1979	296	1979	300	1979	304	1979	307
1979	311	1979	312	1979	314	1979	316	1979	319	1979	320
1979	324	1979	328	1979	332	1979	336	1979	337	1979	341
1979	348	1979	352	1979	354	1979	356	1979	360	1979	361
1980	002	1980	003	1980	005	1980	007	1980	008	1980	011
1980	015	1980	019	1980	023	1980	027	1980	031	1980	035
1980	043	1980	047	1980	051	1980	054	1980	055	1980	056
1980	063	1980	067	1980	071	1980	073	1980	075	1980	079
1980	087	1980	091	1980	097	1980	099	1980	103	1980	107
1980	114	1980	115	1980	119	1980	123	1980	127	1980	131
1980	133	1980	135	1980	138	1980	139	1980	147	1980	151
1980	159	1980	163	1980	167	1980	171	1980	179	1980	183
1980	188	1980	191	1980	195	1980	199	1980	307	1980	327
1980	335	1980	339	1980	342	1980	343	1980	347	1980	351
1980	359	1980	363	1981	005	1981	009	1981	013	1981	017
1981	024	1981	025	1981	029	1981	033	1981	036	1981	037
1981	042	1981	044	1981	045	1981	049	1981	053	1981	057
1981	065	1981	067	1981	069	1981	073	1981	075	1981	076
1981	081	1981	082	1981	085	1981	089	1981	090	1981	093
1981	101	1981	105	1981	109	1981	113	1981	117	1981	121
1981	129	1981	133	1981	137	1981	145	1981	149	1981	153
1981	161	1981	165	1981	169	1981	173	1981	181	1981	265
1981	273	1981	277	1981	281	1981	285	1981	289	1981	293
1981	301	1981	305	1981	309	1981	313	1981	317	1981	321
1981	329	1981	333	1981	335	1981	337	1981	341	1981	345
1981	353	1981	357	1981	361	1981	363	1981	365	1982	004
1982	009	1982	012	1982	016	1982	020	1982	024	1982	026
1982	032	1982	036	1982	040	1982	044	1982	048	1982	052
1982	056	1982	060	1982	061	1982	064	1982	068	1982	070
1982	076	1982	077	1982	080	1982	082	1982	084	1982	088
1982	096	1982	098	1982	100	1982	101	1982	104	1982	108
1982	112	1982	116	1982	120	1982	122	1982	124	1982	126
1982	130	1982	132	1982	136	1982	138	1982	140	1982	144
1982	148	1982	152	1982	156	1982	160	1982	164	1982	168
1982	172	1982	174	1982	176	1982	178	1982	180	1982	184
1982	188	1982	192	1982	200	1982	204	1982	206	1982	208
1982	214	1982	216	1982	220	1982	224	1982	228	1982	230
1982	234	1982	236	1982	238	1982	240	1982	241	1982	244
1982	250	1982	252	1982	254	1982	256	1982	260	1982	262
1982	268	1982	270	1982	272	1982	276	1982	278	1982	280
1982	284	1982	288	1982	290	1982	292	1982	294	1982	296
1982	304	1982	306	1982	308	1982	309	1982	311	1982	312
1982	316	1982	318	1982	320	1982	324	1982	328	1982	332
1982	338	1982	340	1982	342	1982	344	1982	346	1982	348
1982	352	1982	354	1982	356	1982	360	1982	364	1983	003
1983	009	1983	011	1983	013	1983	019	1983	020	1983	023
1983	027	1983	028	1983	031	1983	032	1983	035	1983	037
1983	041	1983	043	1983	044	1983	047	1983	051	1983	053
1983	059	1983	063	1983	064	1983	067	1983	069	1983	071
1983	077	1983	079	1983	083	1983	085	1983	087	1983	091
1983	098	1983	099	1983	103	1983	107	1983	108	1983	111
1983	119	1983	121	1983	123	1983	125	1983	127	1983	129
1983	135	1983	139	1983	143	1983	147	1983	149	1983	151
1983	153	1983	155	1983	159	1983	160	1983	163	1983	165
1983	171	1983	172	1983	173	1983	175	1983	177	1983	179
1983	183	1983	187	1983	188	1983	191	1983	193	1983	195
1983	203	1983	207	1983	211	1983	215	1983	217	1983	219
1983	227	1983	229	1983	231	1983	233	1983	235	1983	239
1983	251	1983	262	1983	267	1983	272	1983	273	1983	279
1983	290	1983	292	1983	295	1983	299	1983	301	1983	307
1983	318	1983	324	1983	329	1983	332	1983	334	1983	340
1983	347	1983	352	1983	358	1983	363	1984	004	1984	010
1984	017	1984	018	1984	021	1984	027	1984	029	1984	032
1984	041	1984	044	1984	047	1984	049	1984	055	1984	061
1984	066	1984	072	1984	077	1984	083	1984	089	1984	094
1984	106	1984	111	1984	114	1984	117	1984	123	1984	123
1984	134	1984	140	1984	145	1984	152	1984	157	1984	168
1984	181	1984	185	1984	196	1984	204	1984	206	1984	207
1984	219	1984	225	1984	228	1984	230	1984	232	1984	234
1984	238	1984	240	1984	242	1984	247	1984	248	1984	253
1984	263	1984	264	1984	270	1984	275	1984	281	1984	282
1984	293	1984	297	1984	298	1984	300	1984	302		

