Long Term Trends in IUE Radiation Background

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7 July 1985

Abstract: The current radiation levels experienced by IUE during the US2 shifts can be expected to continue for the next several years, due to the minimum in the solar activity cycle.

Radiation encountered by IUE, especially during the US2 shifts, significantly affects the scientific observations that can be made. This study explores whether there are long-term trends in the radiation levels, how they correlate with other quantities, and what might be expected in the remaining years of IUE's lifetime. This report was originally presented at the IUE Project's Three Agency Coordination Meeting in April 1985, as part of the overall assessment of long-range plans for IUE.

The IUE Project has monitored the peak Flux Particle Monitor (FPM) values for each day since soon after launch. Monthly statistics on the radiation levels are gathered and published periodically in this newsletter (e.g. Broude and Imhoff, NASA IUE Newsletter No. 24, pg. 127). These statistics have been compiled into yearly averages in Table 1. An estimate of the effects on the cameras is given on the right side of the table. A clear minimum in the radiation levels is noted around 1980. During that year, several hour exposures could be obtained during over half of the US2 shifts. In 1984, this was true for only about 30% of the shifts.

An anticorrelation between solar activity and radiation during US2 on a daily basis (and over a few solar rotations) has been recognized for some time. This suggests that the eleven-year solar activity cycle might play a role in the long-term trends in IUE's radiation background. To study this possibility, the average Zurich sun spot number for each year was determined from data presented in the Preliminary Report and Forecast of Solar Geophysical Data (13 November 1984) as an indicator of the overall solar activity. The solar maximum, or solar activity peak, was reached in late 1979, according to these data (Figure 1).

Figure 2 depicts the correlation between IUE radiation levels and mean sun spot numbers. The proportion of low radiation shifts clearly peaked at the same time as solar maximum. In addition, the proportion of high radiation shifts reached a minimum during that period. These striking correlations demonstrate the relation of IUE's radiation levels with solar activity over several years' time scale.

Using this information one can estimate what radiation levels can be expected for the next several years. Currently the Sun is approaching its activity minimum. Solar activity is expected to remain low for the next several years and is not expected to increase significantly until 1989. Thus the current IUE radiation levels are expected to continue for the foreseeable future.

The pattern of radiation has changed somewhat during the US2 shifts since launch (Figure 3). In the first few years of IUE, the higher of the two FPM maxima tended to occur early in the shift. For a period of time the maxima were roughly equal. In recent years, the higher maximum occurs in the latter half of the shift. The reason for this change is not altogether clear, but may have to do with the changing shape of IUE's orbit. Figure 4 shows the ground track of IUE since 1978. The bottom of the ellipse, near perigee and thus during the US2 shift, has changed in location; thus the satellite must be passing through a somewhat different portion of the Earth's Van Allen belts. It seems plausible that this may account for the small change in radiation pattern during US2 seen by IUE. If so, then this pattern is expected to continue over the next several years.

It is instructive to examine where IUE's orbit lies within the Earth's magnetic field. Figures 5a and 5b depicts the normal geometry of the Van Allen belts and the Earth's magnetosphere (taken from Smith and Jacobs, 1973, Introductory Astronomy and Astrophysics, pp. 144-145). IUE's eccentric orbit takes the satellite from 8.0 Earth radii at apogee to 5.2 R_o at perigee. Thus it barely dips into the outer Van Allen belt. The entire orbit lies well within the shocked transition region between the solar wind and the Earth's magnetosphere. Because of the asymmetry of the Earth's magnetosphere, one might expect a yearly variation in the radiation levels experienced by IUE. For instance, during the late Spring perigee occurs around noon; the magnetic field on the sunward side of the Earth is compressed by the solar wind. In the fall, the opposite would occur. An examination of the monthly radiation statistics over several years reveals no repeatability of any annual variation. Apparently the portion of the magnetic field that IUE passes through is sufficiently shielded from the solar wind that it is fairly symmetric.

