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NOAA Data Report ERL SEL-4

AN ATLAS OF POLAR CAP ENERGETIC PARTICLE OBSERVATIONS

VOLUME II. NOAA-6: 8 JULY 1979 TO 10 MAY 1983

Space Environment Laboratory
Boulder, Colorado
September 1984

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Environmental Research Laboratories

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Herbert H. Sauer

Space Environment Laboratory
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AN ATLAS OF POLAR CAP ENERGETIC PARTICLE OBSERVATIONS

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An Atlas of Polar Cap Energetic Particle Observations:

Volume II. NOAA-6: 8 July 1979 to 10 May 1983

I. Introduction

The Space Environment Laboratory of the National Oceanic and Atmospheric Administration maintains Energetic Particle Sensors (EPS) aboard the NOAA-TIROS series of satellites. The instruments constituting the EPS measure the flux of protons (ions) and electrons mirroring above, and precipitating into, the top of the polar atmosphere. Beyond contributing to the Laboratory mission of providing continual monitoring of the geophysical environment, these data provide a continuous archive data base available to support both Laboratory research directed toward improvement of its services, and the needs of the community of users, both public and private, to whom knowledge of the geophysical environment is important.

This series presents graphical displays of the polar cap (herein defined as geomagnetic latitudes greater than 70°) averages of the proton and electron fluxes precipitating into the polar atmosphere, over the energy range of 30 keV to greater than 80 MeV for protons and greater than 300 keV for electrons. Volume I presents data over the operational lifetime of the TIROS-N spacecraft from 1 January 1979 to 28 February 28 1981, while Volume II presents data from the NOAA-6 spacecraft from 8 July 1979 to 10 May 1983. Subsequent volumes using data from the NOAA-6, -7 and -8 satellites will extend the data presentations.

No elaborate data analysis procedures have been used in the processing of these data other than the conversion to physical units, the restriction in geomagnetic latitude, and the removal of demonstrably bad data points. This decision has been dictated by economic constraints as well as consideration of the intended use of these data. The adopted definition of the polar cap ($\geq 70^{o}$

geomagnetic) is arbitrary: energetic particles arising from auroral or magnetospheric processes are known to precipitate into the atmosphere at latitudes above 70° geomagnetic.

II. The NOAA-TIROS Spacecraft

The NOAA-TIROS spacecraft are low-altitude, polar-orbiting, sun-synchronous satellites, including to date TIROS-N, NOAA-6, NOAA-7, and NOAA-8. Nominal characteristics of their respective orbits and associated data availability are given in Table 1.

TABLE I

Nominal Satellite Characteristics

Satellite Designation	Altitude (km)	Period (min)	Local Time Plane (hours)	EPS Data Acquisition (dates)
TIROS-N	853.5	102	0330, 1530	1/1/79 - 2/28/81
NOAA-6	815.5	102	0730, 1930	7/8/79 - 5/10/83
NOAA-7	849.2	102	0330, 1500	7/11/81- 4/1/82
NOAA-8	815.5	102	0730, 1930	4/11/83-Current

The spacecraft are in retrogade 98° inclination orbits as required for sun-synchronism. Because of the tilt of the earth's rotation axis with respect to the celestial pole, and the tilt of the dipole axis with respect to the rotation axis of the earth, the time spent within the polar cap during each orbit varies both diurnally and seasonally. The range is from zero to a maximum of about 12 minutes. This behavior, together with the consequences of the arbitrary polar cap definition noted earlier, produces the apparent noisiness of some of the traces, with a diurnal variation that is quite evident in the data displays. The Energetic Particle Sensors (EPS) aboard the

NOAA-TIROS series of spacecraft are nominally identical.

III. The Medium Energy Proton and Electron Detector

Each Medium Energy Proton and Electron Detector (MEPED) consists of two sensor subassemblies: the Telescope Sensors, and the Dome Detectors.

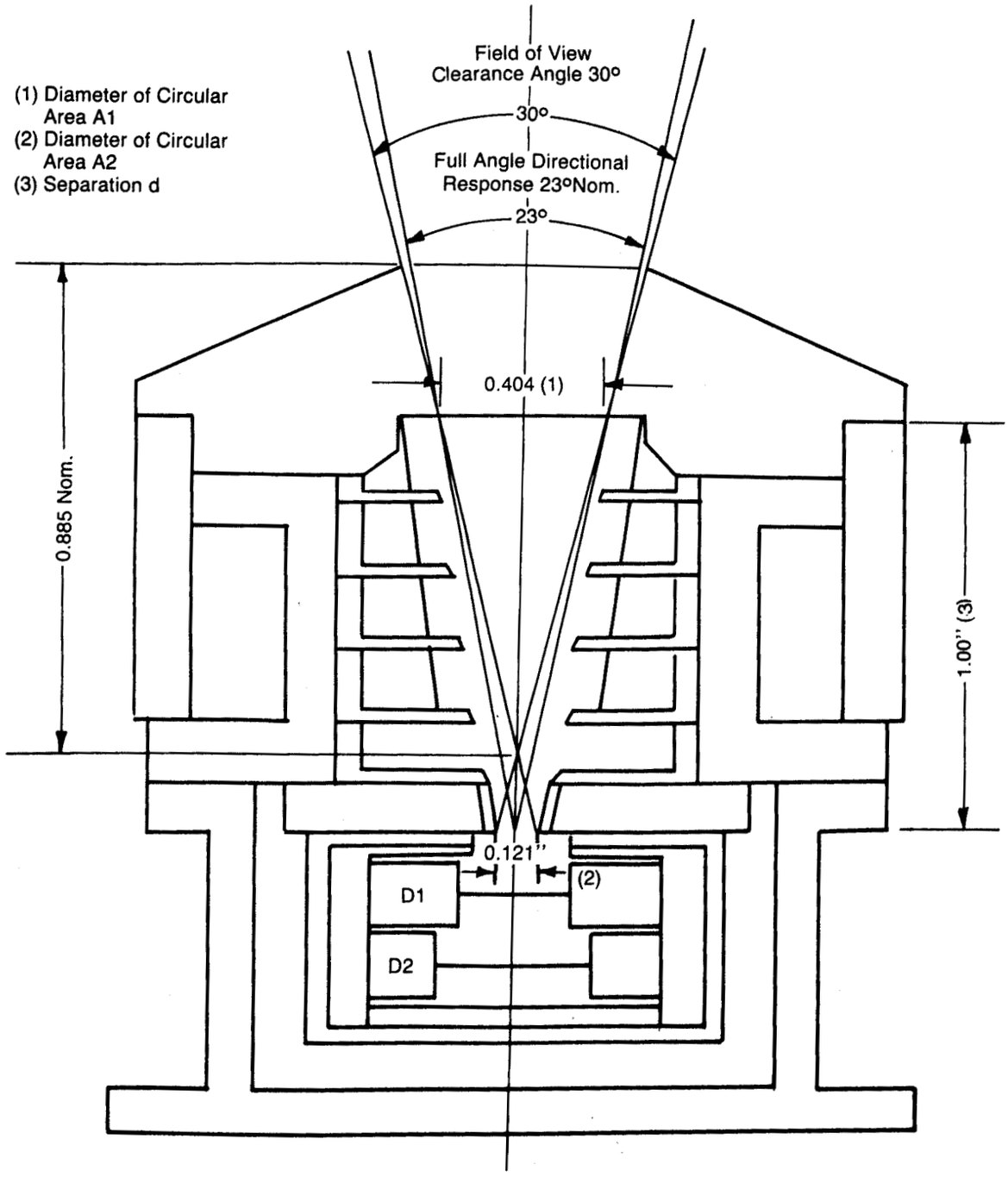
III.1 The Telescope Sensors:

The Telescope Sensors consist of four sensor systems, a pair of which view the local zenith (precipitating particles), and a pair that "look" at approximately 90° to the zenith (locally mirroring or trapped particles). Each pair consists of a proton telescope and an electron detector.

The proton telescope (Figure 1) has a geometric factor of 9.5×10^{-3} cm-ster. Electrons are eliminated with a 2.5 kilogauss (minimum field strength) Alnico VIII Magnet. No particle with a magnetic rigidity of less than 6200 gauss-cm can strike the detector unless it scatters. This threshold corresponds to 1.5 MeV for electrons and 2 keV for protons. The proton threshold for the telescope is $\simeq$ 30 keV. These ions have a radius of curvature greater than 40 cm in the field of the magnet, and should therefore be virtually unaffected by the presence of the magnetic field. The telescope consists of two 200 micron thick silicon surface barrier detectors. The front detector (D1) has an effective area of 25 mm^2, and the other (D2) has an effective area of 50 mm^2.

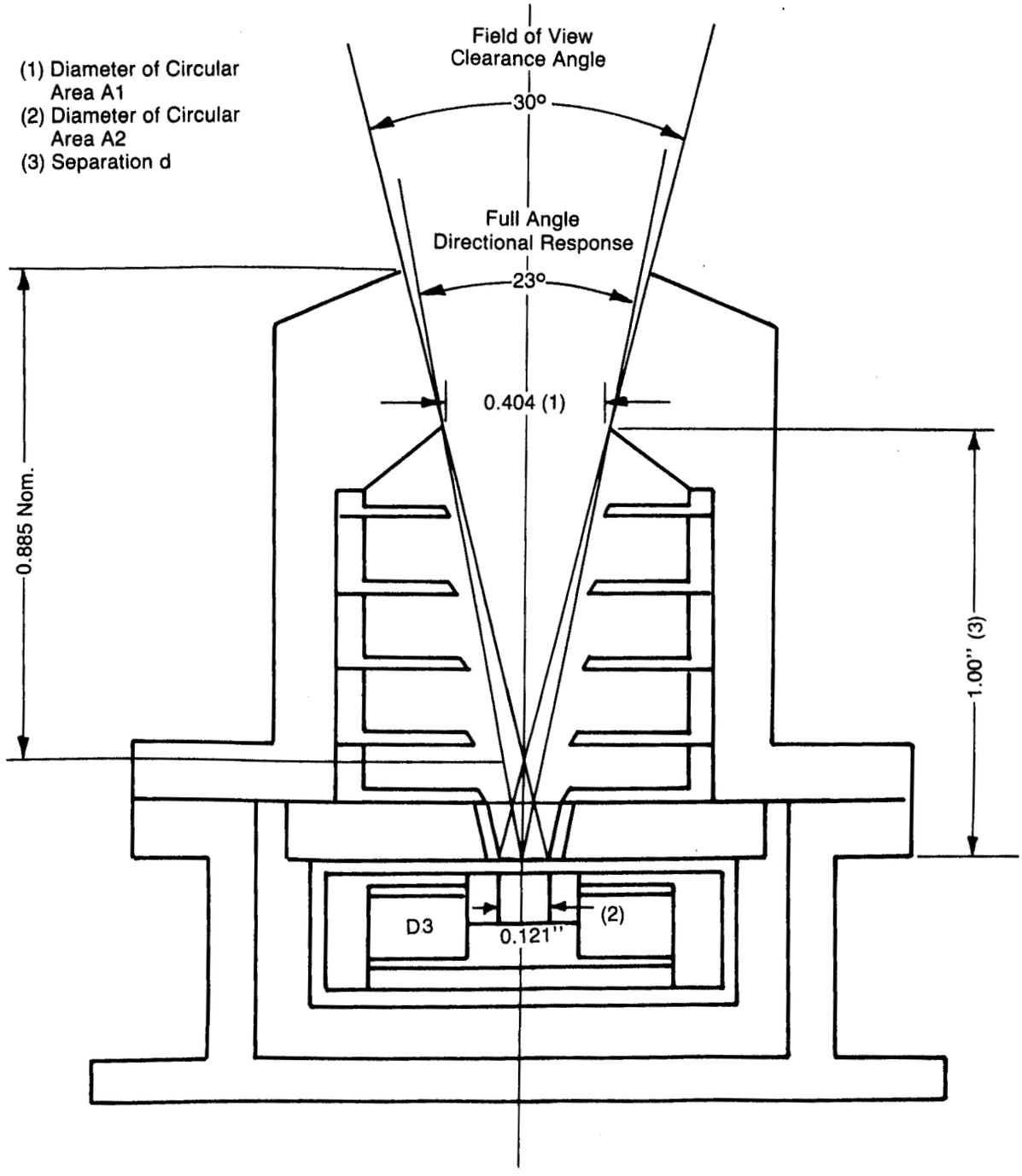
Each proton telescope measures ions in five energy passbands over the range of 30 keV to greater than 2.5 MeV through the application of selective logic on the detector discrimination levels.

The electron detector (Figure 2), has the same geometric factor as the proton telescope, 9.5×10^{-3} cm^2-ster. The detector is a 1700 um thick, 25 mm^2 silicon surface barrier. A thin nickel foil in front of the detector aperture reduces the proton contribution to the detector count rate. The foil



PROTON TELESCOPE

Figure 1



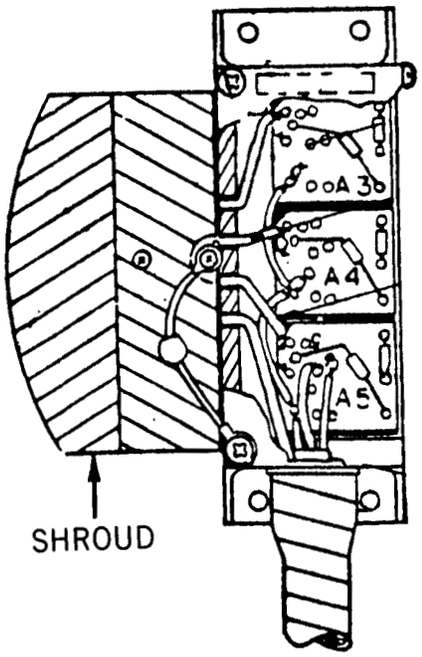
ELECTRON DETECTOR

Figure 2

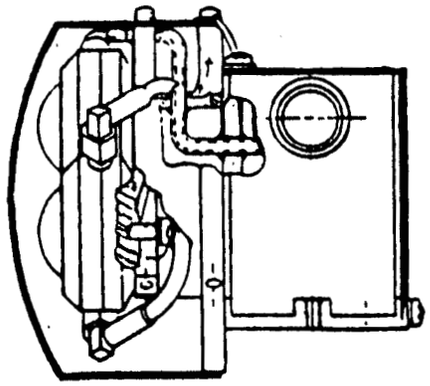
is approximately 20 um thick, and removes any sensitivity to protons below 175 keV. Anti-coincidence logic effectively removes any proton sensitivity above 1.1 MeV from the electron detector.

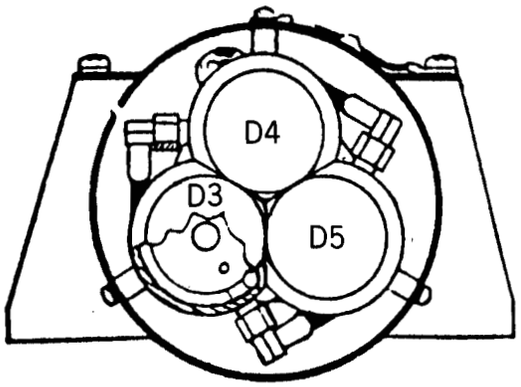
III.2 The Dome Detector

The Dome or omnidirectional sensors consist of three nominally identical Kevex, lithium-drifted, silicon solid-state detectors of 50 cm^2 area, and 3 mm thickness. They are independently mounted under spherical shell moderators to provide sensitivity in three integral data channels. Each detector has a full opening angle of 120° in the zenithal direction as mounted on the spacecraft. The overall out-of-aperture shielding of each detector is an identical 80 MeV, in order that the principal spurious response may be eliminated through simple subtraction of the appropriate detector count rates. Figure 3 is a schematic view of the Dome detectors.