Table 4.2

## Continuous Scan Earth Radiance Days

YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY
1978	316	1979	323	1979	022	1979	046	1979	047	1979	114
1979	137	1979	153	1979	154	1979	155	1979	157	1979	158
1979	161	1979	162	1979	163	1979	165	1979	166	1979	167
1979	171	1979	172	1979	173	1979	174	1979	175	1979	177
1979	179	1979	181	1979	182	1979	183	1979	185	1979	186
1979	189	1979	190	1979	191	1979	193	1979	195	1979	196
1979	198	1979	199	1979	200	1979	201	1979	202	1979	203
1979	205	1979	206	1979	207	1979	209	1979	210	1979	211
1979	213	1979	215	1979	217	1979	218	1979	219	1979	221
1979	223	1979	225	1979	227	1979	229	1979	230	1979	231
1979	235	1979	237	1979	239	1979	241	1979	242	1979	243
1979	246	1979	247	1979	253	1979	254	1979	263	1979	265
1979	278	1979	279	1979	281	1979	282	1979	283	1979	285
1979	287	1979	289	1979	290	1979	291	1979	293	1979	295
1979	298	1979	299	1979	300	1979	302	1979	303	1979	305
1979	309	1979	310	1979	311	1979	313	1979	314	1979	315
1979	317	1979	318	1979	319	1979	321	1979	322	1979	323
1979	326	1979	327	1979	329	1979	330	1979	331	1979	333
1979	335	1979	337	1979	338	1979	339	1979	340	1979	341
1979	343	1979	345	1979	346	1979	347	1979	349	1979	350
1979	352	1979	353	1979	354	1979	355	1979	357	1979	358
1979	361	1979	362	1979	363	1980	365	1980	001	1980	004
1980	006	1980	008	1980	009	1980	010	1980	012	1980	013
1980	016	1980	017	1980	018	1980	019	1980	020	1980	021
1980	024	1980	025	1980	026	1980	028	1980	029	1980	030
1980	034	1980	036	1980	037	1980	038	1980	040	1980	041
1980	044	1980	045	1980	046	1980	048	1980	049	1980	050
1980	053	1980	054	1980	056	1980	057	1980	058	1980	060
1980	062	1980	064	1980	065	1980	066	1980	068	1980	069
1980	072	1980	073	1980	074	1980	076	1980	077	1980	078
1980	081	1980	082	1980	084	1980	085	1980	086	1980	088
1980	090	1980	093	1980	094	1980	095	1980	096	1980	097
1980	100	1980	101	1980	102	1980	104	1980	105	1980	106
1980	109	1980	110	1980	112	1980	113	1980	114	1980	116
1980	118	1980	120	1980	121	1980	122	1980	124	1980	125
1980	127	1980	128	1980	129	1980	130	1980	132	1980	133
1980	136	1980	137	1980	138	1980	140	1980	141	1980	142
1980	144	1980	145	1980	146	1980	148	1980	149	1980	150
1980	153	1980	154	1980	155	1980	156	1980	157	1980	158
1980	161	1980	162	1980	164	1980	165	1980	166	1980	168
1980	170	1980	172	1980	173	1980	174	1980	175	1980	176
1980	178	1980	180	1980	181	1980	182	1980	184	1980	185
1980	189	1980	190	1980	192	1980	193	1980	194	1980	196
1980	212	1980	213	1980	224	1980	236	1980	260	1980	261
1980	309	1981	332	1981	014	1981	015	1981	038	1981	039
1981	062	1981	063	1981	086	1981	087	1981	110	1981	111
1981	135	1981	139	1981	158	1981	159	1981	182	1981	183
1981	230	1981	231	1981	254	1981	255	1981	278	1981	279
1981	303	1981	326	1981	327	1981	338	1982	350	1982	009
1982	033	1982	034	1982	057	1982	058	1982	080	1982	081
1982	105	1982	122	1982	129	1982	130	1982	153	1982	154
1982	177	1982	178	1982	201	1982	202	1982	225	1982	226
1982	250	1982	273	1982	274	1982	275	1982	293	1982	294
1982	296	1982	297	1982	298	1982	299	1982	300	1982	302
1982	307	1982	308	1982	315	1982	321	1982	322	1982	329
1982	344	1982	345	1983	357	1983	004	1983	028	1983	029
1983	050	1983	051	1983	052	1983	076	1983	077	1983	100
1983	140	1983	148	1983	149	1983	160	1983	172	1983	173
1983	196	1983	220	1983	221	1983	244	1983	245	1983	268
1983	292	1983	299	1983	316	1983	340	1983	341	1983	364
1984	017	1984	023	1984	047	1984	071	1984	072	1984	090
1984	092	1984	093	1984	094	1984	095	1984	096	1984	097
1984	100	1984	101	1984	102	1984	103	1984	104	1984	119
1984	167	1984	168	1984	179	1984	191	1984	192	1984	193
1984	216	1984	239	1984	263	1984	287				

Table 4.3

Continuous Scan Earth Radiance Days  
(Half Coverage or Greater)

YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY	YEAR	DAY		
1979	046	1979	136	1979	171	1979	205	1979	229	1979	253	1979	265
1979	289	1979	313	1979	318	1979	337	1979	340	1979	351	1979	352
1979	361	1980	020	1980	044	1980	061	1980	068	1980	116	1980	140
1980	164	1980	212	1980	236	1980	260	1980	284	1980	308	1980	332
1981	014	1981	038	1981	062	1981	086	1981	110	1981	134	1981	158
1981	182	1981	206	1981	230	1981	254	1981	278	1981	302	1981	326
1982	009	1982	033	1982	057	1982	081	1982	105	1982	129	1982	153
1982	177	1982	201	1982	225	1982	249	1982	273	1982	297	1982	321
1982	344	1982	345	1983	004	1983	028	1983	051	1983	076	1983	100
1983	124	1983	148	1983	172	1983	196	1983	220	1983	244	1983	268
1983	292	1983	316	1983	340	1983	364	1984	023	1984	047	1984	071
1984	095	1984	119	1984	143	1984	167	1984	191	1984	215	1984	239
1984	263	1984	287	1984	311	1984	335	1984	359	1985	017	1985	041
1985	065	1985	089	1985	113	1985	137	1985	161	1985	185	1985	209
1985	233	1985	257	1985	281								

## PRODUCTION

### 5.1 Method

Continuous scan solar flux archival products are produced from SCUT-S tapes. The SCUT tapes consist of selected records stripped from the more comprehensive RUT tapes. Section 5.2 discusses the SCUT tapes.

SUNC tapes are normally produced from the SCUT tapes with a single run for each year. The software permits production of output data in increments of Bartels periods. The following data sets are required to begin a run:

1. An input SCUT tape for the period covered
2. A trailer documentation holding file, for the information to be written to the trailer documentation file on the output tape
3. A calibration and bad orbit data set, with the following information:
  - a. Wavelengths corresponding to each grating position
  - b. Count-to-irradiance calibration factors
  - c. Values for r and s derived from diffuser and optical degradation models
  - d. Orbit number for first orbit of days containing solar flux data that are incorrect because the instrument was off
4. A data set containing the exposure time and corrections for wavelength-independent instrument change for each day
5. A data set containing the screening limits for each wavelength, as derived from the previous Bartels period

Information in the job input stream includes, but is not limited to, the following:

1. Number of read errors permitted before job termination
2. Permitted ranges of solar azimuth and elevation angles
3. Earliest orbit starting time permissible for calculating quasi-daily averages for next day
4. Identification of input tapes
5. Identification of output tapes and files
6. Range of Bartels periods for which data are to be produced
7. Year, day, and second data on tape begin and end
8. Product version

In addition to the SUNC tape, each run produces two disk data sets related to the solar flux product:

1. A screening limits data set, containing upper and lower screening limits for each monochromator and reference diode wavelength position and for the photometer, to be used to screen the data of the next Bartels period.
2. A data set with information on data screened out: the year, day, orbit, wavelength, data value, and screening limits. These values are inspected as part of the validation process.

