AD-A125 706 COMPARISON OF DATA FROM THE LOW ENERGY ELECTROSTATIC ANALYZERS ON SATELLITE P78-1(U) AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA R P VANCOUR 19 AUG 82 1/1

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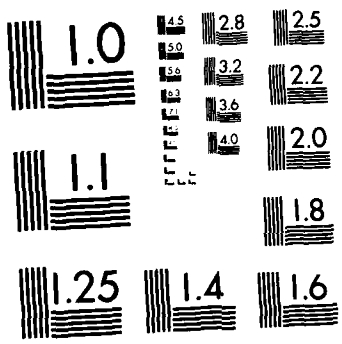

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AFGL-TR-82-0236
ENVIRONMENTAL RESEARCH PAPERS, NO. 790

Comparison of Data From the Low Energy Electrostatic Analyzers on Satellite P78-1

ROGER P. VANCOUR

19 August 1982

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SPACE PHYSICS DIVISION PROJECT 7661
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AIR FORCE SYSTEMS COMMAND, USAF

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-82-0236	2. GOVT ACCESSION NO. AD-A125706	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPARISON OF DATA FROM THE LOW ENERGY ELECTROSTATIC ANALYZERS ON SATELLITE P78-1		5. TYPE OF REPORT & PERIOD COVERED Scientific. Interim.
		6. PERFORMING ORG. REPORT NUMBER ERP No. 790
7. AUTHOR(s) Roger P. Vancour		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Geophysics Laboratory (PHK) Hanscom AFB Massachusetts 01731		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 76611003
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory (PHK) Hanscom AFB Massachusetts 01731		12. REPORT DATE 19 August 1982
		13. NUMBER OF PAGES 11
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Electrostatic analyzers
Energy levels
Electrons

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Air Force satellite P78-1 has aboard, on the wheel section, two detectors each consisting of a low energy and a high energy electron electrostatic analyzer. The low energy analyzer collects electrons in the energy range of 50 eV to 1 keV and the high energy analyzer collects electrons in the energy range of 1 keV to 20 keV. The two detectors were placed 90° apart on the wheel section of the satellite. The leading detector in the wheel's rotation is denoted as Detector 1.

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Counts of low energy electrons made by the low energy analyzers on board the satellite do not agree, but can be corrected so that all data are usable. Multiplying the readings of the low energy analyzer of Detector 1 by a factor of 1.64 brings them into agreement with counts from the other low energy analyzer and the two high energy analyzers. Three different comparisons of data from the four analyzers were used to derive the correction factor.

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Comparison of Data From the Low Energy Electrostatic Analyzers on Satellite P78-1

1. DESCRIPTION OF THE PROBLEM

As previously reported,[1] the low energy analyzer of Detector 1 on satellite P78-1 consistently returns significantly lower counts than the low energy analyzer of Detector 2. This has been observed in the reduced data from many orbits. The problem does not exist in the high energy analyzers.

The four analyzers had been tested with four tritium radioactive sources prior to launch. Two sources were mounted on each of two holders in such a way that the sources fit exactly over the slits of each analyzer of the two detectors. Tests were run prior to satellite integration to compare the counts observed by each analyzer. The same type of tests were run on two other detectors which were also calibrated[2] at Rice University, Houston, Texas. In all cases, the response of the analyzers for the same energy range agreed within 20%. The problem can be due to a malfunction in one or both channeltrons of the low energy analyzer of Detector 1 or in the electronic circuitry of that analyzer. In either case, the geometric factors

(Received for publication [illegible] August 1982)

1. [illegible], R. P. (1981) High Latitude Electron Detectors on Satellite P78-1: [illegible], AFGL-TR-81-0131, AD A104518.

2. [illegible], D. A., Gussenhoven, M. S., and Huber, A. (1979) The Precipitating Electron Detectors (SSJ/3) for the Block 5D/Flights 2-5 DMSP Satellite: [illegible] Presentation, AFGL-TR-79-0210, AD A083136.

can be corrected by comparing the four analyzers and the data is useful. The problem is resolved by making such comparisons.