SIDE VIEWS





"KEVEX"
Si (Li)
DETECTOR 3 PLACES

D3 = ALUMINUM DOME
D4 = COPPER DOME
D5 = TUNGSTEN DOME

DOME DETECTORS

Figure 3

III.3 MEPED Characteristics

The pertinent characteristics of the MEPED detectors appropriate to this report are given in Table 2.

TABLE 2. MEPED CHARACTERISTICS

Ion	Channel Designation	Energy	Geometric Factor (cm^2 ster)	Accumulation Time (s)
Proton	P1	30-80 keV	9.4×10^{-3}	1
Proton	P2	80-250 keV	9.4×10^{-3}	1
Proton	P3	250-800 keV	9.4×10^{-3}	1
Proton	P4	800-2500 keV	9.4×10^{-3}	1
Proton	P5	>2.5 MeV	9.4×10^{-3}	1
Proton	P6	16-80 MeV 80-215 MeV	1.57 5.4	2
Proton	P7	36-80 MeV 80-215 MeV	1.57 5.4	2
Proton	P8	80-215 MeV	5.4	2
Electron	E1	>30 keV	9.5×10^{-3}	1
Electron	E2	>100 keV	9.5×10^{-3}	1
Electron	E3	>300 keV	9.5×10^{-3}	1

The equality of the secondary energy response of channels P6 and P7 is an indication of the design decision to have the out-of-aperture response of the three Dome detectors equal. This allows correction through subtraction of the P8 channel output from the primary channel response from P6 and P7.

IV. The Data Presentation

The figures in the Appendix display the observed fluxes of the indicated particles and their energy ranges, time-averaged over that portion of each orbit lying above 70° geomagnetic latitude. The display format is identical throughout.

IV.1 The Display Format

- Each page displays data for a period of up to 11 days (3 pages per month).
- The lower left panel identifies the particle type, i.e., electrons or protons (ions), and the corresponding energy range for each data channel displayed.
- The legend at the upper right inside each data frame gives the order of presentation of the channels and identifies the scale factor applied to each channel. For example, P1 • E05 denotes a scale factor of 10^5 on channel P1.
- The ordinates are in day of the year (Day 1 = January 1).
- The abscissae are in differential flux units for the lower energy proton channels P1 through P4 displayed in the upper left panel. Integral flux units are used for the higher energy proton channels P5 through P8 and the electron channels E1 through E3 displayed on the right panels of each page.
- The calendar date corresponding to the start day of the year for the data displayed is given at the bottom of each page. (Note: A table of conversions from calendar date to day of year is given in the Appendix.)

IV.2 Display Data Interpretation

No analysis of the data has been done beyond that necessary to provide an intended level of information including the following:

- Identification of solar cosmic ray events.
- Identification of entry of enhanced fluxes of particles from other sources (for example, those possibly associated with an approaching shock).
- Identification of periods of interest within the archive data base.
- Establishment of an event chronology.
- Intercomparison with equivalent sensors on other platforms.

The information goal has been achieved; however certain things should be borne in mind in interpreting the data displayed.

- Invalid data points have not been entirely removed. This should not be a severe problem - isolated spikes are usually identifiable.
- Particle injections resulting from auroral and magnetospheric processes often intrude to latitudes above 70° geomagnetic. This is the cause of the increasing spikiness in the data as the energy decreases. The lower envelope of these curves, however, well represent the fluxes arriving at the top of the atmosphere along "open" field lines from the interplanetary medium.
- The use of the amplitude of the spikiness referred to, as some "measure" of geophysical activity is compromised by aliasing, owing to the limited local time coverage of the NOAA-TIROS satellite. This situation improves somewhat if the data from simultaneous observations on spacecraft at different local times, i.e., TIROS-N and NOAA-6, are compared.

- The spikiness of channel P6 (E_p > 16 MeV) is not due to anomalous 16 MeV protons; it is apparently due to frequent occurrences of large fluxes of trapped energetic electrons just equatorward of the auroral regions.

In sum, the lower envelope of the display traces gives a reliable measure of energetic particle fluxes of interplanetary orgin, such as solar cosmic rays. Small or short-duration events at lower energies (<1 MeV) may be distinguished from fluctuations in the aurorally produced "noise" with some experience, because of the characteristic, apparent diurnal variation of that noise.

V. Data Availability

The choice of data periods covered in each plot was dictated by the period of time covered by the associated archive data tape; i.e., there is a one-to-one correspondence between display plots and source tape. For information concerning the NOAA-TIROS archive data, and its availability, contact:

National Geophysical Data Center, E/GC2
ATTN: Dan Wilkinson
National Oceanic and Atmospheric Administration
325 Broadway
Boulder, Colorado 80303

For information concerning the data contained in this report, contact:

Dr. Herbert H. Sauer R/E/SE
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VI. Acknowledgment

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Appendix: Tables A-1 and A-2 may be used to convert between calendar date and day of the year. Data Plots of observed polar cap average fluxes are given in terms of numerical day of the year with day 1 = January 1.

TABLE A-1

DAY OF THE YEAR CALENDAR

(FOR NON LEAP YEARS)

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31
DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY

(FOR NON LEAP YEARS)

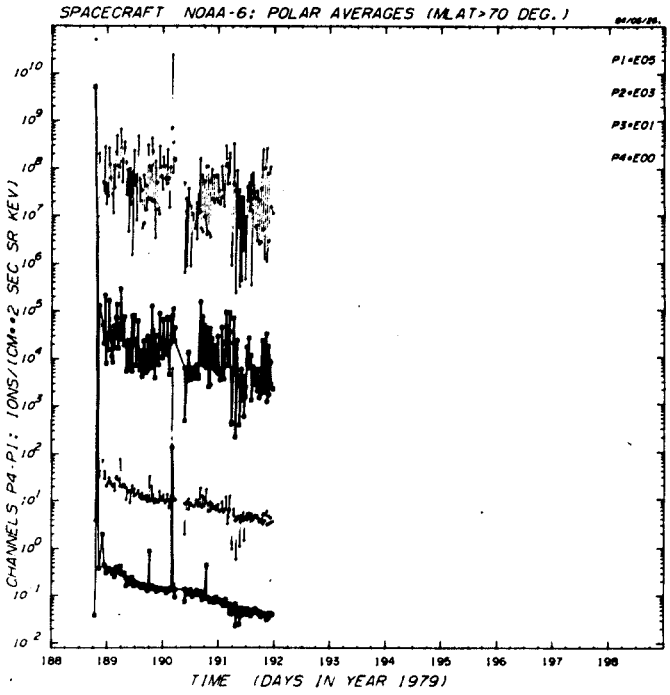
TABLE A-2

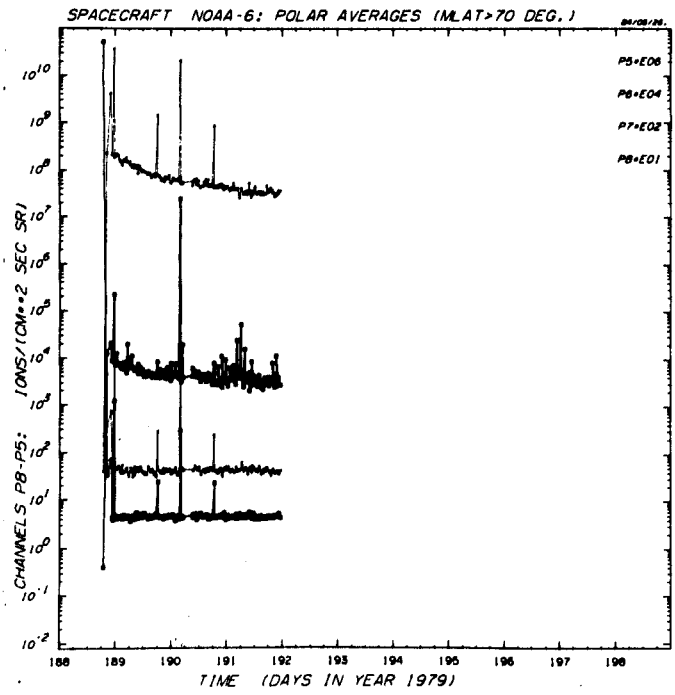
DAY OF THE YEAR CALENDAR

(FOR LEAP YEARS)

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31
DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY

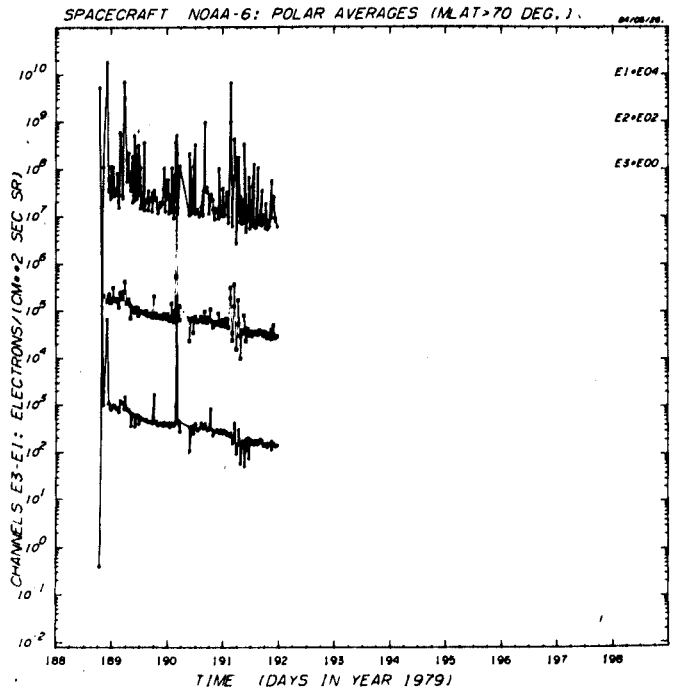
(FOR LEAP YEARS)





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
P2: E= 80 - 250 KEV
P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
E2: E > 100 KEV
E3: E > 300 KEV



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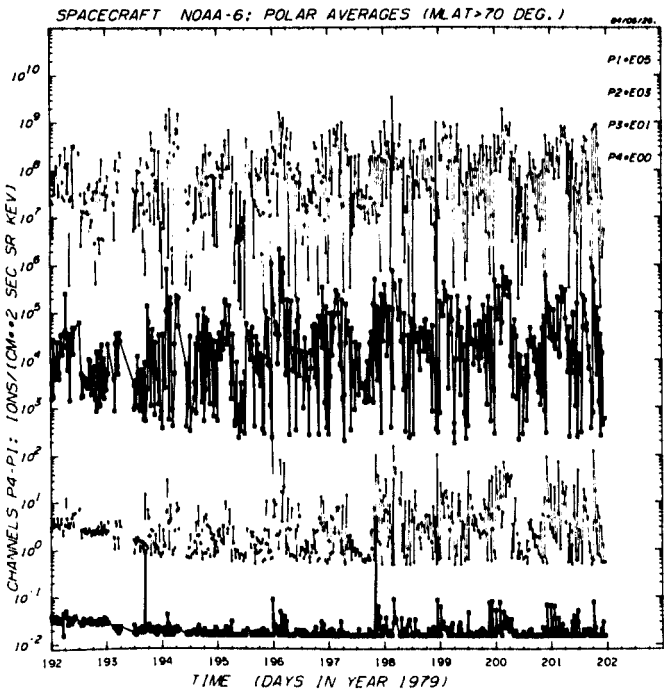
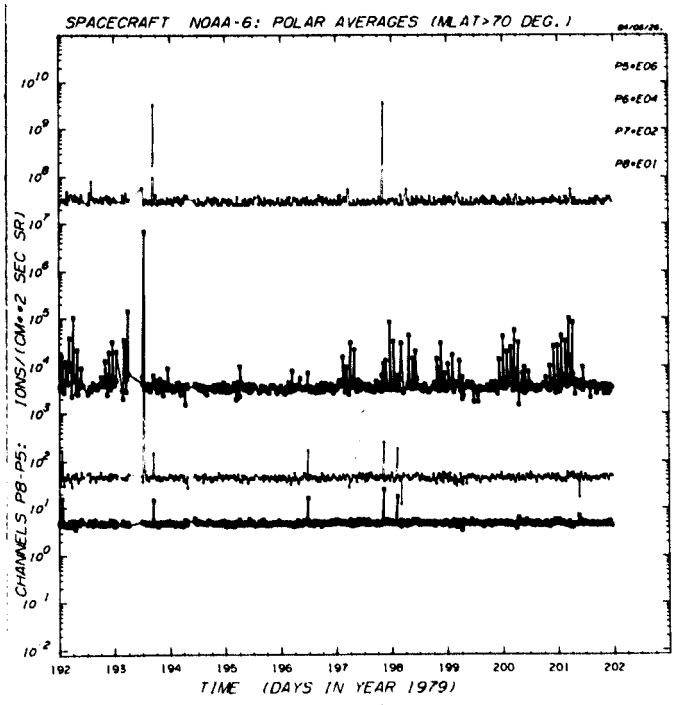
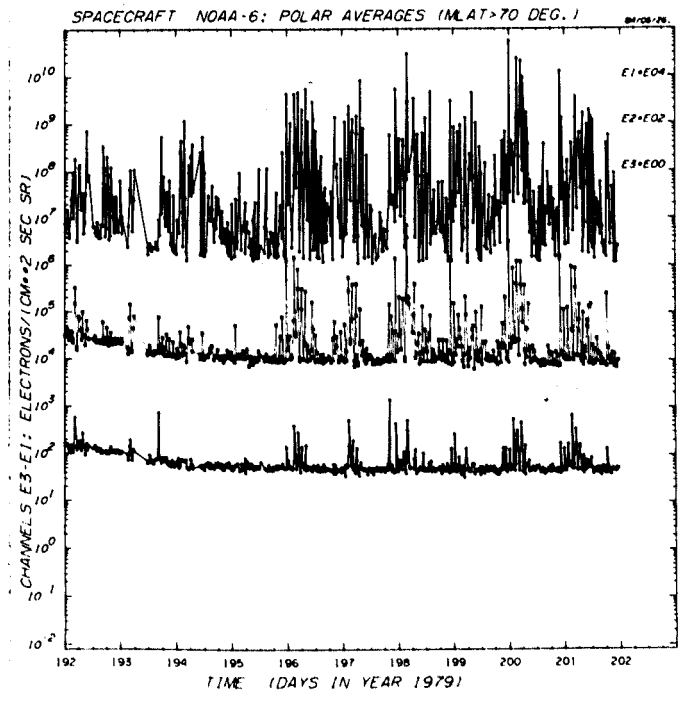




ENERGY CHANNELS:

P1: E= 30 - 80 KEV
P2: E= 80 - 250 KEV
P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
E2: E > 100 KEV
E3: E > 300 KEV