Additional support software exits to aid production and validation:

1. Software to dump selected values from the output tape
2. Software to provide a formatted printout of the information on values screened out
3. Software to load screening from tape to disk, for use when a Bartels period must be reprocessed

The program to produce the SUNC and EARTH tapes operates in the following manner. At the start of a run, the run control information described above and the required data sets are read into core. The output tape is mounted, the header file created or checked, and the wavelength data written to the tape. The year and day when the specified Bartels period begins are calculated, the input tape is mounted, and the specified year and day are located on the input tape. Data for each scan in turn are extracted from the input tape and the data flags checked. For appropriate flag settings, irradiance or radiance, depending upon the type of data, is calculated, including the count to physical unit conversion, goniometric and instrument corrections, and screening. The irradiances or radiances are then organized for output and written to the appropriate tape. The next day is checked to see if it is one of the fourth days for which the data are rejected; if it is, the time of the previous day is checked to see if a quasi-daily average is to be calculated. Information required for computing 27-day averages is accumulated. At the end of a Bartels period, the period mean and standard deviations are calculated and the screening limits are calculated and written to disk for use in the next period. At the end of a year, trailer files are written. Although the software can run for one Bartels period at a time, all archived tapes were produced with a single run for 1 year of data.

## 5.2 Input SCUT-S Tape

The SCUT-S tapes consist of data records of the following types taken as is from the RUT-S tapes:

- a. Step scan solar flux records
- b. Wavelength calibration records
- c. Continuous scan earth radiance data records for both day and night
- d. Continuous scan solar flux records
- e. Orbital header (for GMT time of first good scan in orbit - needed for daily average grouping) and housekeeping summary data records. (These records are included even if no other data are selected for the orbit)
- f. Electronic calibration records

Table 5.1 shows the selection criteria for each type of data. Time, location of the subsatellite point, and solar ephemeris are provided for all data. When records are copied, they are not edited or flagged in any way. As on the RUT tape, data are grouped by orbit. Orbit-by-orbit inventories and weekly data volumes by type of data are automatically produced. Detailed descriptions of the contents of each type of record can be found in Fleig *et al.* (1983).



Table 5.1

## SCUT-S Data Selection Criteria

RUT-S	SCUT-S	
Description of Record Type (Data Mode)	Description of Data Type Selected	Selection Criteria
Step Scan	Solar Flux	Diffuser Deployed for SBUV (Flag X <sub>7</sub> on)
Wavelength Calibration	Wavelength Calibration	All
Cage Cam and Scan Off a) Continuous Scan off at night b) Continuous Scan on at night	Electronic Calibration	ECAL (X <sub>6</sub> ) on
Continuous Scan a) Solar Flux once/day b) Solar Flux once/orbit c) Earth Radiance one day/4 wks d) Continuous scan on through night (daily from 6/15/79 to 7/15/80)	Continuous Scan Solar Flux once/day Solar flux once/orbit Earth Radiance Daytime Earth Radiance Nighttime	All
Housekeeping (last record) -one/orbit	Housekeeping	All
Orbit Header (first record) -one/orbit	Orbit Header	All

## TAPE STRUCTURE

The SUNC and EARTH data are produced on unlabeled, 9-track, 6250 bpi tapes in IBM binary format. Each tape contains a NOPS Standard Header File followed by data files, a trailer file, and a Trailer Documentation File (TDF). These files will be described in detail in the following sections.

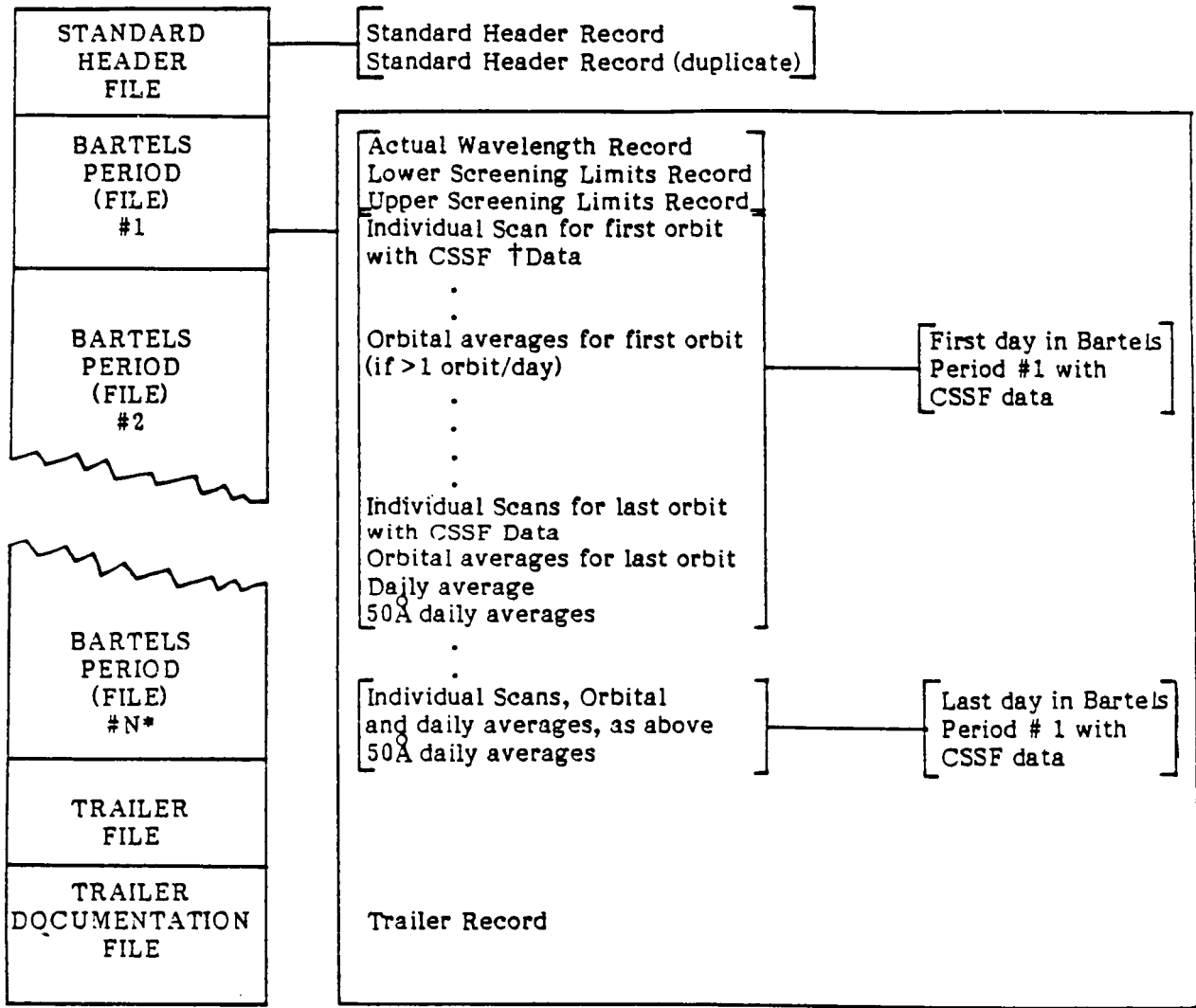
The number of files a tape contains depends on the number of Bartels periods in the data year on that tape. A year will contain either 13 or 14 Bartels periods; hence, the tape may contain up to 17 files (including trailer file and NOPS files).