Table 1

Yearly Statistics for IUE's Daily Peak Radiation Levels Since Launch

FPM (volts)	Per Cent of Shifts							Fogging Rate (DN/hour)	Longest Exposure
	1978	1979	1980	1981	1982	1983	1984		
< 1.0	6.3	13.2	18.6	19.2	5.9	1.4	8.5	< 10	> 10 hrs
1.0 - 1.69	26.6	42.2	43.2	39.2	22.5	19.7	23.5	10 - 50	2 - 10 hrs
1.7 - 1.99	14.8	16.2	18.3	21.4	26.9	15.9	12.6	50 - 100	60 - 120 min
2.0 - 2.39	23.0	20.3	14.8	14.2	20.9	26.3	18.9	100 - 250	30 - 60 min
2.4 - 2.79	20.2	7.4	4.1	4.7	20.3	26.6	20.8	250 - 500	15 - 30 min
2.8 - 2.99	5.1	0.8	1.1	1.1	1.6	6.8	5.7	500 - 1000	7 - 15 min
> 3.0	3.9	0.0	0.0	0.3	1.9	3.3	10.1	> 1000	< 7 min

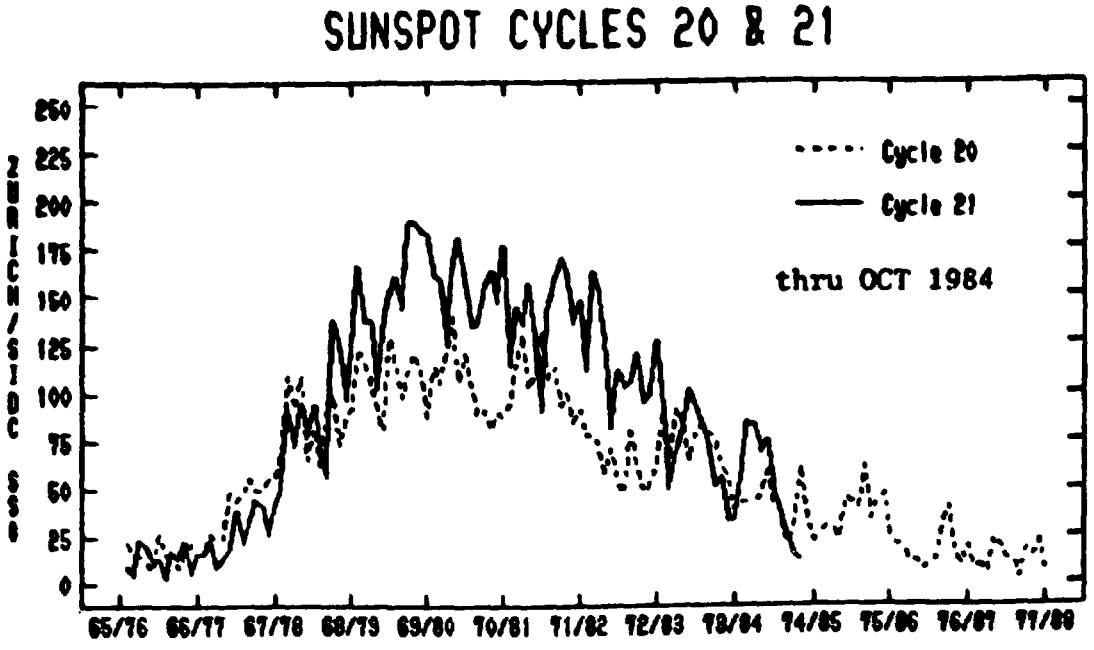

Figure 1: Sun spot numbers for this solar activity cycle.