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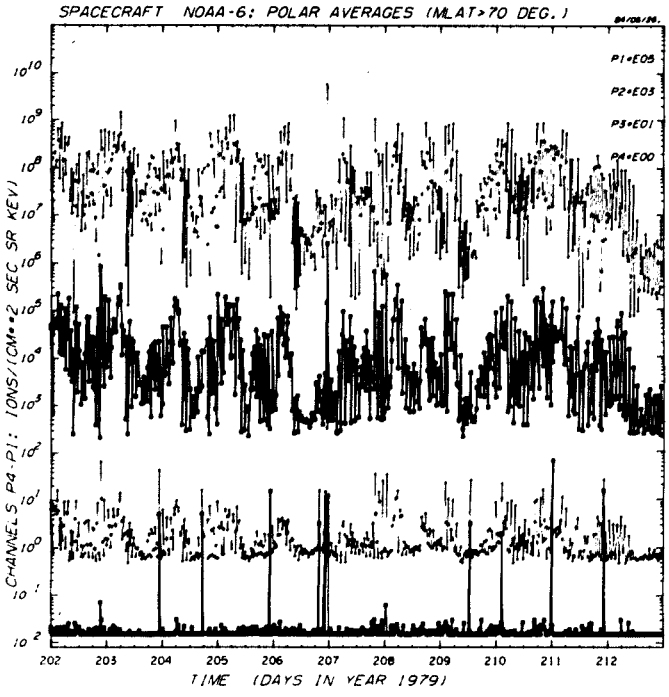

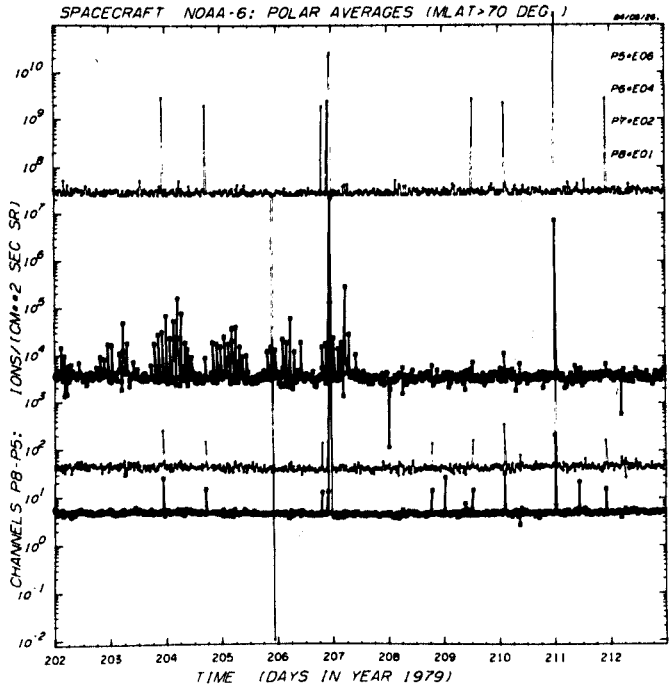

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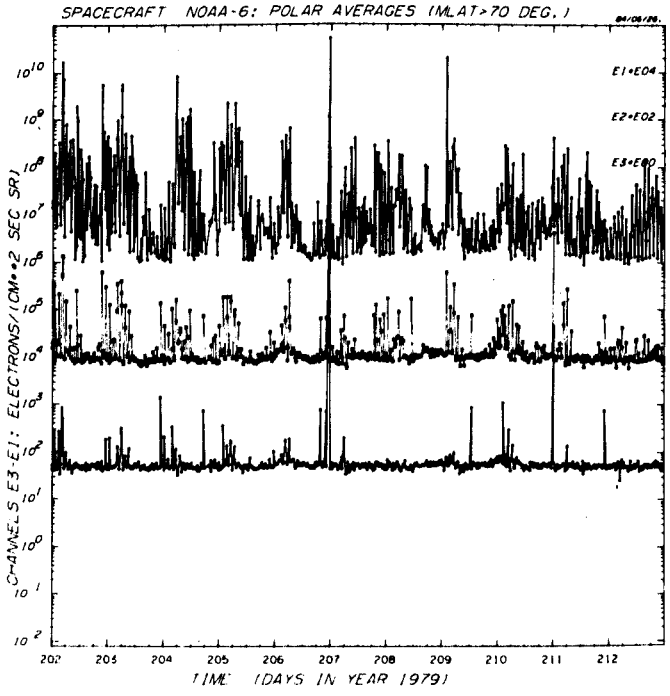
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
E2: E > 100 KEV
E3: E > 300 KEV



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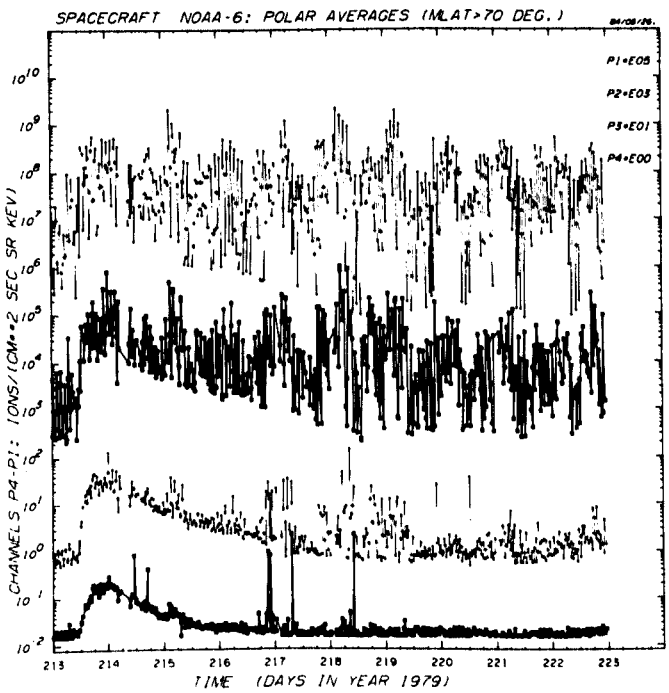

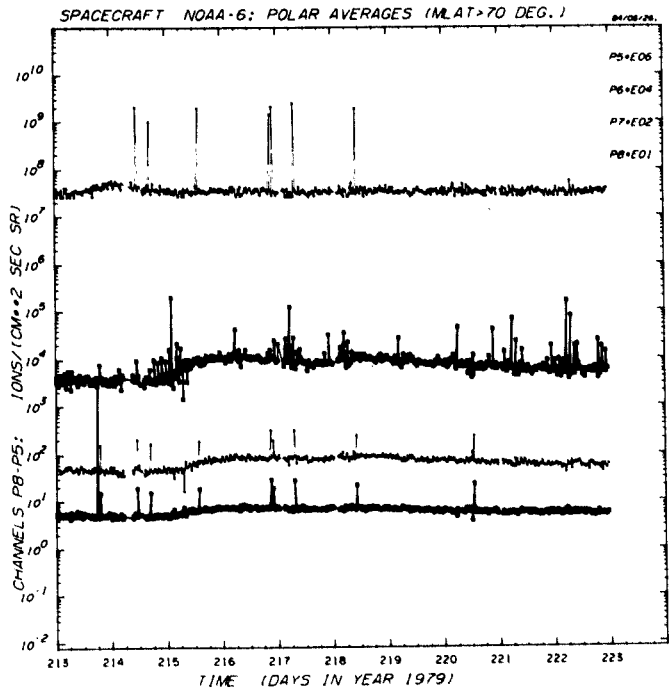

ENERGY CHANNELS:

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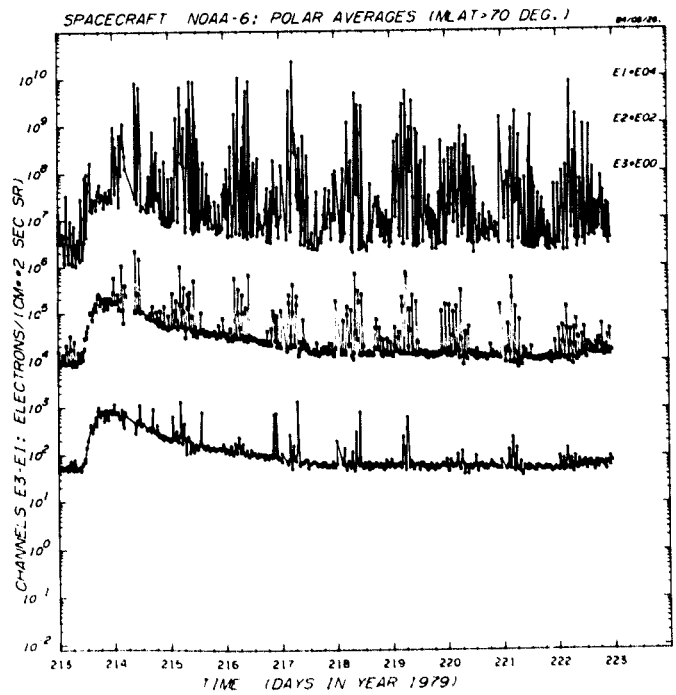
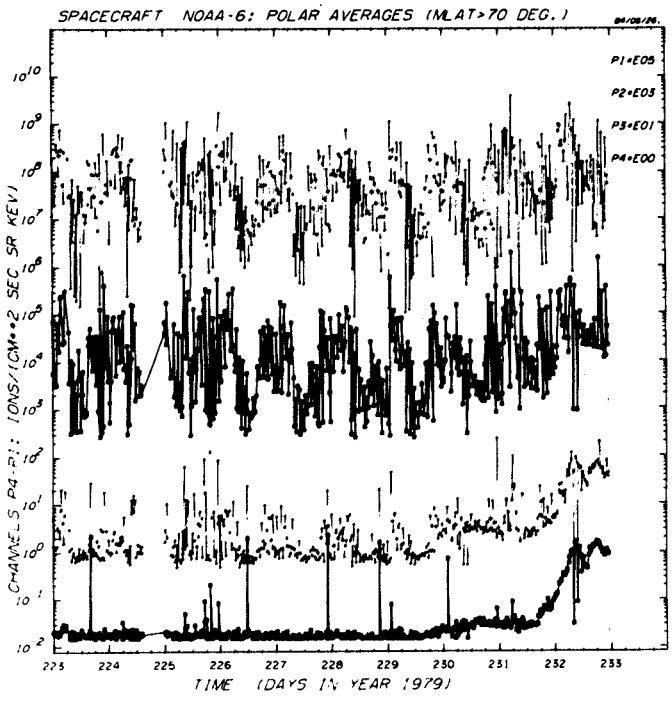
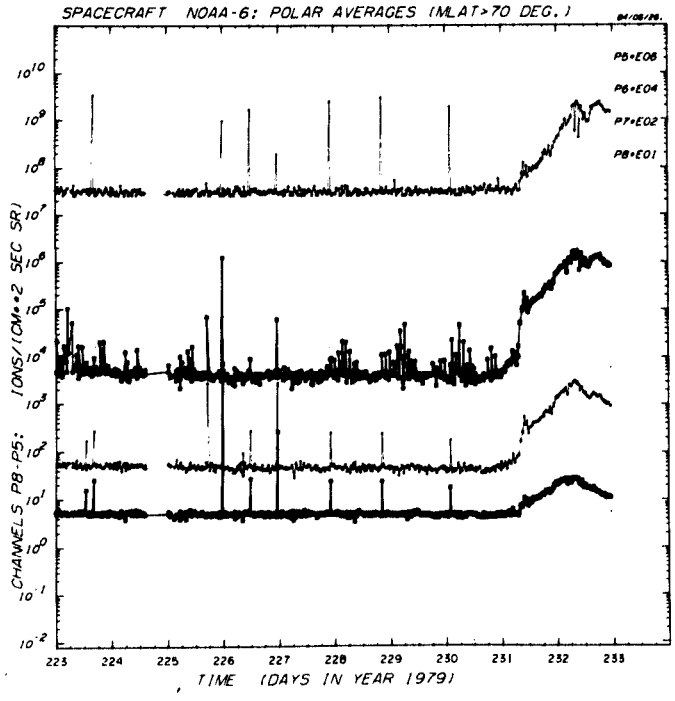
P2: E= 80 - 250 KEV
P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
E2: E > 100 KEV
E3: E > 300 KEV



August 1, 1979





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
P2: E= 80 - 250 KEV
P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
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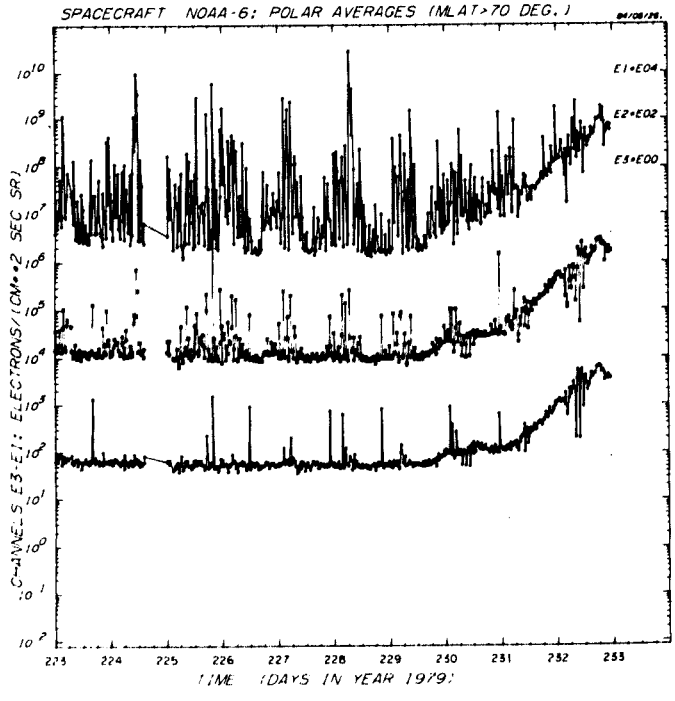
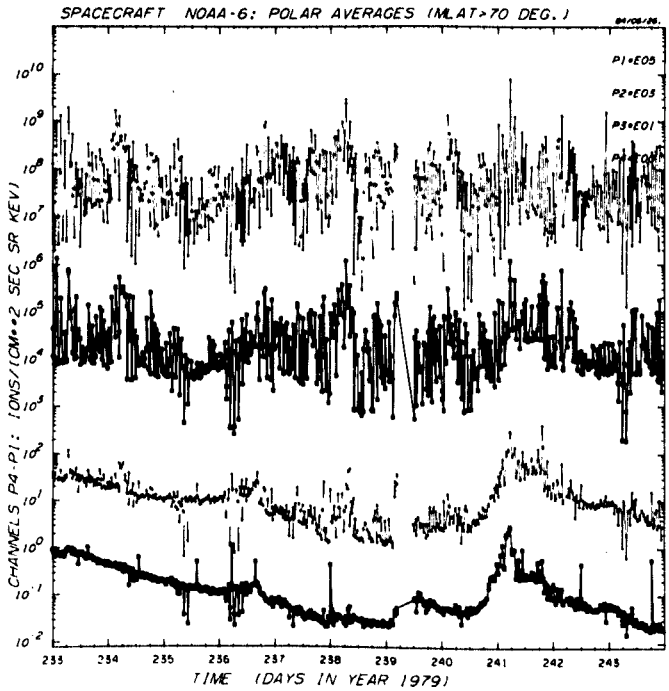
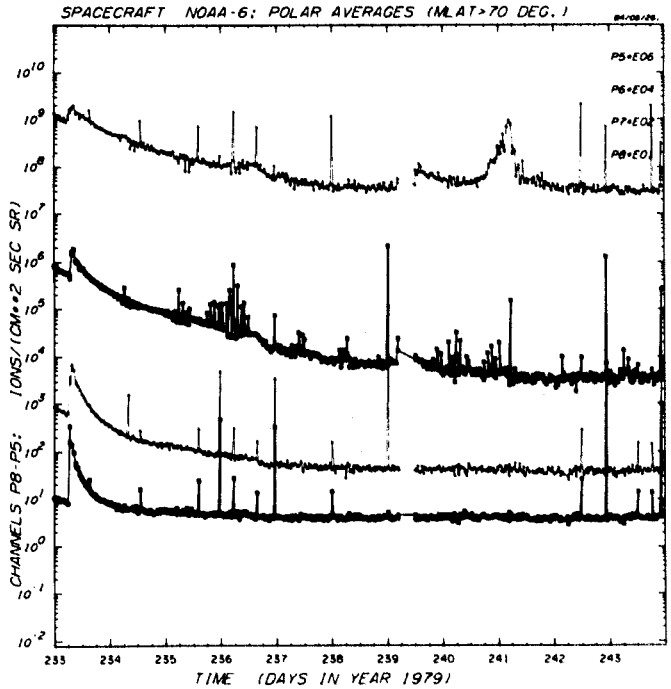