Section 6.1 presents an overview of the two tapes in the form of structure charts, see Figures 6-1 and 6-2.

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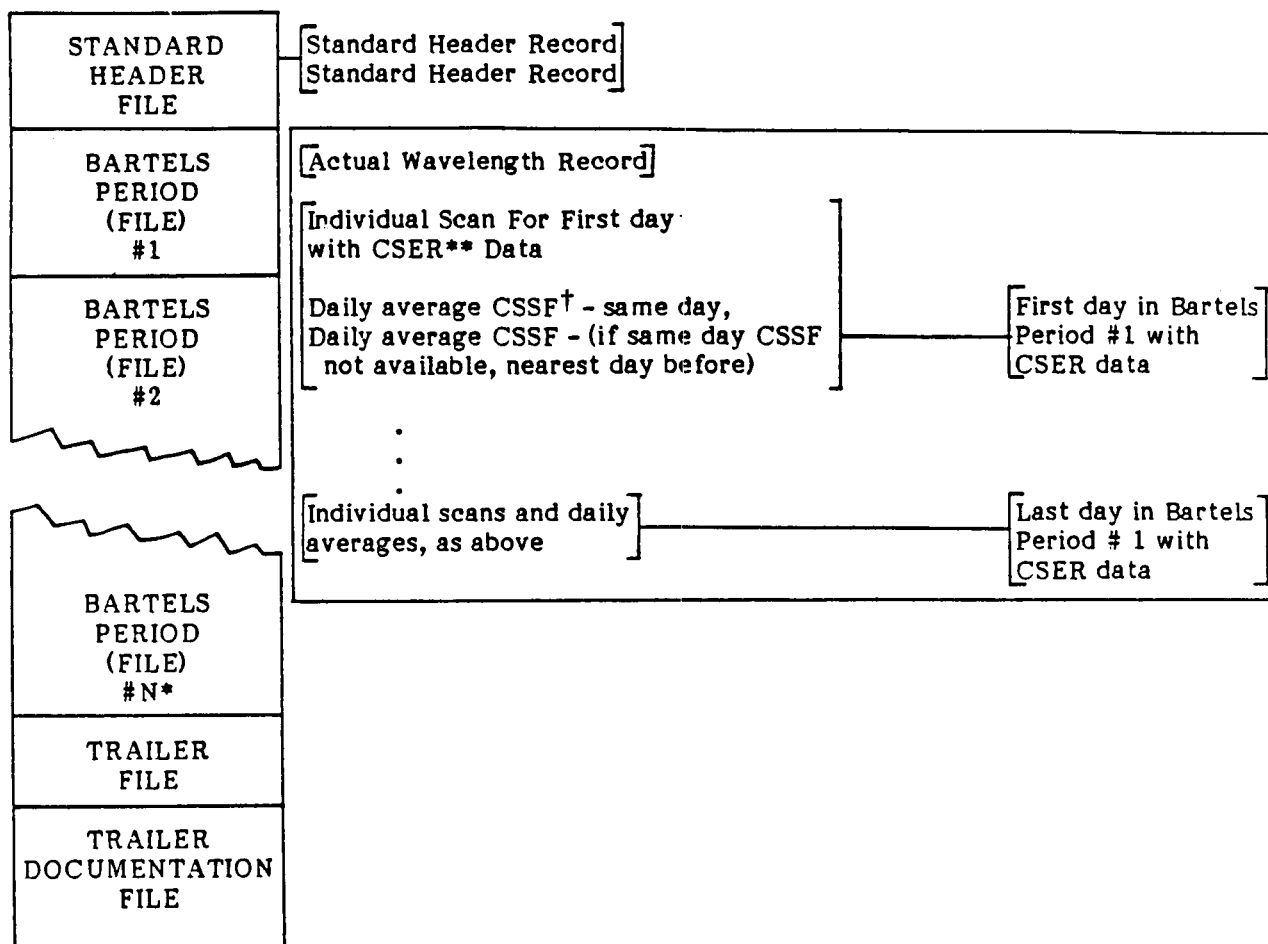
PAGE 32 INTENTIONALLY BLANK

## 6.1 Overview



\*N = Last full Bartels period within data (Satellite) year  
 †CSSF = Continuous Scan Solar Flux

Figure 6.1 Structure of continuous scan solar flux (SUNC) tape.



\*N = Last full Bartels period within data (Satellite) year  
 \*\*CSER = Continuous Scan Earth Radiance  
 †CSSF = Continuous Scan Solar Flux

Figure 6.2 Structure of continuous scan Earth radiance (EARTH) tape.

## 6.2 Format of NOPS Standard Header File

The standard header file contains two identical blocks (physical records) of 630 characters written in EBCDIC. Each block may be thought of as consisting of five 126-character lines.

Lines 1 and 2 are written according to a standardized format called the NOPS Standard Header Record.

Line 1:

COLUMNS	DESCRIPTION
1	An indicator to show whether a TDF will be found at the end of a tape blank = No TDF * = TDF present
2-24	Label: NIMBUS-7 <sub>b</sub> NOPS <sub>b</sub> SPEC <sub>b</sub> NO <sub>b</sub> T
25-30	Tape Specification Number: 634241 for SUNC 634251 for EARTH
31-37	Label: <sub>b</sub> SQ <sub>b</sub> NO <sub>b</sub>
38-39	PDF Code: FU for SUNC FC for EARTH
40-45, 47	Tape sequence number, defined as follows:
40	Last digit of the year in which the data were acquired.
41-43	First day of the first Bartels period of the year in which the data were acquired.
44	Sequence number for this particular product.
45	The existing hyphen remains unless there is a remake of the tape for any reason. In this case, an ascending alpha character replaces the hyphen, and the most recent reasons for remake are recorded in line 4 of the header.
47	Blank before October 24, 1988. Afterwards may contain information about the decade, which will be indistinguishable after this date using the current notation.
46	Copy number: 1=original 2=copy
47-52	Subsystem ID (with leading and trailing blank). For continuous scan/solar flux products, valid code is SBUV.

b=blank

COLUMNS	DESCRIPTION
53-56	Generation (Source) Facility: SACC (Science Applications Computing Center)
57-60	Label: bTOb
61-64	Destination Facility. For SBUV/TOMS products, this is IPDb (Information Processing Division, Goddard)
65-87	Start year, day of year, hour, minute, second for data coverage on this tape, in the form bSTARTb19YYbDDDbHHMMSSb
88-106	End year, day of year, hour, minute, second for data coverage on this tape, in the form TOb19YYbDDDbHHMMSSb In order to avoid unnecessary processing complications, the true ending date does not appear in the header record, Instead a fill date is used: 1999b365b240000
107-126	Generation year, day of year, hour, minute, second that the tape was created in the form: GENb19YYbDDDbHHMMSS
Line 2:	
1-12	Software program name and version number.
13-18	Program documentation reference number, if it exists.
19-126	Blank.
Line 3:	
1-24	CONTINUOUS SCAN VERSION
25-28	Version number
29-126	Blank.
Lines 4-5:	Blank.

b=blank

## 6.3 Data File Organization

The data in a data file are organized as logical records containing 1872 4-byte words each, for a logical record length of 7488 bytes. These records are written to the tape in blocks of 2, for a block size of 14,976 bytes.