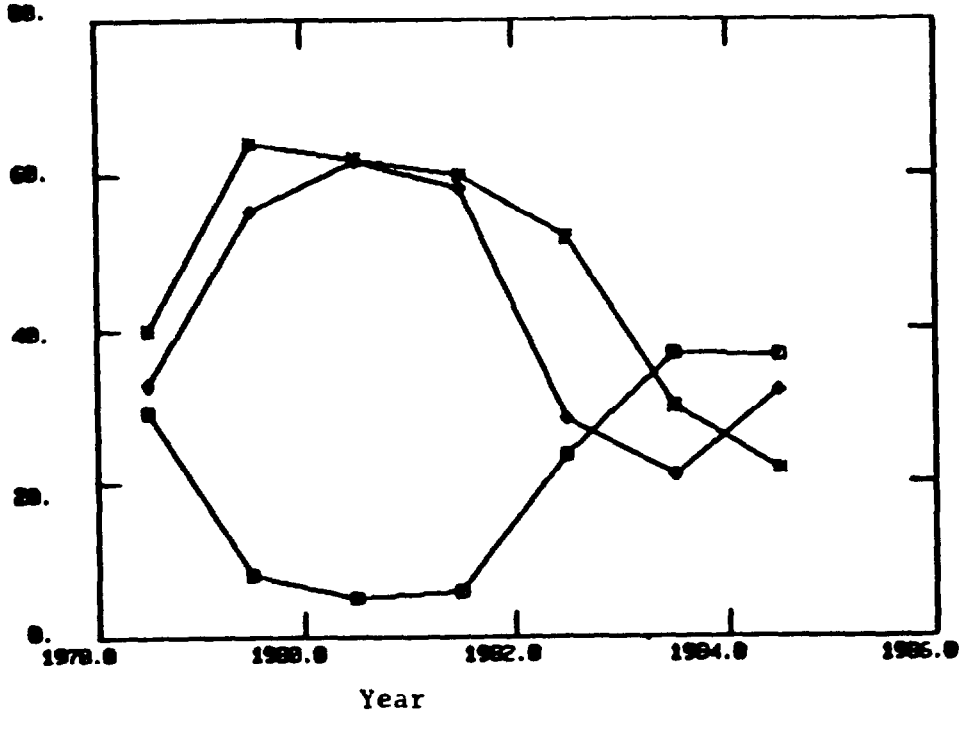

Figure 2: Comparison between IUE radiation statistics and mean sun spot numbers. Asterisks represent sun spot numbers divided by 2.5. Diamonds represent the percentage of shifts for which the peak FPM was under 1.7 volts. Squares represent the percentage of shifts for which the peak FPM was 2.4 volts or higher.

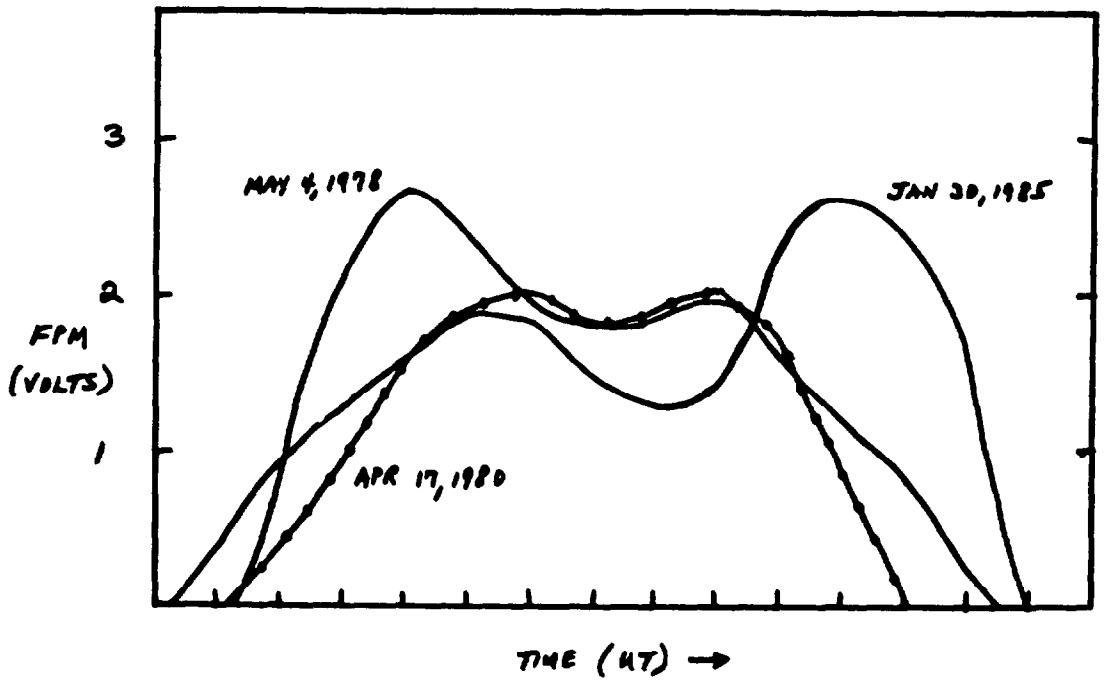

Figure 3: The daily pattern of FPM variation for three typical days in 1978, 1980, and 1985. Note the change of time for the higher maximum from early in the shift to late in the shift.