August 11, 1979





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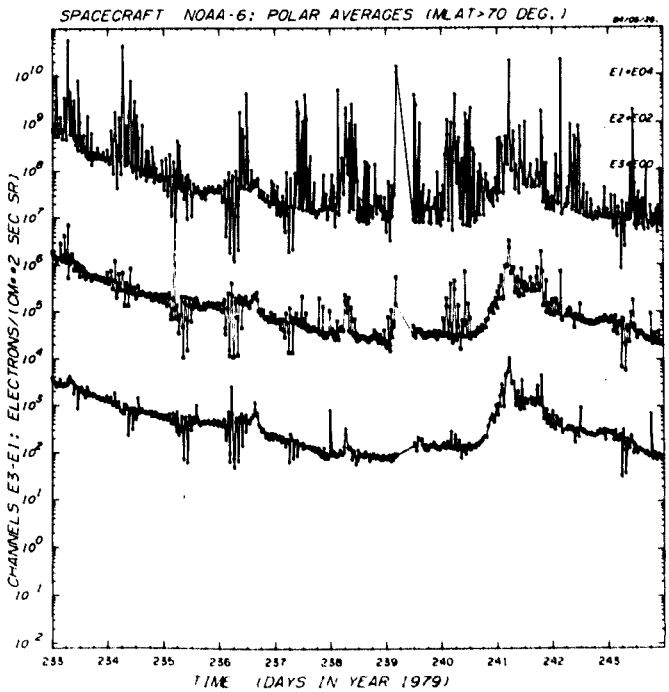
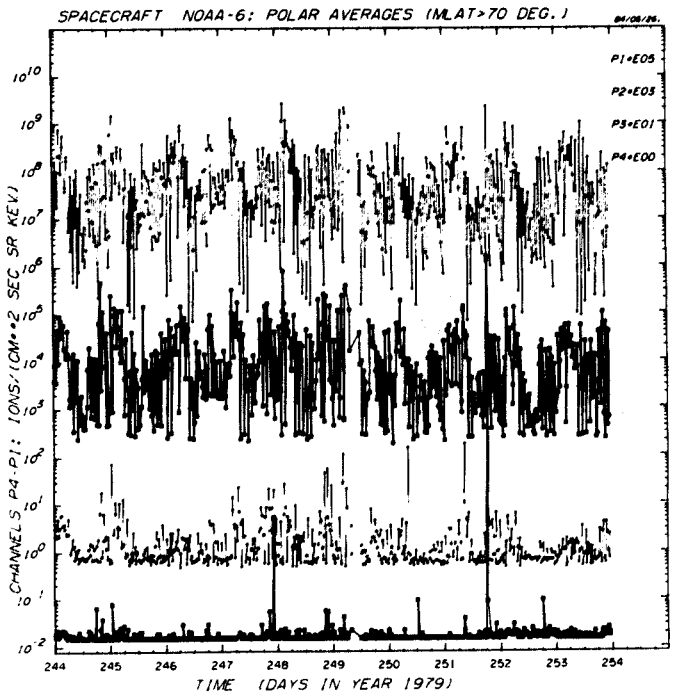
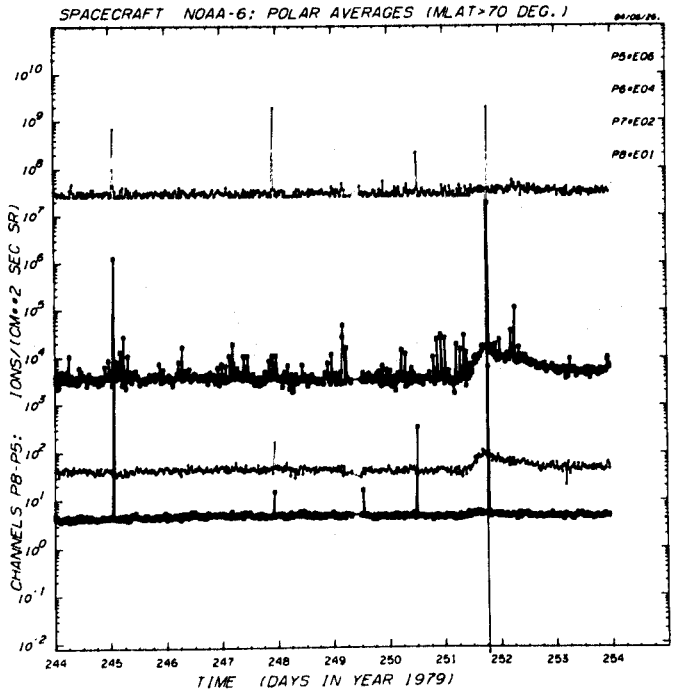


August 21, 1979





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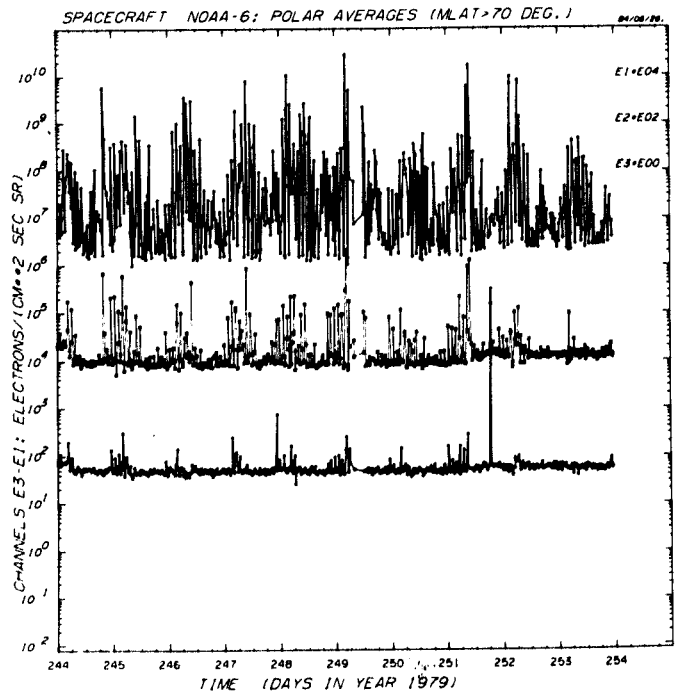
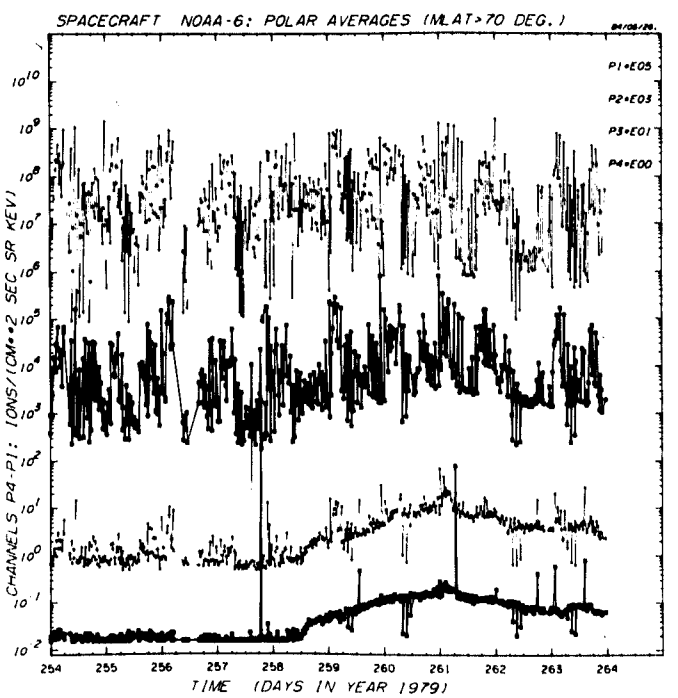
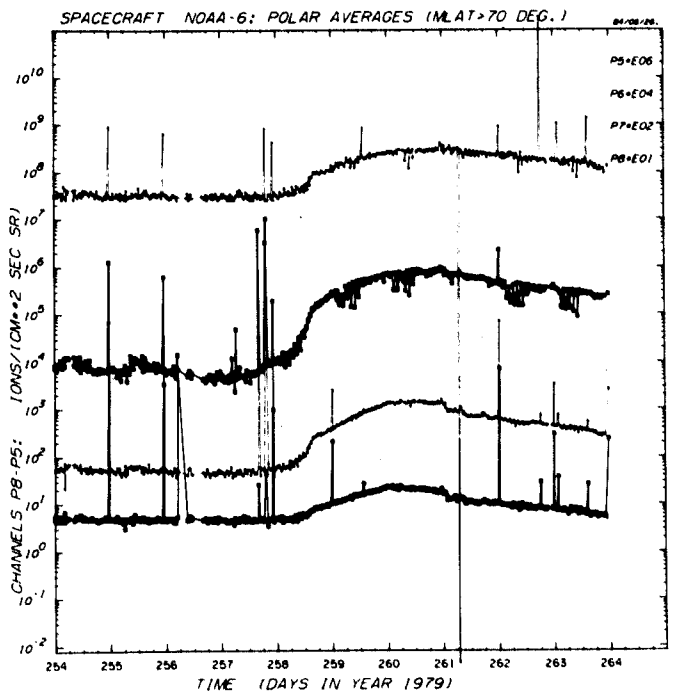


September 1, 1979





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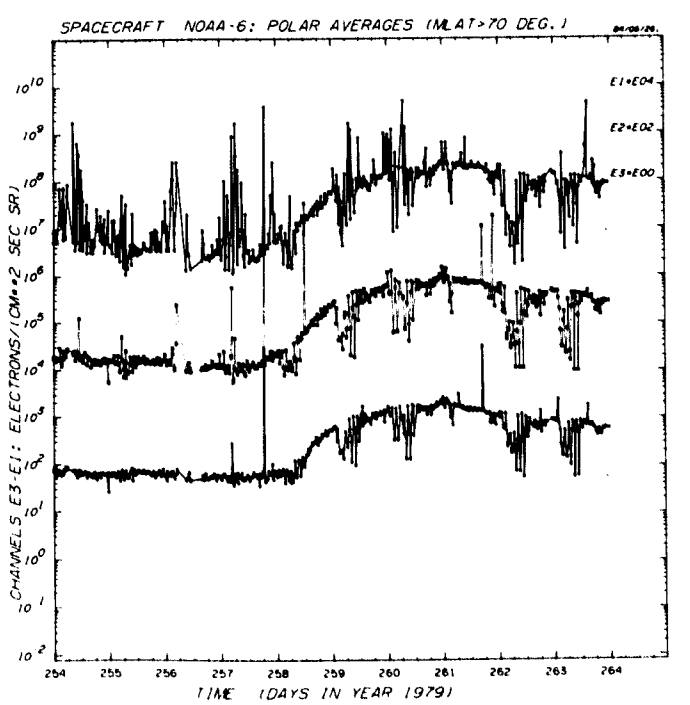
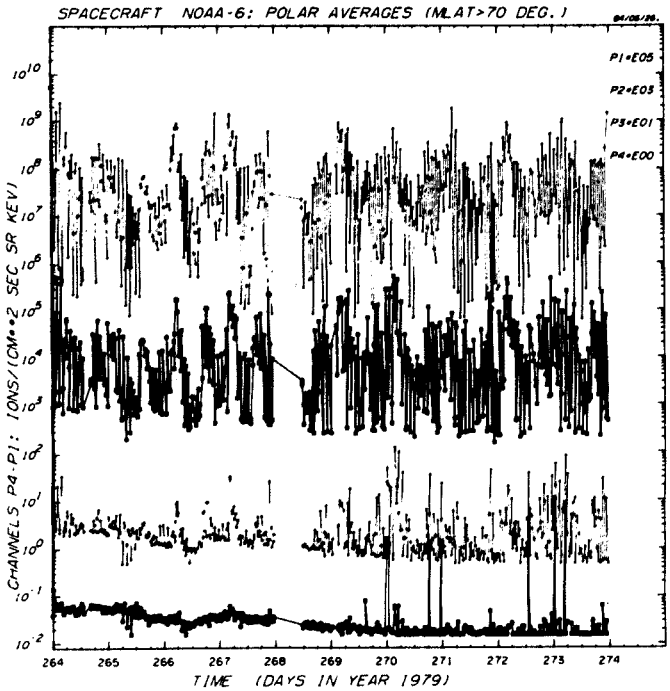
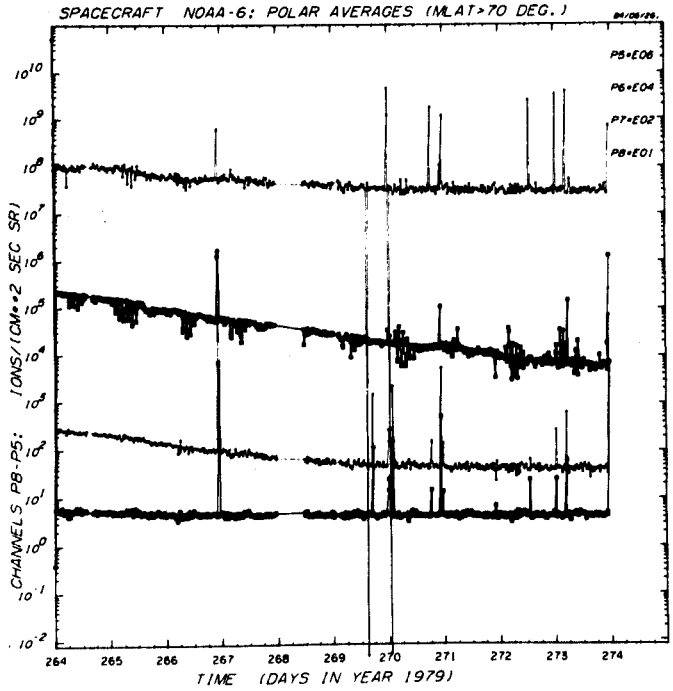