As outlined in Sections 1.3 and 6.1, the SUNC and EARTH data files contain various types of data records. For both products, the first record of each file contains the actual continuous scan solar flux wavelengths. For the SUNC tape, the wavelength record is followed by two records containing screening limits for the solar flux. After these are the various types of solar flux data records, which occur in the following order:

- a) Individual scans for an orbit
- b) Orbital average record (present only if there is more than one orbit of continuous scan measurements for that day)
- c) Daily average data (usually 3 consecutive records)
- d) Daily 5 nm averages

This pattern is repeated for each day in which solar flux measurements were made for the Bartels period. For the EARTH tape data files, the records after the wavelength record appear as follows:

- a) Earth radiance individual scans
- b) Solar flux averages for the day of radiance measurements, or the latest previous day with solar flux values

SUNC and EARTH data files conclude with a block of trailer records. If the last block containing data records has only one data record, the block will be completed with a trailer record. In any case, the last block of the file always consists entirely of trailer records.

The following are various types of record formats and a brief description of the data they contain.

### 6.3.1 SUNC Record Descriptions

FORMAT OF BLOCK IDENTIFIER  
(First word of each logical record)

Bits:	1-12	13-16	17	18	19-24	25-32
Block		Spare	1 if last	1 for each	Record ID	Spare
Number			block	block on		
				last file		

Record IDs:

46	Continuous scan solar flux individual scan, wavelengths, or screening limits
48	Continuous scan solar flux daily average
49	Continuous scan solar flux orbital average
61	Continuous scan solar flux 50A interval daily average
53	Trailer record
0	Trailer file



## SUNC Tape

### Format of Continuous Scan Solar Flux Wavelengths Record (First record of each file)

Word	Description
1	Block identifier.
2	(a) Logical sequence number. (b) Bartels number corresponding to this file.
3-30	Spares.
31-1230	Actual wavelengths (in <u>Angstroms</u> ) for 1200 samples.
1231-1872	Spares.
Notes:	Words 1-30 are 4-byte INTEGER format, with the exception of word 2, which consists of 2 INTEGER*2 words. All others are 4-byte REAL format.

## SUNC Tape

### Format of Continuous Scan Solar Flux Screening Limits Record (Second and third records of each file)

Second record contains lower limits  
Third record contains upper limits

Word	Description
1	Block identifier.
2	(a) Logical sequence number. (b) Bartels number corresponding to this file.
3-30	Spares.
31-1230	Screening limit for monochromator solar irradiance at 1200 wavelengths.
1231	Screening limit for photometer solar irradiance at 343.3 nm.
1232-1327	Screening limit values for reference diode solar irradiance for 6 frames of 16 samples each.
1328-1872	Spares.
Notes:	Words 1-30 are 4-byte INTEGER format, with the exception of word 2, which consists of 2 INTEGER*2 words. All others are 4-byte REAL format.

## SUNC Tape

### Format of Continuous Scan Solar Flux Individual Scan Record

Word	Description
1	Block identifier.
2	(a) Logical sequence number - number of this data record in the file. (b) Bartels number corresponding to this file.
3	Data ID: Zero for individual scan record.
4	Year number (2-digit) at start of first good major frame of scan.
5	Day of year at start of first good major frame of scan.
6	GMT of day (seconds) at start of first major frame of scan.
7	Subsatellite geodetic latitude at start of the first good major frame of scan. Values range from $-\pi/2$ to $\pi/2$ , expressed in radians $\times 10^4$ ; north latitudes are positive. -7777. indicates fill data.
8	Subsatellite geodetic longitude at start of the first good major frame of scan. Values range from $-\pi$ to $\pi$ , expressed in radians $\times 10^4$ , east longitudes are positive. -7777. indicates fill data.
9	Solar zenith angle $z$ at the start of the first good major frame of scan. Expressed in radians $\times 10^4$ ( $0 \leq z \leq \pi$ ). -7777. indicates fill data.
10	Solar azimuth angle measured in the tangent plane from north to the projection of the sun line at the start of the first frame of scan. Measured clockwise as seen from the zenith. Values range from $-\pi$ to $\pi$ , expressed in radians $\times 10^4$ . -7777. indicates fill data.
11	Solar azimuth angle in diffuser coordinate at the start of the first good frame of scan. Values range from $-\pi$ to $\pi$ , expressed in radians $\times 10^4$ . -7777. indicates fill data.
12	Solar elevation angle in diffuser coordinate at the start of the first good frame of scan. Values range from $-\pi/2$ to $\pi/2$ , expressed in radians $\times 10^4$ . -7777. indicates fill data.
13	Data orbit number based on descending node at start of the first good frame of scan.
14-23	Same as words 4-13, but for end of last good major frame of scan.
24-30	Spares.
31-1230	Monochromator solar irradiance, normalized to 1 astronomical unit, at each of 1200 wavelengths. Values are expressed in $\text{watts/cm}^3$ .

## SUNC Tape

### Format of Continuous Scan Solar Flux Individual Scan Record (continued)

1231-1326            Photometer solar irradiance at 343.3 nm for 6 frames of 16 samples each, expressed in watts/cm<sup>3</sup>. Each photometer sample coincides with 12 1/2 monochromator samples.

1327-1422            Reference diode solar irradiance for 6 frames of 16 samples each, expressed in watts/cm<sup>3</sup>.

1423-1872            Spares.

Notes:                Words 1, 3-30 are 4-byte INTEGER format; word 2 contains two INTEGER\*2 words; words 31-1422 are in 4-byte REAL format.