2. EXPERIMENT AND INSTRUMENTS

2.1 Satellite Orbit

Satellite P78-1, launched 25 February 1979, carries high latitude electron detectors. The satellite is in a circular, polar, sun-synchronous orbit (noon-midnight meridian plane) at an altitude of 600 ± 30 km, with an inclination of 97.73°. The satellite consists of a wheel section, carrying the instruments, and a sail section, carrying the photocells that power the satellite. The wheel section spins at 11 ± 1 rpm, so that the spin period is 5.45 ± 0.150 sec. The spin axis of the wheel section is perpendicular to the orbital plane of the satellite.

2.2 Instruments

Two electron detectors are mounted in a single container so their look directions are 90° apart. Both look outward from the rim of the wheel section. The spin of the satellite scans the detectors through all pitch angles in each spin period. The two detectors are identical to those flown on the DMSP satellites. The calibrations used for the detectors are found in Hardy et al.[2] The calibrations used are an average of the values for Detectors 4 and 5 in that work. Each detector consists of two curved plate electrostatic analyzers with channeltrons. One analyzer of each detector collects electrons in the energy range of 50 eV to ~1 keV and the other analyzer of each detector collects electrons in the energy range of 1-20 keV. Each analyzer has eight energy channels. All four analyzers are stepped through the eight channels simultaneously every 256 msec. Thus, each set of analyzers produces four 16-point spectra in just over 1 sec or about 22 spectra in each vehicle rotation. The lead detector in the vehicle rotation is called Detector 1 and the detector following by 90° is called Detector 2.

3. COMPARISON OF RESULTS

Since the two detectors are 90° apart, a comparison can best be made when both of them are near a 45° pitch angle in the northern hemisphere or both are near a 135° pitch angle in the southern hemisphere.

Data are used from four different satellite orbits, namely, 220, 438, 530, and [illegible], and only in the auroral regions when the counting is sufficiently high. Data [illegible] three pitch angle bins:

a. When the stated values of the pitch angles of the two detectors, pa 1 and pa 2, differ by 2° or less,

b. When the difference is greater than 2° but less than or equal to 10°, and,

c. When the difference is greater than 10° but less than or equal to 20°.

Three comparisons are made. The integrated number flux, J_{tot}, is used to compare the two low energy analyzers (Channels 1-8). Whenever J_{tot} for the eight channels was less than 2×10^7 e cm^{-2} sec^{-1} sr^{-1}, the counts were very low, gave poor statistics, and so were not used. The second comparison is of each channel (1-8) of one detector with the corresponding channel of the other detector. The third comparison uses the differential flux values, dJ/dE, of both detectors for Channels 8 and 9. Channel 8 is centered at 0.974 keV and Channel 9 at 1.000 keV. Since they are very nearly at the same energy level, the differential fluxes can be compared.

3.1 J_{tot} Values, Channels 1-8, Both Detectors

Data from all four orbits are used for each pitch angle bin. Orbits 530 and 959 occurred during fairly active K_p periods while orbits 220 and 438 occurred during moderate K_p periods.

In this section J_{tot} is calculated for each time period for both detectors by

$$J_{tot} = \sum_{i=1}^{8} \frac{dJ}{dE_i} \Delta E_i \, . \tag{1}$$

As can be seen in Eq. (1), only Channels 1-8 are used in the determination of J_{tot} since a comparison is being made of the low energy analyzers only. The ratio of Detector 2 to Detector 1 values is written as $\frac{J_{tot}(2)}{J_{tot}(1)}$ and is determined. Values are found for all three pitch angle bins and the average of all values in each bin and in each orbit are calculated. Table 1 lists the results showing the number of samples, n; the average value of the ratio $\frac{J_{tot}(2)}{J_{tot}(1)}$, $\bar{x}$; and the standard deviation of the ratio, s.

The results of all pitch angle bins and all four orbits are in good agreement and give an overall average value for all cases of $\frac{J_{tot}(2)}{J_{tot}(1)}$ = 1.640 for 314 samples.