September 11, 1979





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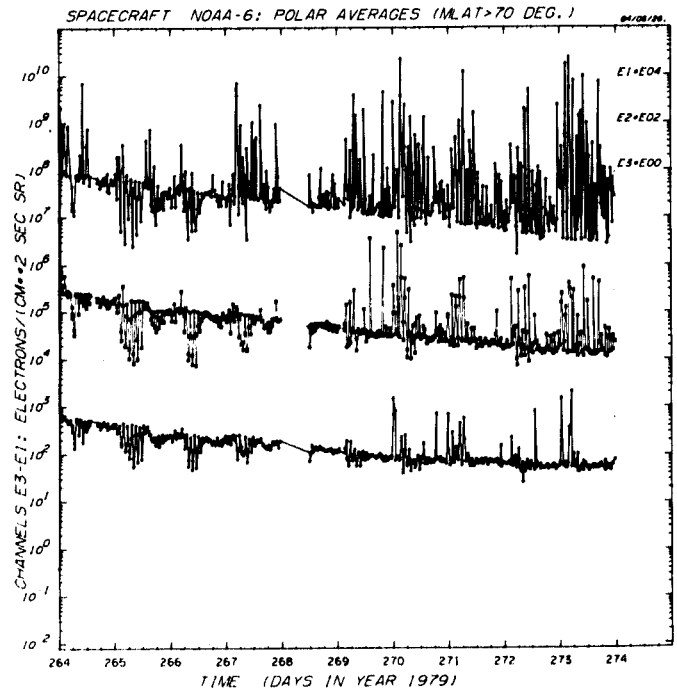
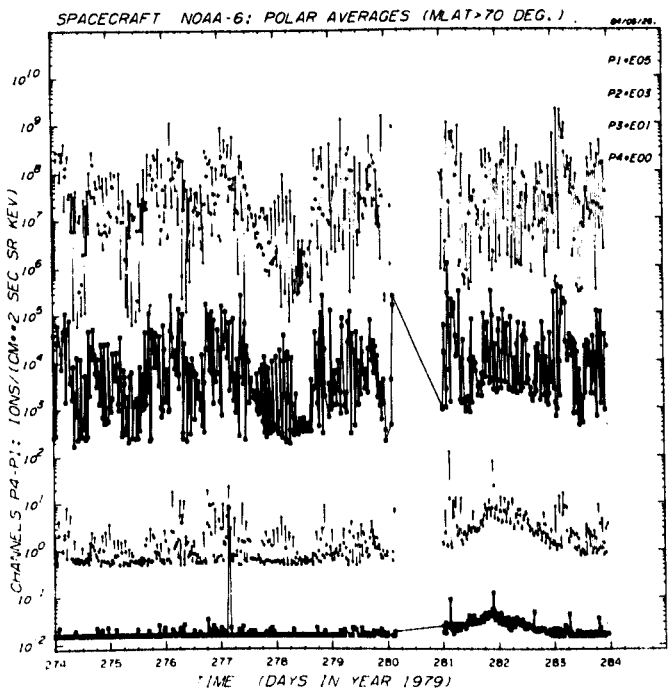
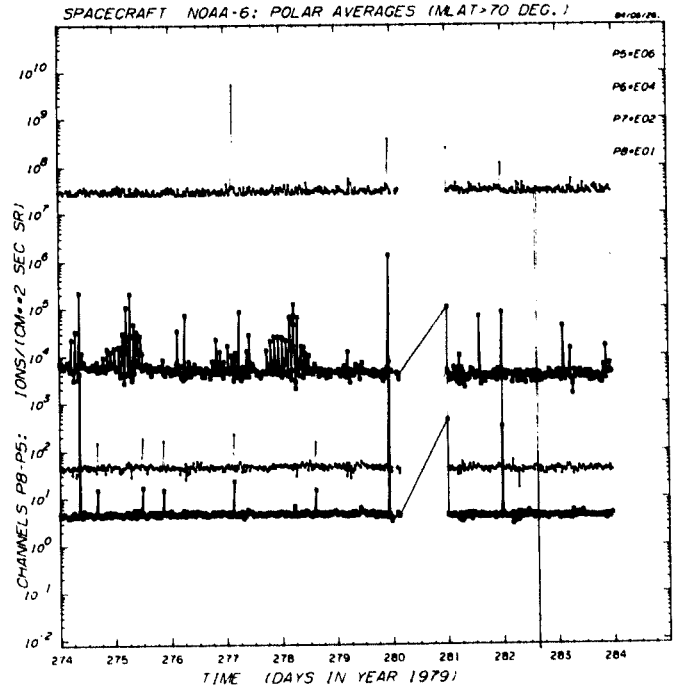


September 21, 1979





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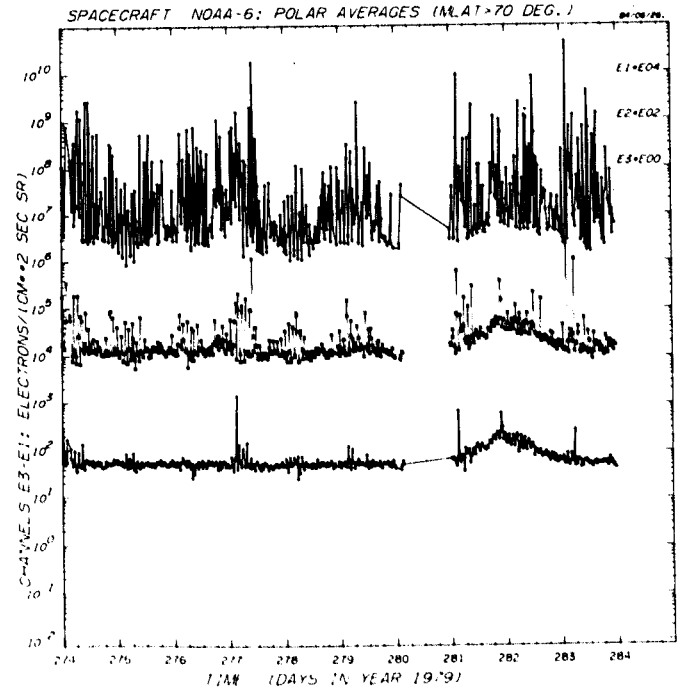
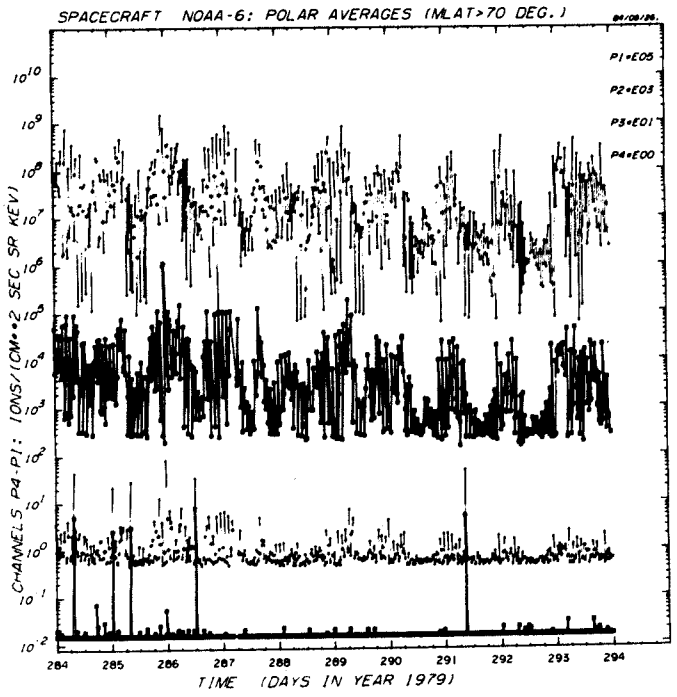
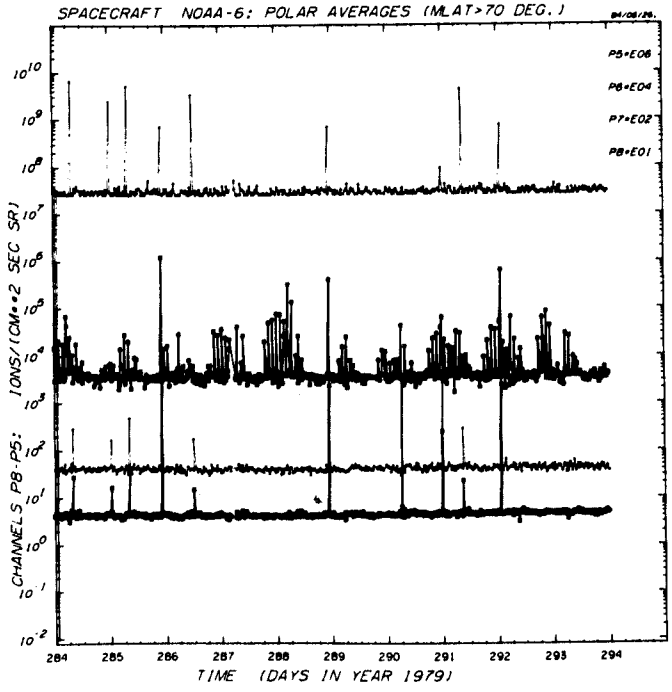


October 1, 1979





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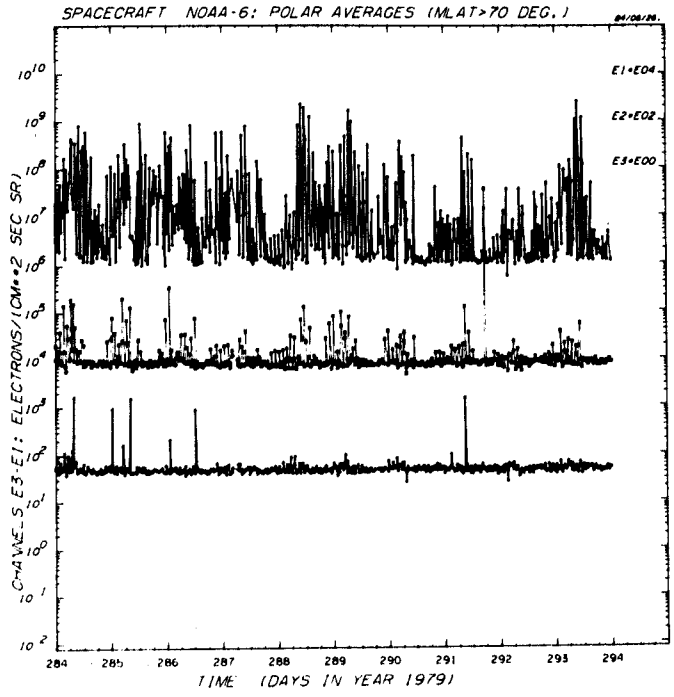
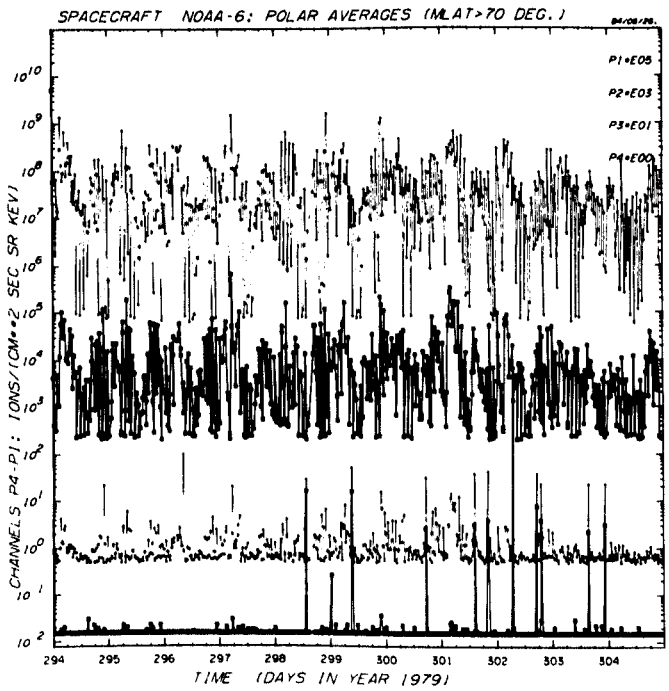
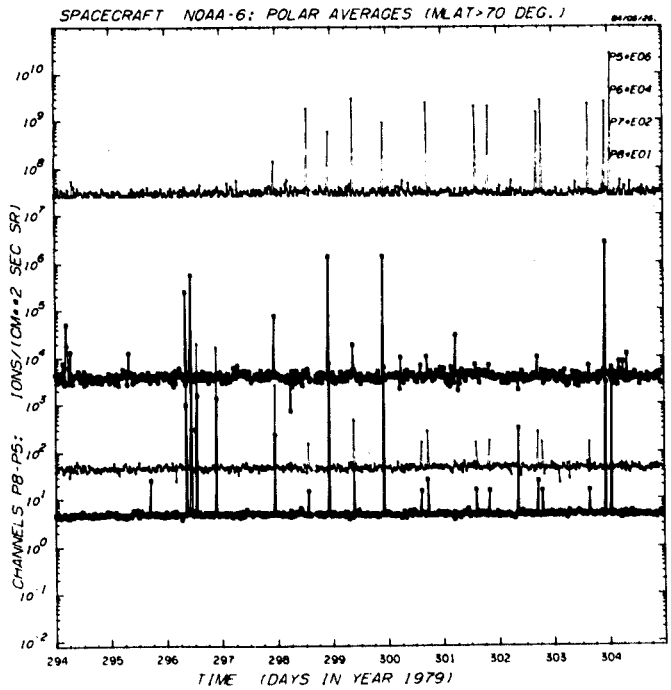


October 11, 1979





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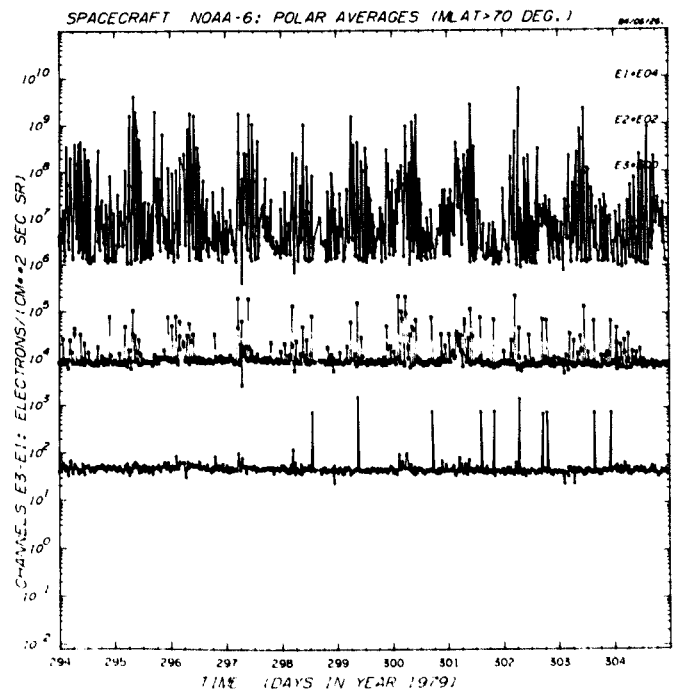
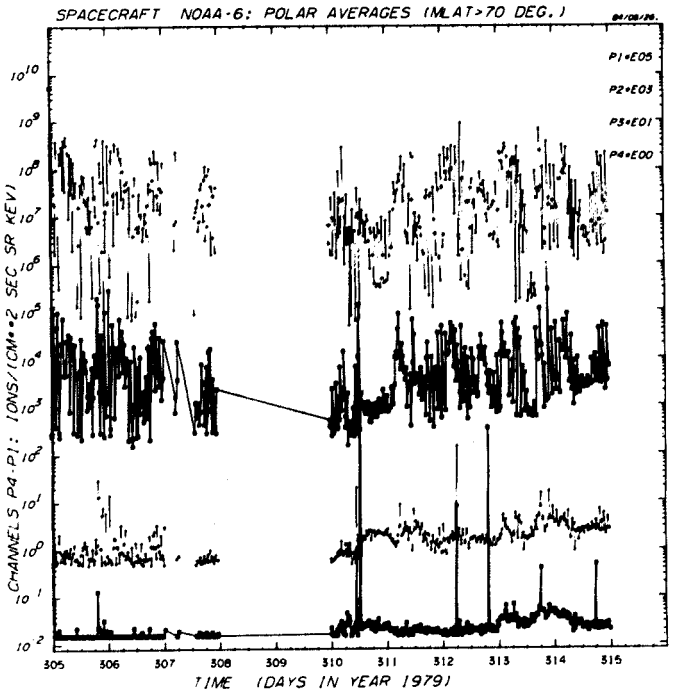
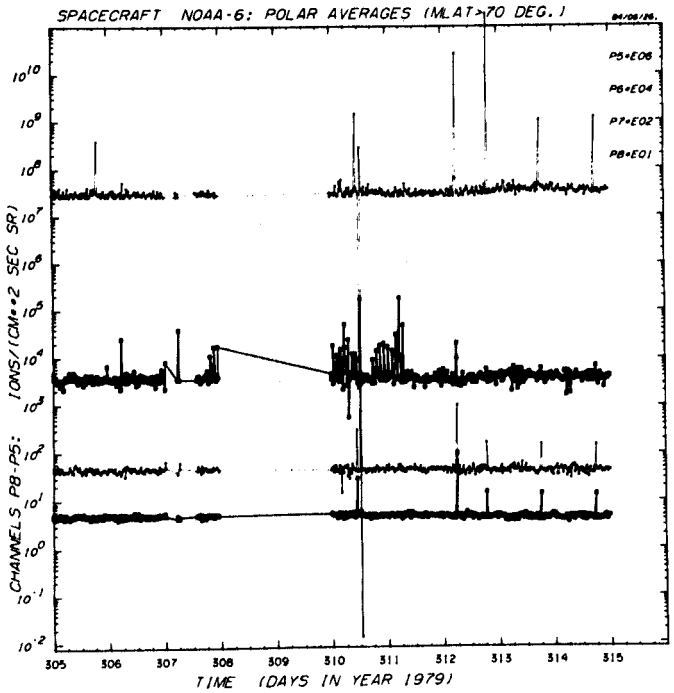