## SUNC Tape

### Format of Continuous Scan Solar Flux Orbital Average Data Record

Word	Description
3	Data ID: 0 for orbital average record.
1-30	Except for word 3, same as words 1-30 of Individual Scan Record with the exception that start/end values are for orbit instead of scan.
31-1230	Orbital averages of monochromator solar irradiance for each of 1200 wavelengths. -7777. indicates fill data.
1231-1830	Number of samples in the orbit for each of 1200 wavelengths (half-word storage; hence, each 4-byte word consists of two 2-byte words).
1831	Orbital average of photometer solar irradiance at 343.3 nm.
1832	Standard deviation of photometer solar irradiance at wavelength 343.3 nm.
1833	Orbital minimum photometer solar irradiance at wavelength 343.3 nm.
1834	Orbital maximum photometer solar irradiance at wavelength 343.3 nm.
1835	Number of photometer solar irradiance samples in the orbit at wavelength 343.3 nm.
1836-1872	Spares.
Notes:	Words 1-30 are 4-byte INTEGER format, words 1231-1830 are 2-byte INTEGER format (i.e., each 4-byte word consists of 2 INTEGER*2 words), all other words are 4-byte REAL format.

## SUNC Tape

### Format of Continuous Scan Solar Flux Daily Average Data Record

Word	Description
3	Data ID: 1 = daily averages for first (shortest) 400 wavelengths (160-240 nm). 2 = daily averages for second 400 wavelengths (240-320 nm). 3 = daily averages for last 400 wavelengths (320-400 nm).
1-30	Except for word 3, same as words 1-30 of Individual Scan Record with the exception that start/end values are for day instead of scan.
31-430	Daily averages for monochromator solar irradiance for each of 400 wavelengths.
431-830	Standard deviation of monochromator solar irradiance for each of 400 wavelengths.
831-1230	Daily minimum monochromator solar irradiance for each of 400 wavelengths.
1231-1630	Daily maximum monochromator solar irradiance for 400 wavelengths.
1631-1830	Number of monochromator solar irradiance samples in the day for each of 400 wavelengths (half-word storage, hence each 4-byte word consists of two 2-byte words).
1831	Daily average of photometer solar irradiance at wavelength 343.3 nm.
1832	Standard deviation of photometer solar irradiance at wavelength 343.3 nm.
1833	Daily minimum photometer solar irradiance at wavelength 343.3 nm.
1834	Daily maximum photometer solar irradiance at wavelength 343.3 nm.
1835	Number of photometer solar irradiance samples in the day at wavelength 343.3 nm.
1836-1872	Spares.
Notes:	Three records are required to provide daily averages for 1200 wavelengths (words 4-23 and 1831-1835 are duplicated on each of the 3 records). Words 1-30 are 4-byte INTEGER format, words 1631-1830 are 2-byte INTEGER format (i.e., each 4-byte word consists of 2 INTEGER*2 words), all other words are 4-byte REAL format. For words 31-1630, -7777. indicates no valid irradiances for given wavelength on day.

## SUNC Tape

### Format of Continuous Scan Solar Flux 5.0 nm (50 A) Daily Average Data Record

Word	Description
1-30	Same as words 1-30 of Daily Average Record.
31-125	Centered wavelength ( <u>in Angstroms</u> ) for each 5 nm of solar irradiance between 160.0 nm and 400.0 nm at 2.5 nm intervals (162.5 nm, 165.0 nm, 167.5 nm, ..., 397.5 nm).
126-220	Daily mean monochromator solar irradiance for 5 nm intervals between 160.0 nm and 400.0 nm centered every 2.5 nm starting at 162.5 nm. Values of 0. indicate no data.
221-315	Number of samples for each 5 nm interval.
316-1872	Spares.
Notes:	Words 1-30 and words 221-315 are 4-byte INTEGER format, all other words are 4-byte REAL format.

## SUNC Tape

### Format of Continuous Scan Solar Flux Trailer Record

Word	Description
1	Block identifier.
2	(a) Negative logical sequence number. (b) Bartels number corresponding to this file.
3	Year (2-digit).
4	Day of year at end of Bartels period.
5	Total number of continuous scan records read.
6	Total number of continuous scan solar flux records read.
7	Total number of continuous scan solar flux records written.
8-9	Spares.
10	Total number of good first major frames.
11	Total number of missing first major frames.
12-16	Number of first major frames rejected due to-- word 12 Diffuser moving word 13 Data mode changed within scan word 14 Bad data flags word 15 Bad input DSAS angles word 16 Computed data out-of-range
17-22	Number of first major frames rejected for the following data flags-- word 17 SBUV high voltage off word 18 SBUV power enable off word 19 Mercury lamp on word 20 ECAL indicator on word 21 Cam not in sync word 22 Chopper not in sync
23-122	Total number of values filled with -9999., because values were outside of screening limits for each of 200 wavelengths of first major frame (using half-word storage, hence each 4-byte word consists of two 2-byte words).
123-222	Total number of values filled with -8888. due to bad input data for each of 200 wavelengths of first major frame.
223-229	Spares.
230-1329	Repeat 10-229 for remaining 5 major frames.



## SUNC Tape

### Format of Continuous Scan Solar Flux Trailer Record

Word	Description
1330	Total number of photometer values filled with -9999. due to being outside screening limits.
1331	Total number of reference diode values filled with -9999. due to being outside screening limits.
1332	Total number of days for which quasi-daily average was computed.
1333-1872	Spares.
Notes:	Words 2, 23-222, and 230-1329 are 2-byte INTEGER format (i.e., each 4-byte word consists of 2 INTEGER*2 words). All others are 4-byte INTEGER format.

### 6.3.2 EARTH Record Descriptions

FORMAT OF BLOCK IDENTIFIER  
(First word of each logical record)

Bits:	1-12	13-16	17	18	19-24	25-32
	Block Number	Spare	1 if last block	1 for each block on last file	Record ID	Spare

Record IDs:

47	Continuous scan earth radiance individual scan (or wavelength record)
48	Continuous scan solar flux daily average
53	Trailer record
0	Trailer file

## EARTH Tape

### Format of Continuous Scan Earth Radiance Wavelengths Record (First record of each file)

Word	Description
1	Block identifier.
2	(a) Logical sequence number. (b) Bartels number corresponding to this file.
3-30	Spares.
31-1230	Actual wavelengths ( <u>in Angstroms</u> ) for 1200 samples.
1231-1872	Spares.

Notes: Words 1-30 are 4-byte INTEGER format, with the exception of word 2, which consists of 2 INTEGER\*2 words. All others are 4-byte REAL format.