Table 1. Average Values of $\frac{J_{tot}(2)}{J_{tot}(1)}$ for Several Orbits

(J_{tot} Values are for Channels 1-8 Only)

Orbit	220	438	530	959	Total
Case A, |pa 1 - pa 2| ≤ 2°					
n	12	4	17	2	35
$\overline{x}$	1.614	1.651	1.578	1.425	1.590
s	0.182	0.079	0.272	0.093	0.221
Case B, 2° < |pa 1 - pa 2| ≤ 10°					
n	35	14	68	19	136
$\overline{x}$	1.650	1.622	1.650	1.682	1.651
s	0.179	0.165	0.209	0.224	0.198
Case C, 10° < |pa 1 - pa 2| ≤ 20°					
n	43	13	69	18	143
$\overline{x}$	1.606	1.648	1.638	1.734	1.642
s	0.194	0.172	0.361	0.274	0.294
Case A + B + C					
n	90	31	154	39	314
$\overline{x}$	1.624	1.637	1.637	1.693	1.640
s	0.186	0.156	0.292	0.249	0.248

3.2 Comparison of Each Energy Channel (1-16) of the Two Detectors

As a second technique, we compared the counts for each energy channel of the two detectors. Table 2 shows the ratio of the counts from Detector 2 to the counts of Detector 1 for each of the 16 energy channels. Eighty-eight samples were used from Orbit 220 for Channels 1-8 and 40 samples were used for Channels 9-16. It can be seen that in the lower energy analyzers, the lowest average ratio is in Channel 7 (1.579) and the highest value is in Channel 4 (1.655). The average for all values of Channels 1-8 is 1.619. The ratios in Channels 9-16 vary from [illegible] to 1.08[illegible] and the average ratio for these channels is 1.022. Thus, the [illegible] energy analyzers are in excellent agreement.

Figure 1 shows a sample of the differential spectra for the [illegible] channels of the two detectors. It can be seen that the low energy portion [illegible] two curves are not in agreement. By correcting the [illegible] values of Channel [illegible] Detector 1 by multiplying each value by 1.6[illegible] [illegible] third spectrum. This gives good agreement with the lower energy portion of the spectrum from Detector 2.

Table 2. Ratio of Counts for Each Energy Channel, Both Detectors

	Cts (Det 2) / Cts (Det 1)		Cts (Det 2) / Cts (Det 1)
Ch 1	1644 ± 0. 165	Ch 9	1.017 ± 0.189
2	1.652 ± 0.234	10	0.989 ± 0.120
3	1.609 ± 0.267	11	1.000 ± 0.137
4	1.655 ± 0.160	12	1.043 ± 0.189
5	1.594 ± 0.159	13	1.006 ± 0.148
6	1.592 ± 0.199	14	1.020 ± 0.176
7	1.579 ± 0.242	15	1.011 ± 0.180
8	1.626 ± 0.157	16	1.086 ± 0.223

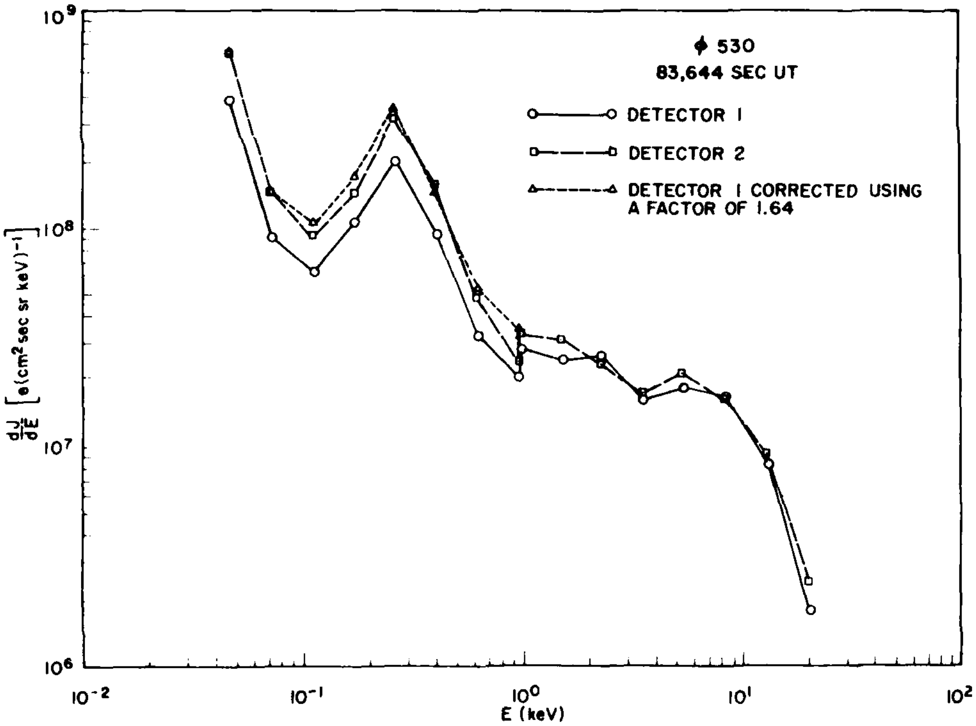

Figure 1. Electron Differential Energy Spectra of All Channels From Both Detectors