October 21, 1979





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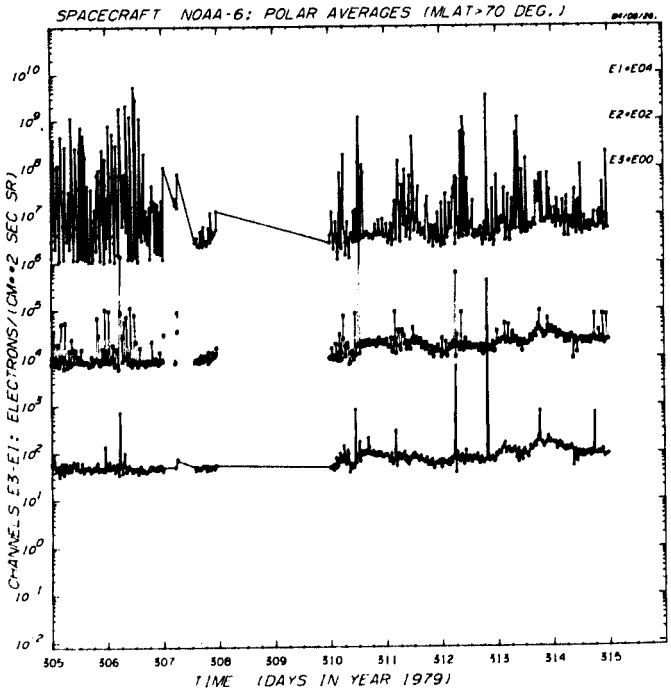
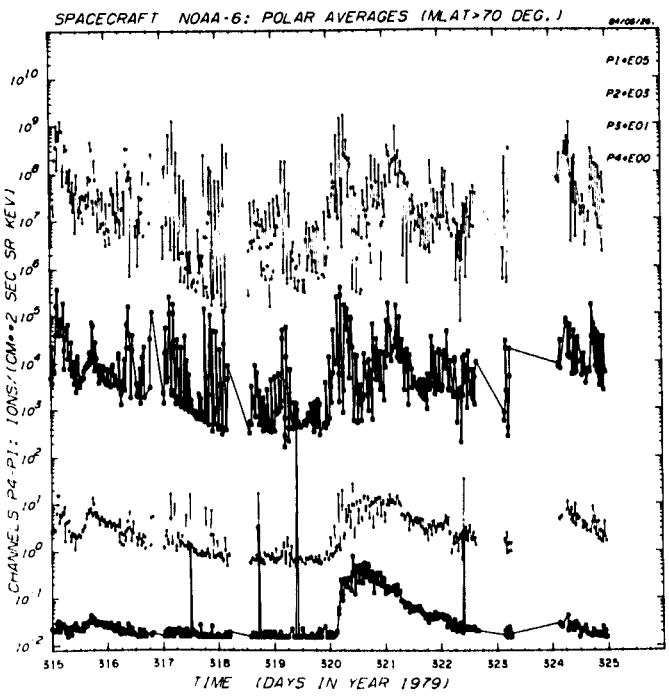
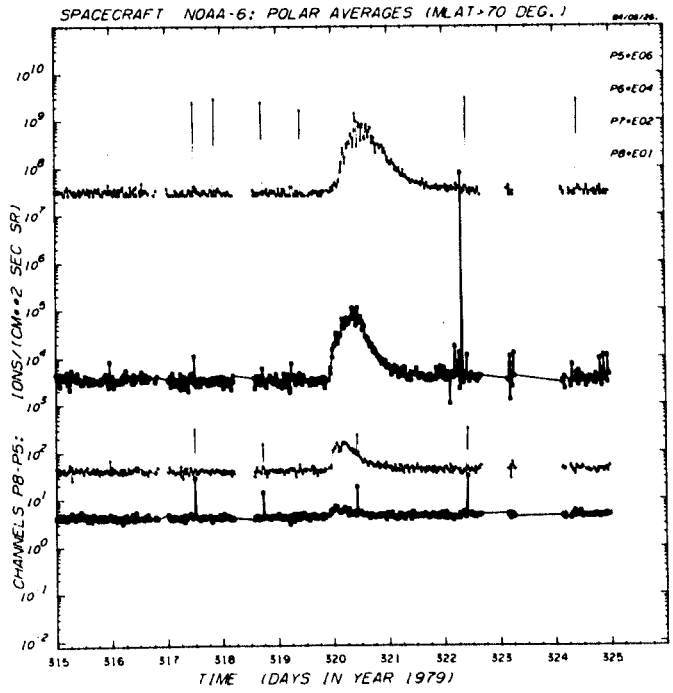


November 1, 1979





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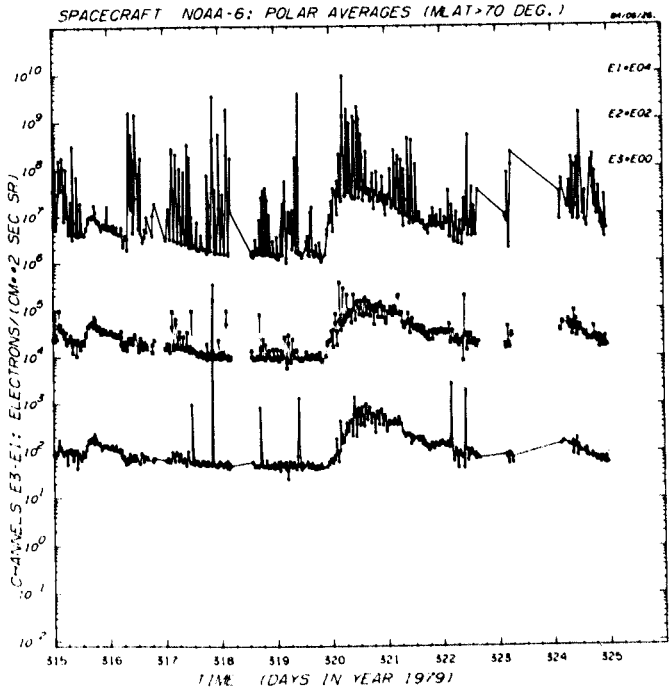
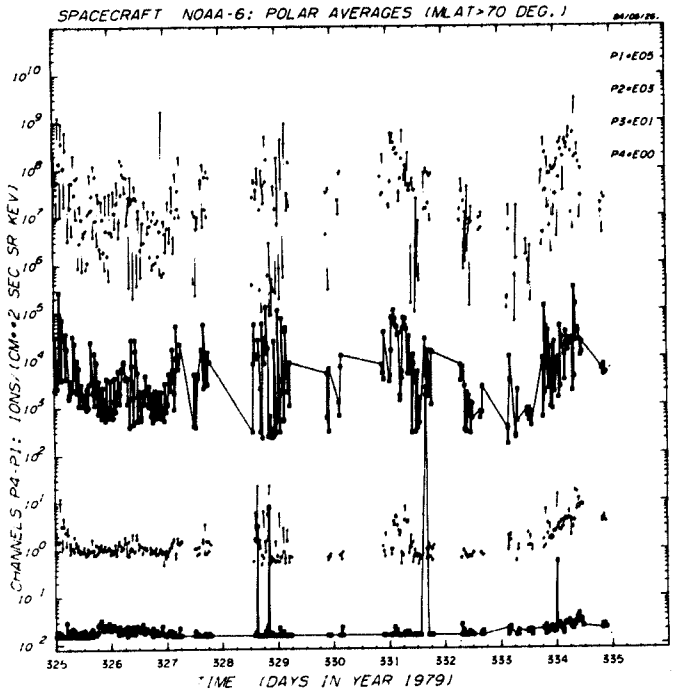
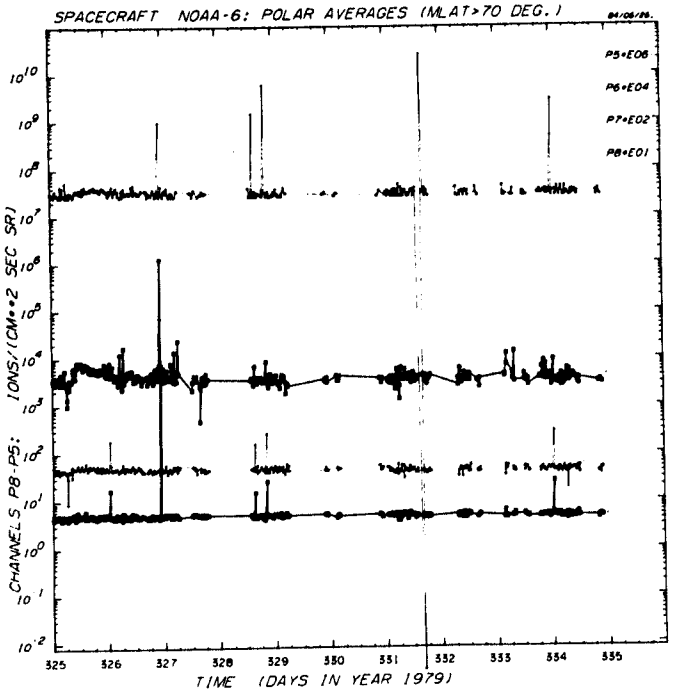


November 11, 1979





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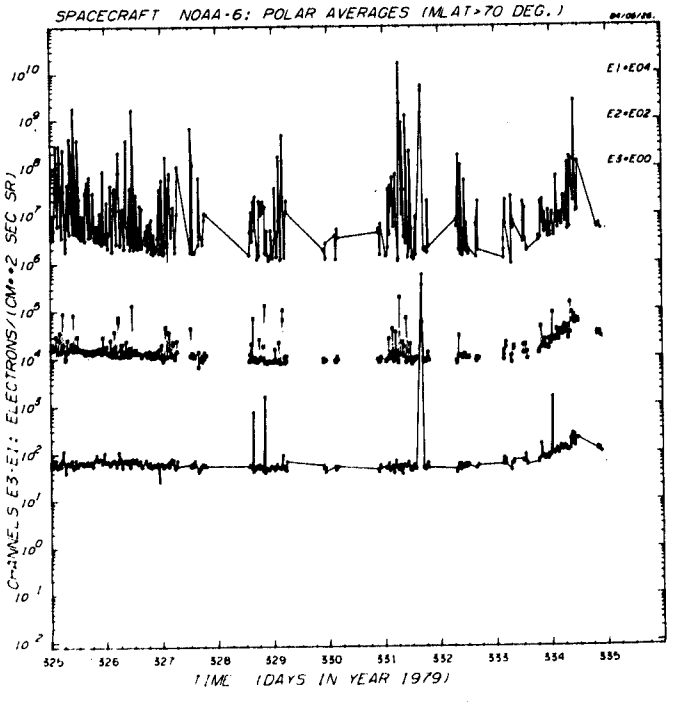
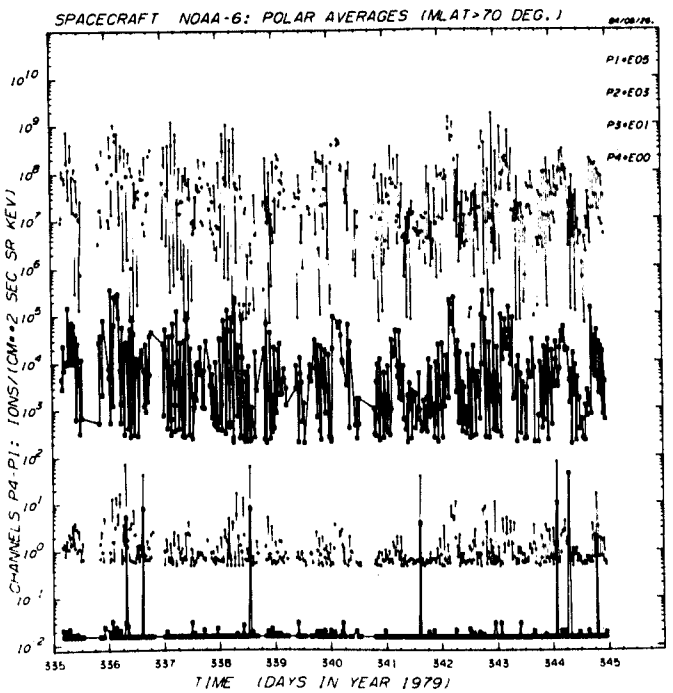
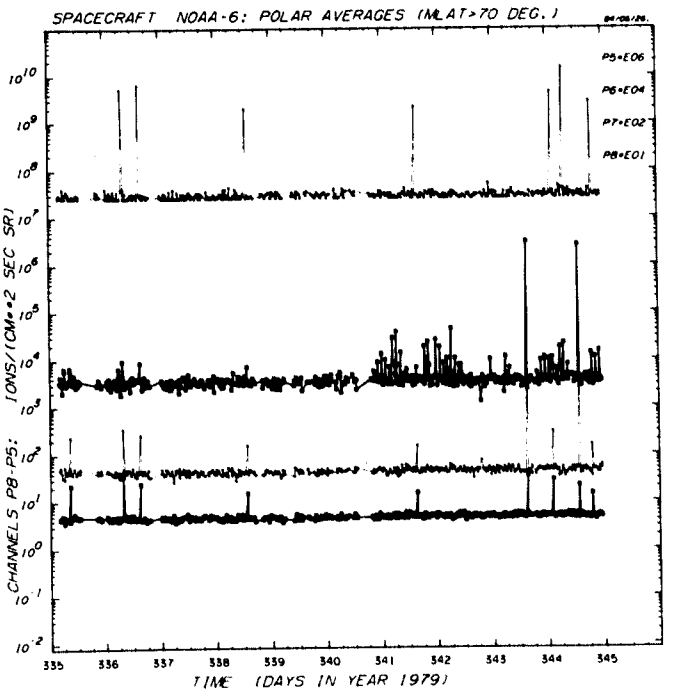