## EARTH Tape

### Format of Continuous Scan Earth Radiance Individual Scan Record

Word	Comment
1	Block identifier.
2	(a) Logical sequence number - number of this data record in the file. (b) Bartels number corresponding to this file.
3	Set to zero (0) to denote Earth radiance individual scan record.
4	Year number (2-digit) at start of first good major frame of scan.
5	Day of year at first good major frame of scan.
6	Greenwich mean time of day (seconds) at start of first major frame scan.
7	Subsatellite geodetic latitude at start of the first good major frame of scan. Values range from $-\pi/2$ to $\pi/2$ , expressed in radians $\times 10^4$ ; north latitudes are positive. -7777. indicates fill data.
8	Subsatellite geodetic longitude at start of the first good major frame of scan. Values range from $-\pi$ to $\pi$ , expressed in radians $\times 10^4$ ; east longitudes are positive. -7777. indicates fill data.
9	Solar zenith angle $z$ at the start of the first good major frame of scan. Expressed in radians $\times 10^4$ ( $0 \leq z \leq \pi$ ). -7777. indicates fill data.
10	Solar azimuth angle, measured in the tangent plane from north to the projection of the sun line at the start of the first frame of scan. Measured clockwise as seen from the zenith. Values range from $-\pi$ to $\pi$ , expressed in radians $\times 10^4$ . -7777. indicates fill data.
11-12	Spares.
13	Data orbit number, starting with descending node at start of the first good frame of scan.
14-23	Same as words 4-13, but for end of last good major frame of scan.
24-30	Spares.

## EARTH Tape

### Format of Continuous Scan Earth Radiance Individual Data Record

Word	Description
31-1230	Monochromator daytime Earth radiance, normalized to 1 astronomical unit, at each of 1200 wavelengths. Values are expressed in watts/cm <sup>3</sup> .
1231-1326	Photometer Earth radiance at 343.3 nm for 6 frames of 16 samples each, expressed in watts/cm <sup>3</sup> . The 96 photometer measurements are made concurrently with the 1200 monochromator measurements.
1327-1872	Spares.

EARTH Tape

Format of Continuous Scan Solar Flux Daily  
Average Data Record

Word	Description
3	Data ID: 4 = solar daily averages of the same day in which Earth radiance measurements were made. 5 = solar daily average of a day before 6 = solar daily average of the nearest day after.
1-30	Except for word 3, same as words 1-30 of individual scan record with the exception that start/end values are for day instead of scan.
31-1230	Daily averages of monochromator solar irradiance for each of 1200 wavelengths.
1231-1830	Number of monochromator solar irradiance samples in the day for each of 1200 wavelengths (half-word storage, hence each 4-byte word consists of two 2-byte words).
1831	Daily average of photometer solar irradiance at wavelength 343.3 nm.
1832	Standard deviation of photometer solar irradiance at wavelength 343.3 nm.
1833	Daily minimum photometer solar irradiance at wavelength 343.3 nm.
1834	Daily maximum photometer solar irradiance at wavelength 343.3 nm.
1835	Number of photometer solar irradiance samples in the day at wavelength 343.3 nm.
1836-1872	Spares.
Notes:	Words 1-30 are 4-byte INTEGER format, words 1231-1830 are 2-byte INTEGER format (i.e., each 4-byte word consists of 2 INTEGER*2 words), all other words are 4-byte REAL format. For words 31-1231, -7777. indicates no valid irradiances for given wavelength on day.

## EARTH Tape

### Format of Continuous Scan Earth Radiance Trailer Record

Word	Description
1	Block identifier.
2	(a) Negative logical sequence number. (b) Bartels number corresponding to this file.
3	Year (2-digit).
4	Day of year at end of Bartels period.
5	Total number of continuous scan records read.
6	Total number of continuous scan earth radiance records written.
8-9	Spares.
10	Total number of good first major frames.
11	Total number of missing first major frames.
12-16	Number of first major frames rejected due to- word 12 Diffuser moving word 13 Data mode changed within scan word 14 Bad data flags word 15 Solar zenith angle greater than user-specified maximum word 16 Computed data out-of-range
17-22	Number of first major frames rejected for the following data flags- word 17 SBUV high voltage off word 18 SBUV power enable off word 19 Mercury lamp on word 20 ECAL indicator on word 21 Cam not in sync word 22 Chopper not in sync
23-122	Total number of values filled with -9999. due to being outside screening limits for each of 200 wavelengths of first major frame (using half-word storage; hence, each 4-byte word consists of two 2-byte words).
123-222	Total number of values filled with -8888. due to bad input data for each of 200 wavelengths of first major frame.
223-229	Spares.
230-1329	Repeat 10-229 for remaining 5 major frames.

## EARTH Tape

### Format of Continuous Scan Earth Radiance Trailer Record (continued)

Word	Description
1330	Total number of photometer values replaced with -9999. fill value because they were outside screening limits.
1331	Total number of reference diode values replaced with -9999. fill value because they were outside screening limits.
1332-1872	Spares.
Notes:	Words 2, 23-222, and 230-1329 are 2-byte INTEGER format (i.e., each 4-byte word consists of 2 INTEGER*2 words). All others are 4-byte INTEGER format.



## 6.4 Trailer File

Every tape contains a Trailer File to mark the end of data on the tape. The Trailer File contains only one physical record. The block size of the Trailer File is the same as that for the data files. It contains a physical record (block) number of 1, a record ID of 0, and has the file control bits 17 and 18 on the Block Identifier set to 1 (see Section 6.3.1). It can also be identified by a logical sequence number of -1. The Trailer File otherwise contains only fill data.

## 6.5 Trailer Documentation File (TDF)

The TDF is the last file on each volume (tape). It is written in EBCDIC and is used to identify the genealogy of each tape. Its structure is the same as that of the standard header and contains a collection of standard headers (non-duplicated) from all input tapes that were used from all stages of processing (not just the input tapes of the computer run that actually created this tape). The TDF only exists for tapes with an \* in the first byte (character) of the NOPS Standard Header File. Since the TDF capability was implemented only after the data processing system was operational, not all NOPS tapes have this file. However, all Continuous Scan/Solar Flux products will have a TDF.

The first record identifies this as the TDF.

Chars. 1-10:	*****
11-126:	NOPS TRAILER DOCUMENTATION FILE FOR TAPE PRODUCT (Spec No. (6 digit)) GENERATED ON DDDHHMM.

The second physical record will be a repeat of the Standard Header File for the current tape with the provision that data referring to end time are correct. The following physical records contain the historical standard header records from the various input tapes.

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- Willson, Richard C., Solar irradiance variations and solar activity, *J. Geophys. Res.*, *87*, 4319-4326, 1982.