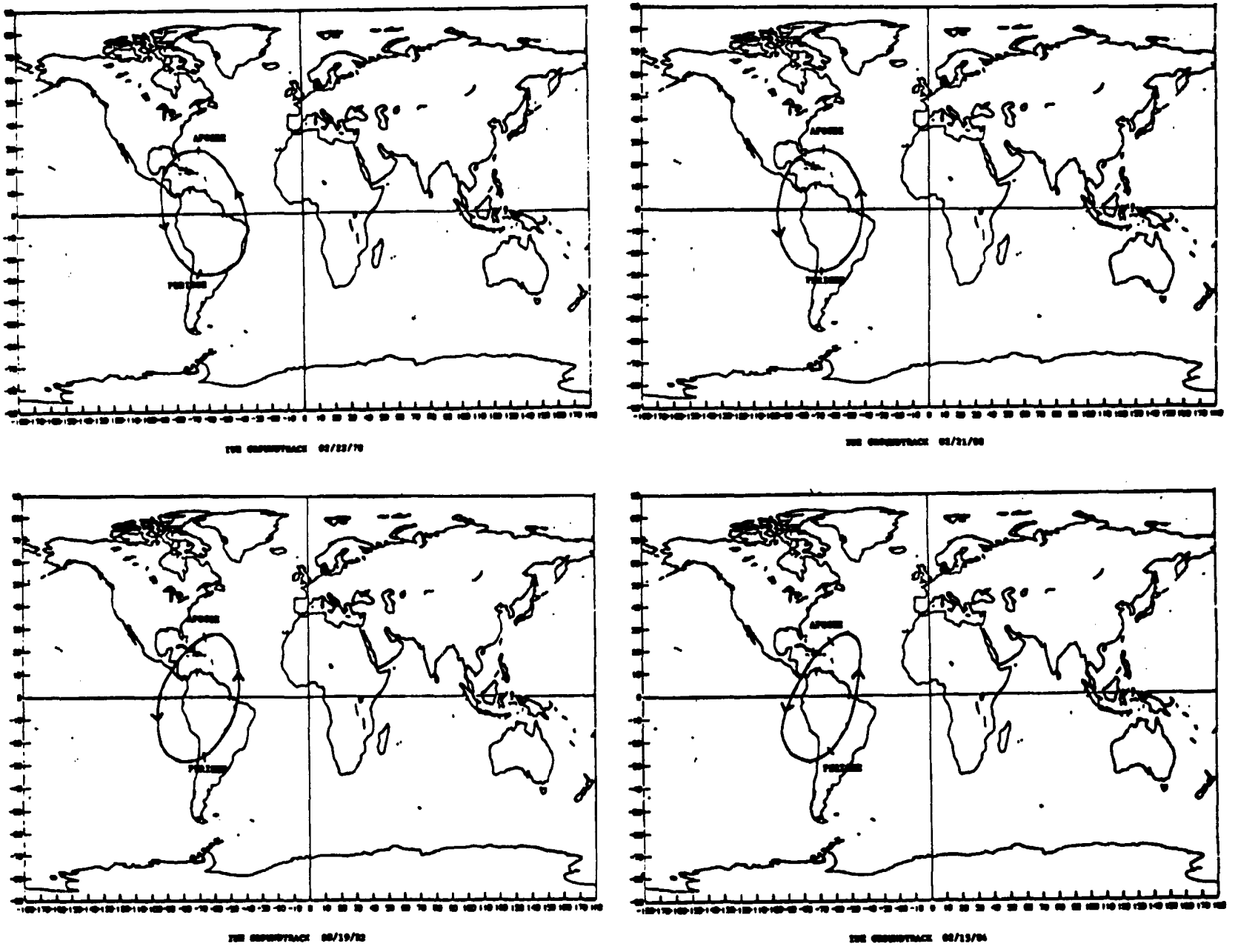

Figure 4: The changing groundtrack of IUE since 1978.