November 21, 1979





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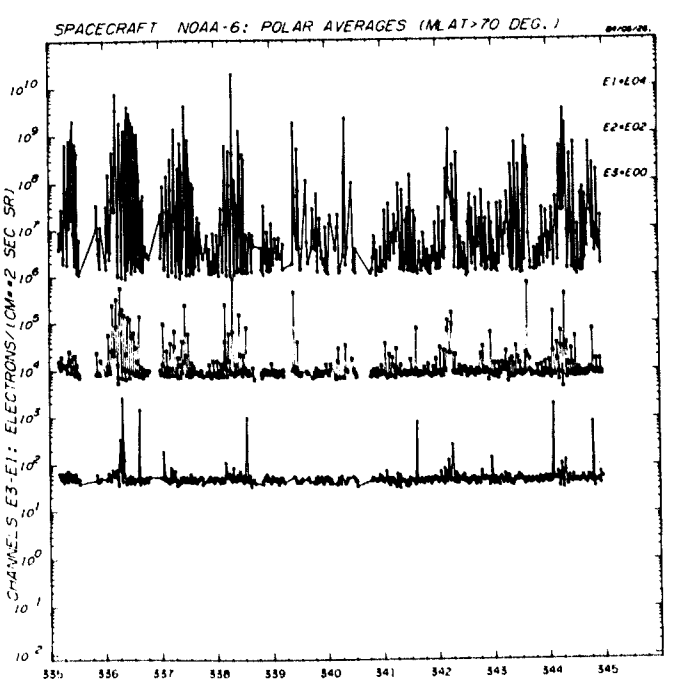
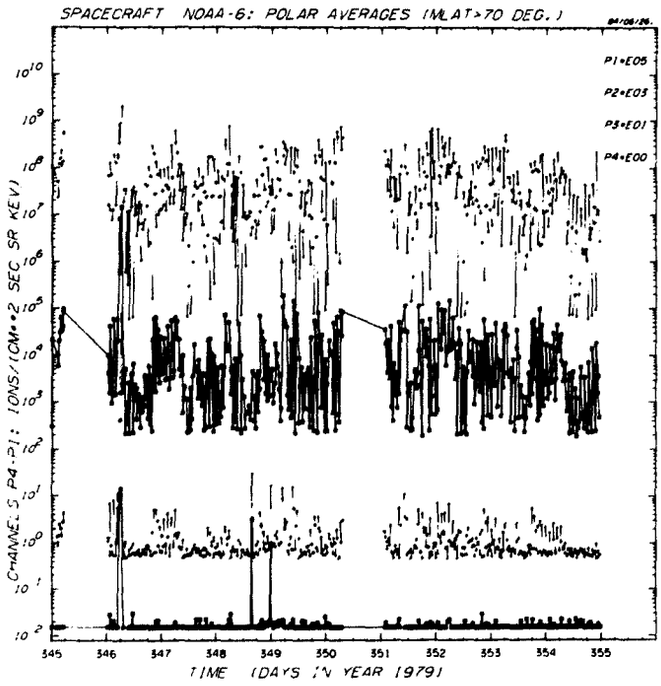
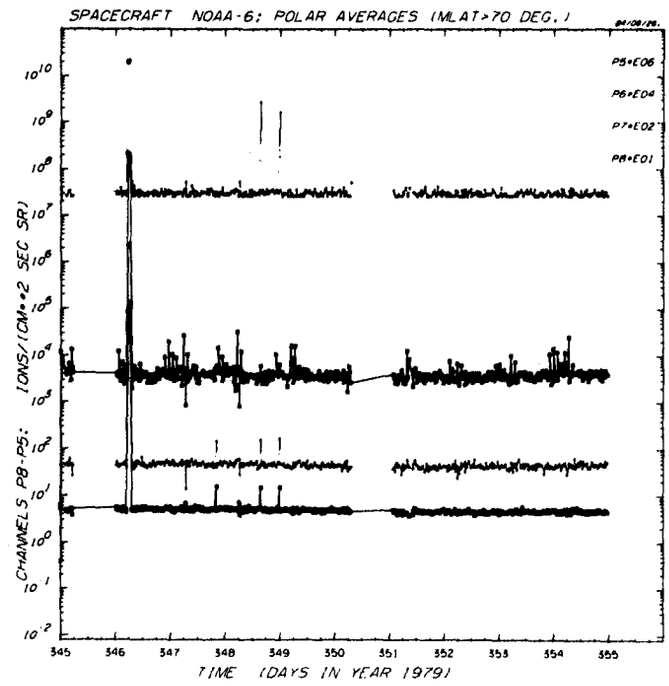


December 1, 1979





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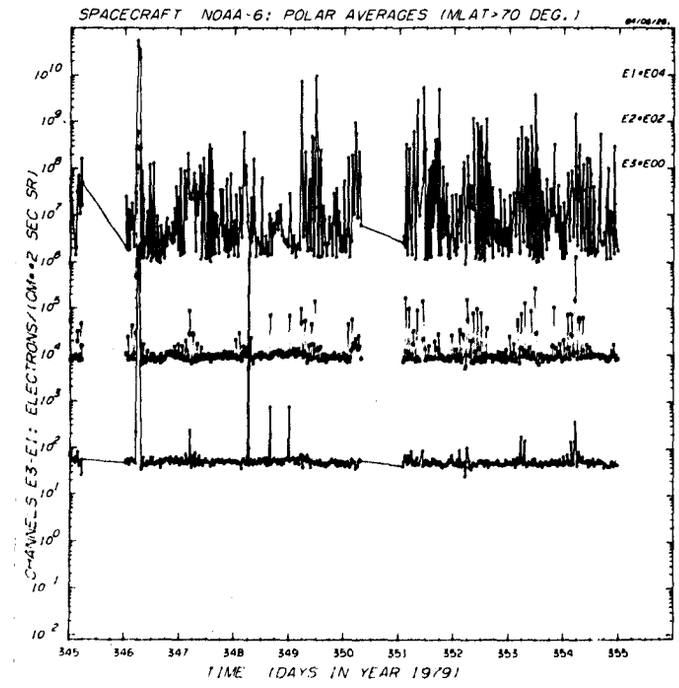
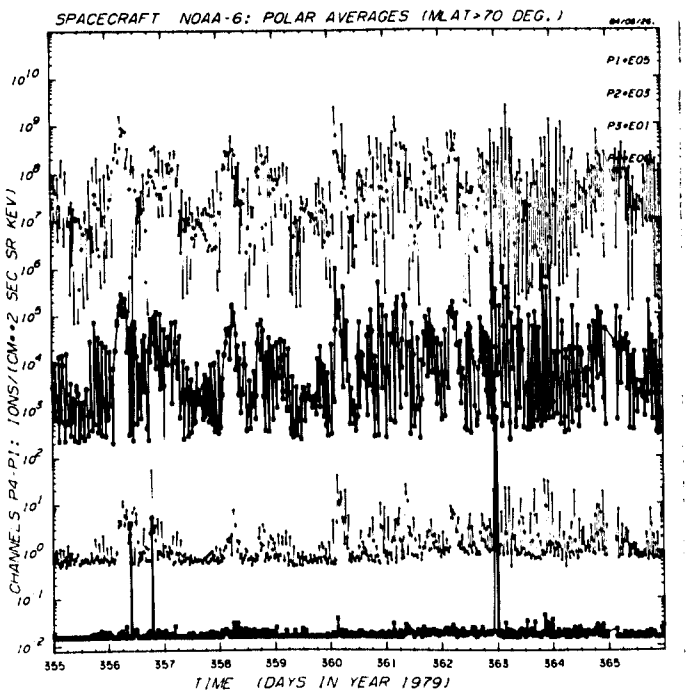
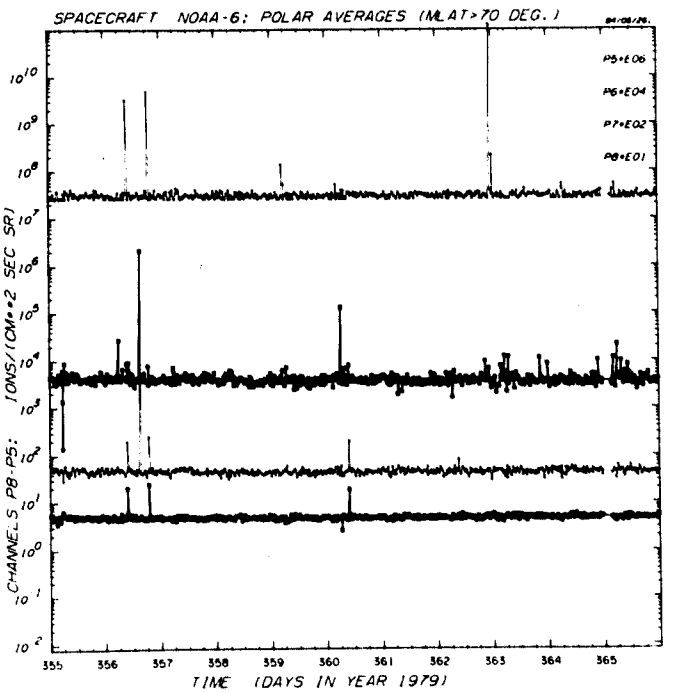


December 11, 1979





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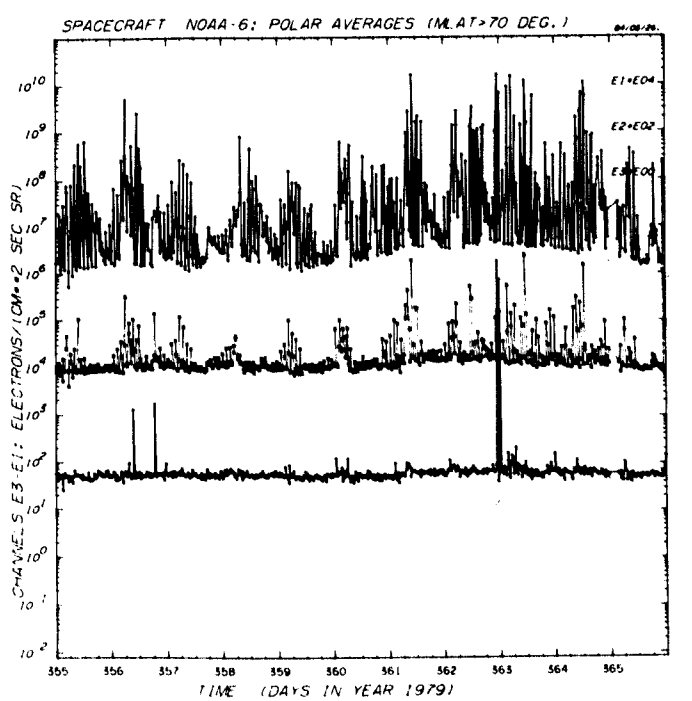
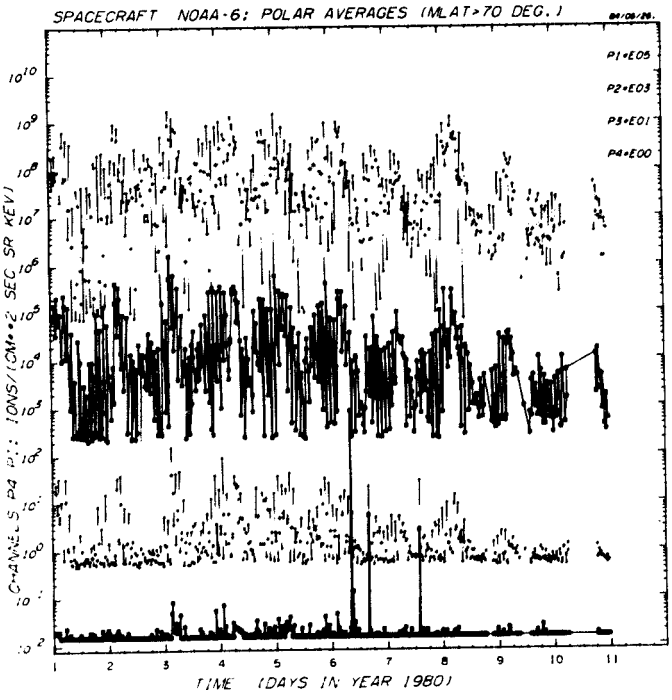
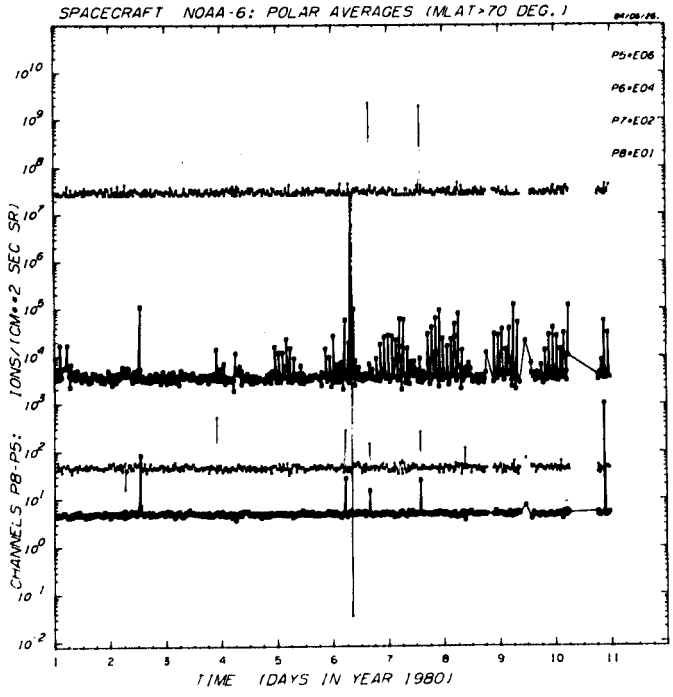