3.3 $\frac{dJ}{dE}$ Values for Channels 8 and 9, Both Detectors

Orbits 220 and 530 are used to obtain counts for Channels 8 and 9 from both detectors. Thirty samples are from orbit 220 and 40 samples from orbit 530.

Since Channel 8 is centered at 0.974 keV and Channel 9 at 1.000 keV, they should count nearly alike. In addition, Channel 8 on each detector should be nearly equal, as should Channel 9 on each detector. The question arises as to whether the low energy analyzer of Detector 1 is counting low or that of Detector 2 is counting high. This question can be resolved by these comparisons.

It can be seen in Table 3 that the ratio $\left(\frac{8_2}{8_1}\right)$ of the differential flux values, dJ/dE, of both channels is 1.639 and the ratio $\left(\frac{9_1}{8_1}\right)$ of the dJ/dE values is 1.611. Both of these values agree very well with the overall average value of 1.640 from Table 1. In addition, the ratios, $\left(\frac{9_2}{9_1}\right)$ and $\left(\frac{9_2}{8_2}\right)$ of the differential fluxes are close to unity. Therefore, Channels 8 and 9 on Detector 2 agree well with each other and with Channel 9 on Detector 1. However, each of them is higher than Channel 8 of Detector 1 by a factor of about 1.600. This indicates that the low energy analyzer Channels 1 through 8 of Detector 1 give counts that are low by this factor.

Table 3. Comparison of Channels 8 and 9, Both Detectors

$\left(\frac{dJ}{dE}\right)$ Ratio	Rev 220	Rev 530	Overall
$8_2/8_1$	1.615	1.650	1.639
$9_2/9_1$	1.011	1.079	1.057
$9_1/8_1$	1.712	1.567	1.611
$9_2/8_2$	1.072	1.025	1.039

4. CONCLUDING REMARKS

It was observed in the early data from the electrostatic analyzers of satellite P78-1 that the $J_{[illegible]}$ values for Detector 1 were lower than those of Detector 2 even when Detector 1 was in a position relative to Detector 2 to measure higher electron counts. It was observed that the counts from the eight channels of the Detector 1 low energy analyzer were substantially lower than those from the eight channels of the Detector 2 low energy analyzer. The high energy analyzers were in good agreement in all channels (9-16).

In discussions with the designers and builders of the instruments,[3,4] the conclusion was reached that either one or both channeltrons in the low energy analyzer of Detector 1 was inefficient and gave a lower count than it should, or the problem was in the electronic circuitry of that analyzer which made the counting inefficient in all eight channels. In either case, the geometric factor of each of the eight energy channels was affected, causing a lower count than normal by a certain factor. In this report, the correction factor for the low energy analyzer data of Detector 1 is determined, to make all data useful.

Several orbits of data are analyzed and each analyzer and energy channel are compared when the two detectors are at or near the same pitch angle value, at which time they should read alike.

Three comparisons are made and all agree that the counts for all eight channels of the low energy analyzer of Detector 1 should be corrected by multiplying the counts of that analyzer by 1.6. If this is done, then the calculations of the differential flux dJ/dE, the integrated number flux J_{tot}, and the integrated energy flux J_{Etot}, will be performed in the same manner that they are for the other analyzers. The data are usable but must be corrected as just noted.

The data used in these calculations came from orbits that were early in the flight of P78-1. Some orbits, from several months later, will be analyzed to see if this correction factor for the low energy analyzer of Detector 1 remains the same or has changed. If the correction factor has changed, it will have to be updated at various intervals during the flight of P78-1.

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3. Pantazis, J., Huber, A., Hagan, M. P. (1977) Design of Electrostatic Analyzer, AFGL-TR-77-0120, AD 042564.

4. Huber, A., Pantazis, J., Besse, A. L., and Rothwell, P. L. (1977) Calibration of the SSJ/3 Sensor on the DMSP Satellites, AFGL-TR-77-0202, AD A045997.