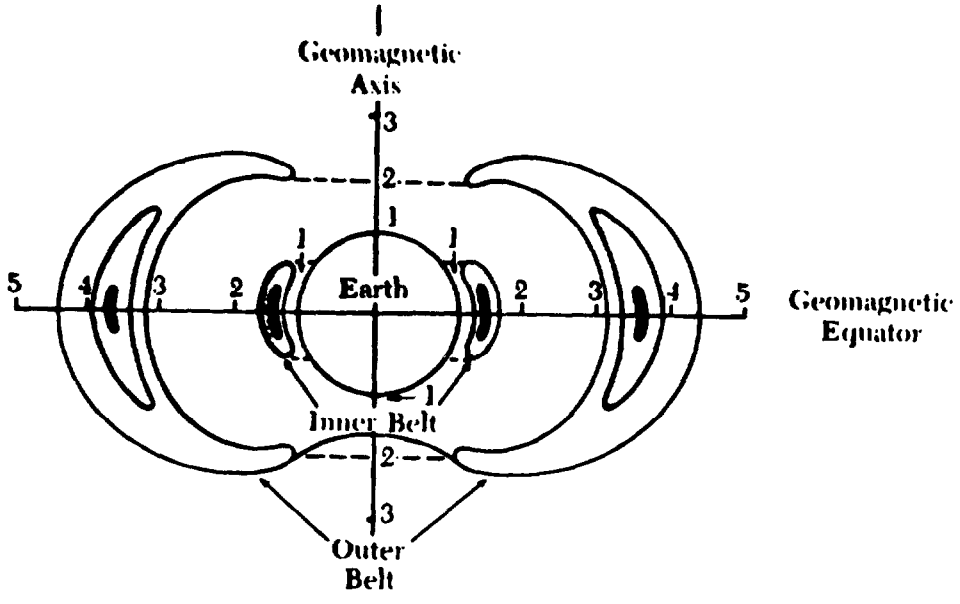

Figure 5a: The Van Allen belts shown in scale with the Earth (units in Earth radii). IUE's orbit varies from 8.0 R_o at apogee to 5.2 R_o at perigee.

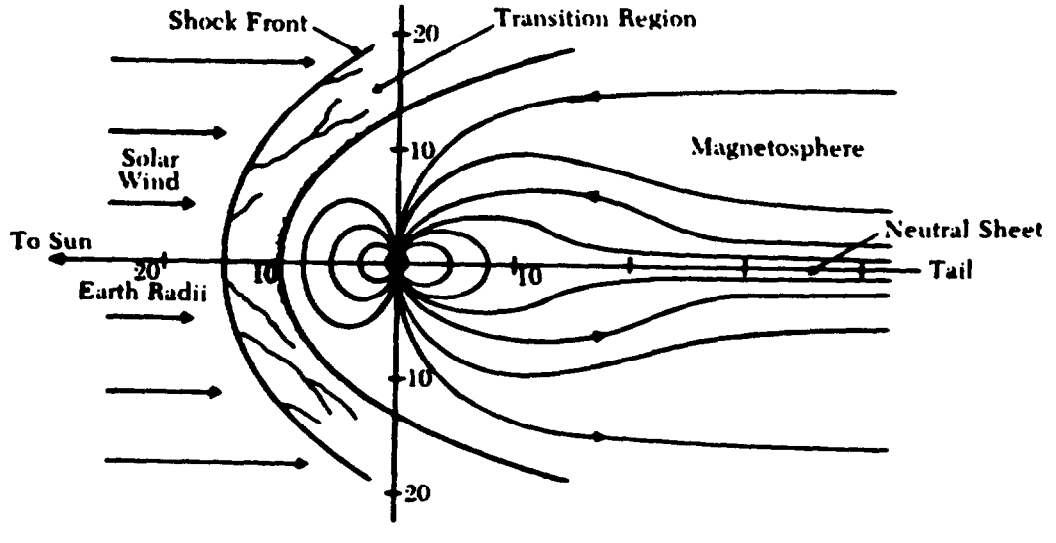

Figure 5b: The Earth's magnetosphere (units in Earth radii). Note that IUE's orbit lies within the shocked front and transition zone in a region which is not greatly deformed by the solar wind.