## LIST OF ACRONYMS, INITIALS, AND ABBREVIATIONS

ACRIM	Active Cavity Radiometer Irradiance Monitor
bpi	bits per inch
DSAS	Digital Solar Aspect Sensor
EARTH	continuous scan Earth radiance
EBCDIC	Extended Binary Coded Decimal Interchange Code
ECAL	Electronic Calibration
GMT	Greenwich Mean Time
IPD	Information Processing Division
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NSSDC	National Space Sciences Data Center
PMT	Photomultiplier
RUT-S	Raw Unit Tape-SBUV
SACC	Science and Applications Computing Center
SBUV	Solar Backscatter Ultraviolet
SMM	Solar Maximum Mission
STX	ST Systems Corporation
SUNC	continuous scan solar flux
TDF	Trailer Documentation File
TOMS	Total Ozone Mapping Spectrometer
UV	Ultraviolet

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## SCUT TAPE CATALOG

Weeks	Orbit Range	Day Range	Number of Files
1-8	100-825	1978/304-357	636
9-16	841-1614	1978/308-1979/48	655
17-24	1617-2374	1979/49-104	657
25-32	2389-3148	1979/105-160	622
33-40	3163-3935	1979/161-216	710
41-48	3937-4710	1979/217-272	754
49-53	4711-5193	1979/273-307	477
54-61	5194-5967	1979/308-363	769
62-69	5968-6740	1979/364-1980/54	764
70-77	6742-7514	1980/55-110	769
78-85	7516-8288	1980/111-166	768
86-93	8290-9062	1980/167-222	722
94-101	9063-9836	1980/223-278	771
102-105	9741-10223	1980/279-306	385
106-113	10224-10997	1980/307-362	775
114-121	10998-11771	1980/363-1981/52	774
122-129	11772-12545	1981/53-108	777
130-137	12546-13319	1981/109-164	777
138-145	13320-14093	1981/165-220	773
146-153	14094-14867	1981/221-276	776
154-157	14868-15254	1981/277-304	390
158-167	15255-16221	1981/305-1982/9	970
168-177	16222-17189	1982/10-79	969
178-187	17190-18156	1982/80-149	970
188-197	18157-19124	1982/150-219	970
198-207	19125-20091	1982/220-289	967
209-210	20093-20382	1982/290-310	293
211-220	20383-21349	1982/311-1983/15	969
221-230	21350-22317	1983/16-85	969
231-240	22318-23284	1983/86-155	970
241-250	23286-24252	1983/156-225	963
251-262	24253-25413	1983/226-309	1160
263-272	25414-26381	1983/310-1984/14	965
273-282	26382-27349	1984/15-84	964
283-302	28317-29284	1984/85-154	967
303-314	29285-30445	1984/225-308	1160

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## SUNC TAPE CATALOG

Year Number	Day Range	Number of Files
1	1978/308 - 1979/293	16
2	1979/294 - 1980/306	17
3	1980/307 - 1981/291	16
4	1981/292 - 1982/304	17
5	1982/305 - 1983/290	16
6	1983/291 - 1984/303	17

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## EARTH TAPE CATALOG

Year Number	Day Range	Number of Files
1	1978/308 - 1979/293	16
2	1979/294 - 1980/306	17
3	1980/307 - 1981/291	16
4	1981/292 - 1982/304	17
5	1982/305 - 1983/290	16
6	1983/291 - 1984/303	17

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## DATA AVAILABILITY AND COST

The derivative tape products defined in this User's Guide are archived and available from the National Space Science Data Center (NSSDC). The NSSDC will furnish limited quantities of data to qualified users without charge. The NSSDC may establish a nominal charge for production and dissemination if a large volume of data is requested. Whenever a charge is required, a cost estimate will be provided to the user prior to filling the data request.

Domestic requests for data should be addressed to--

National Space Science Data Center  
NASA/Goddard Space Flight Center  
Code 633  
Greenbelt, MD 20771

All requests from foreign researchers must be specifically addressed to--

Director, World Data Center A for Rockets  
and Satellites  
NASA/Goddard Space Flight Center  
Code 630.2  
Greenbelt, MD 20771 USA

When ordering data from either NSSDC or the World Data Center, a user should specify why the data are needed, the subject of the work, the name of the organization with which the user is connected, and any Government contracts under which the study is being performed. Each request should specify the experiment data desired, the time period of interest, and any other information that would facilitate the handling of the data request.

A user requesting data on magnetic tapes should provide additional information concerning the plans for using the data, i.e., what computers and operating systems will be used. In this context, the NSSDC is compiling a library of routines that can unpack or transform the contents of many of the data sets into formats that are appropriate for the user's computer. NSSDC will provide, upon request, information concerning its services. When requesting data on magnetic tape, the user must specify whether he or she will supply new tapes prior to the processing, or return the original NSSDC tapes after the data have been copied.

Data product order forms may be obtained from NSSDC/World Data Center A.

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1. Report No.  NASA RP-1199		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle NIMBUS 7 SOLAR BACKSCATTER ULTRAVIOLET (SBUV) SPECTRAL SCAN SOLAR IRRADIANCE AND EARTH RADIANCE PRODUCT USER'S GUIDE				5. Report Date  February 1988	
				6. Performing Organization Code  636	
7. Author(s) Barry M. Schlesinger, Richard P. Cebula, Donald F. Heath, and Albert J. Fleig				8. Performing Organization Report No.  88-0004	
				10. Work Unit No.	
9. Performing Organization Name and Address  Goddard Space Flight Center Greenbelt, MD 20771				11. Contract or Grant No.  NAS5-29386	
				13. Type of Report and Period Covered  Reference Publication	
12. Sponsoring Agency Name and Address  National Aeronautics and Space Administration Washington, DC 20546-0001				14. Sponsoring Agency Code	
15. Supplementary Notes  Barry M. Schlesinger and Richard P. Cebula: ST Systems Corporation (STX), Hyattsville, Maryland. Donald F. Heath and Albert J. Fleig: Goddard Space Flight Center, Greenbelt, Maryland.					
16. Abstract  The archived tape products from the spectral scan mode measurements of solar irradiance (SUNC tapes) and earth radiance (EARTH tapes) by the Solar Backscatter Ultraviolet (SBUV) instrument aboard Nimbus 7 are described. Incoming radiation from 160 to 400 nm is measured at intervals of 0.2 nm. The scan-to-scan repeatability of the solar irradiance measurements ranges from approximately 0.5 to 1 percent longward of 280 nm, to 2 percent around 210 nm and 4 percent near 175 nm. The repeatability of the earth radiance values ranges from 2-3 percent at longer wavelengths and low zenith angles to 10 percent at shorter wavelengths and high zenith angles. The tape formats are described in detail, including file structure and contents of each type of record. Catalogs of the tapes and the time period covered are provided, along with lists of the days lacking solar irradiance measurements and the days dedicated to earth radiance measurements. The method for production of the tapes is outlined and quality control measures are described. How radiances and irradiances are derived from the raw counts, the corrections for changes in instrument sensitivity, and the uncertainties therein are discussed in detail.					
17. Key Words (Suggested by Author(s)) Solar ultraviolet irradiance; earth radiance; earth albedo.			18. Distribution Statement Unclassified - Unlimited  Subject Category 42		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of pages 74	22. Price A04