December 21, 1979





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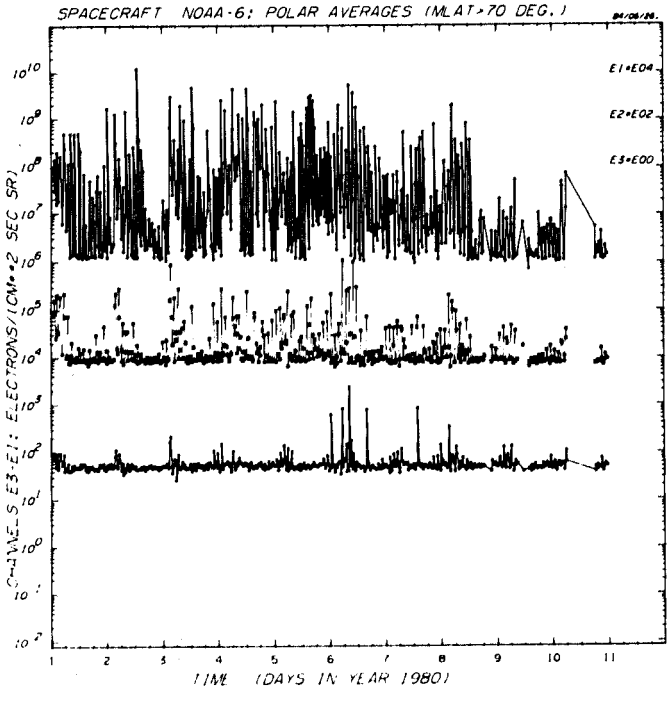
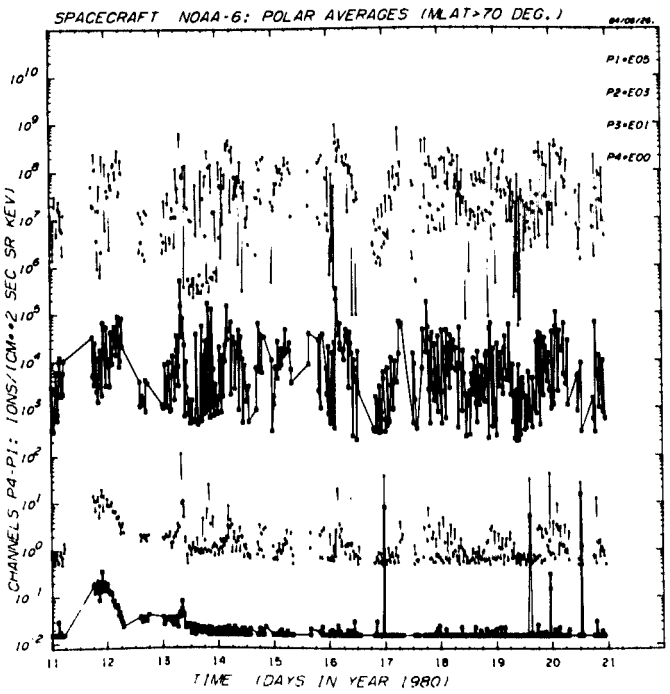
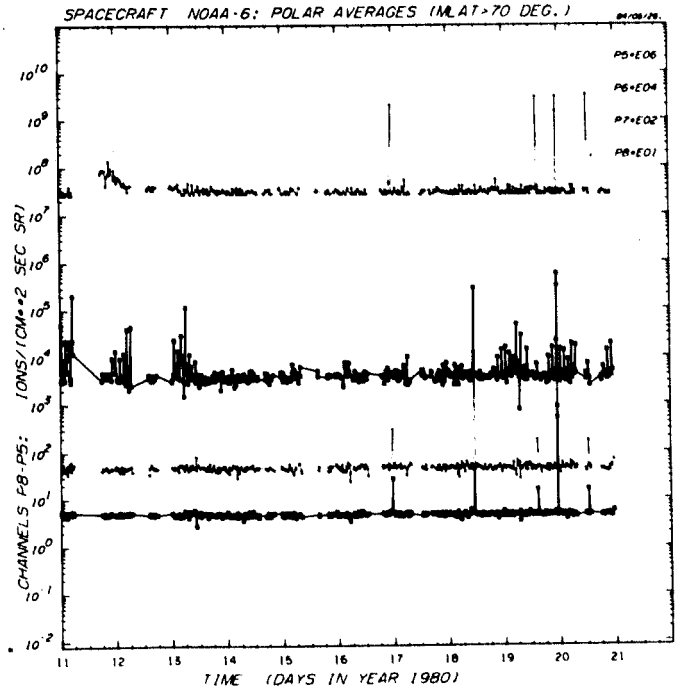


January 1, 1980





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
P2: E= 80 - 250 KEV
P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
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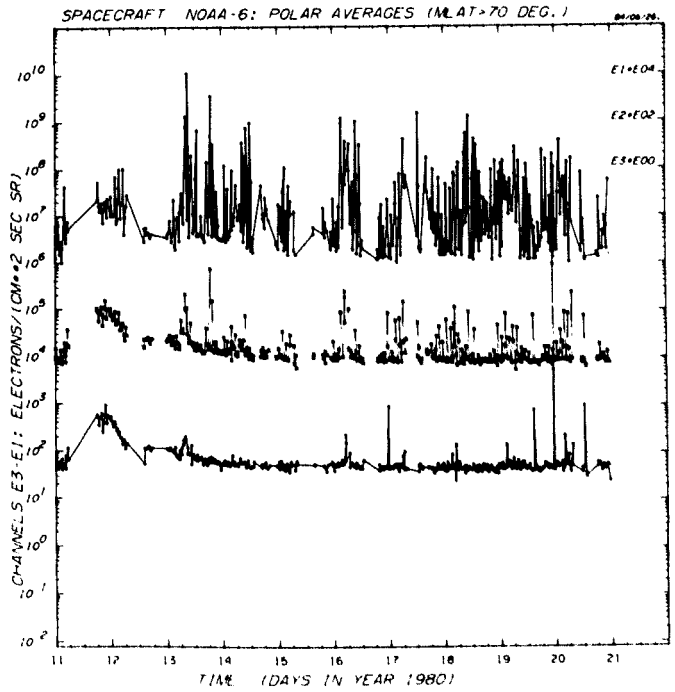
E3: E > 300 KEV



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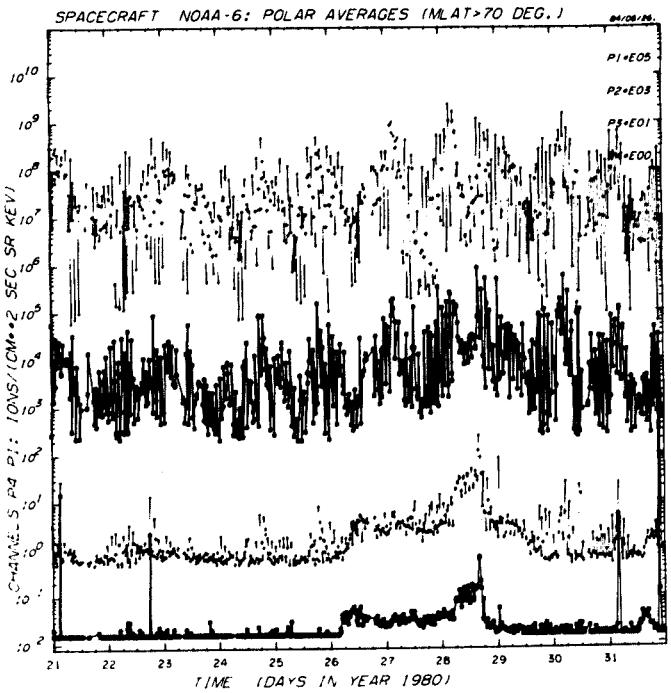

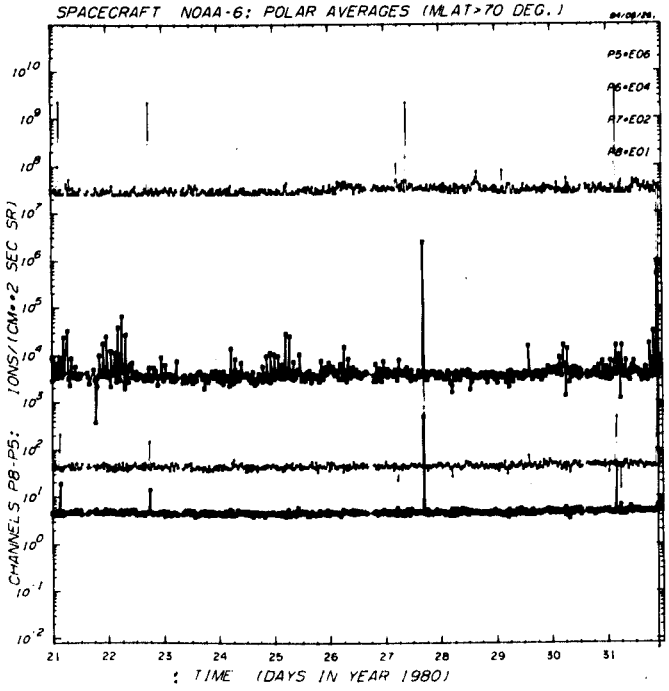

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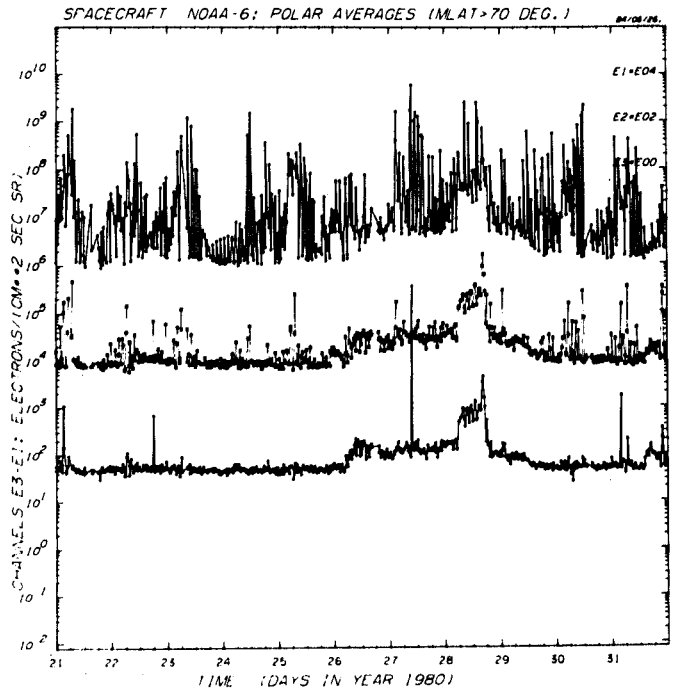
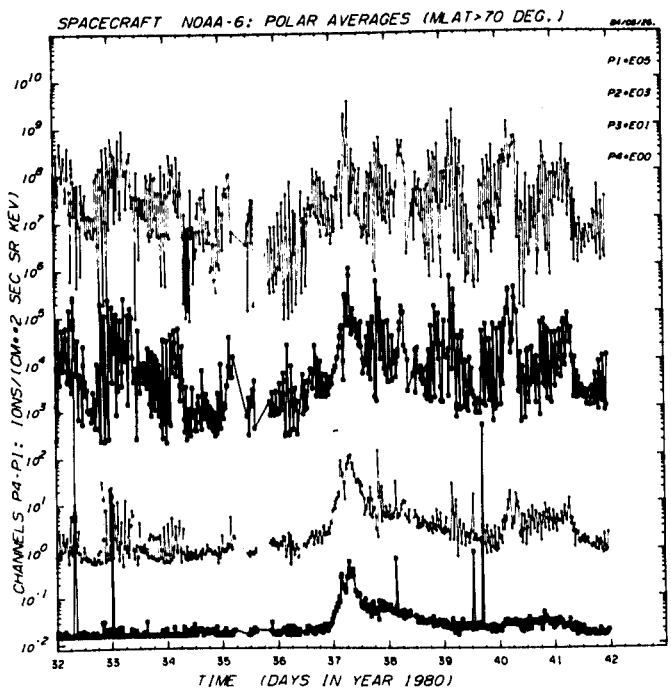
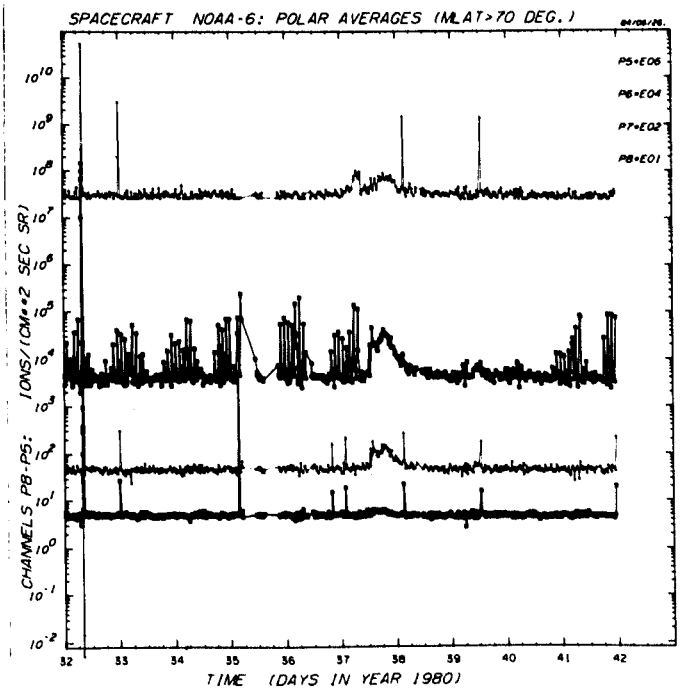


January 21, 1980





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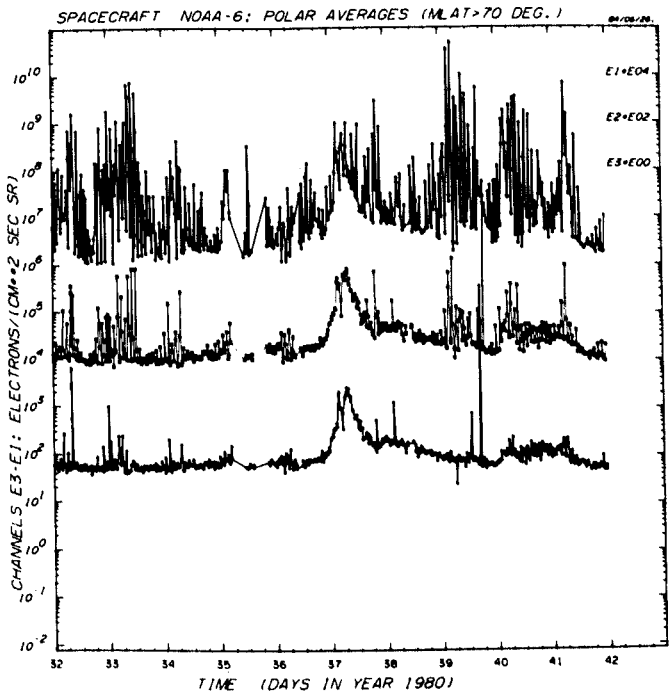
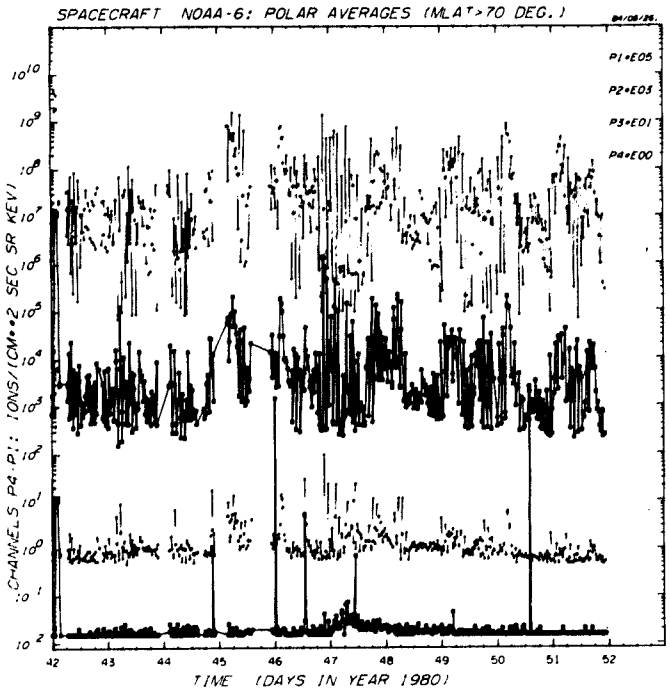
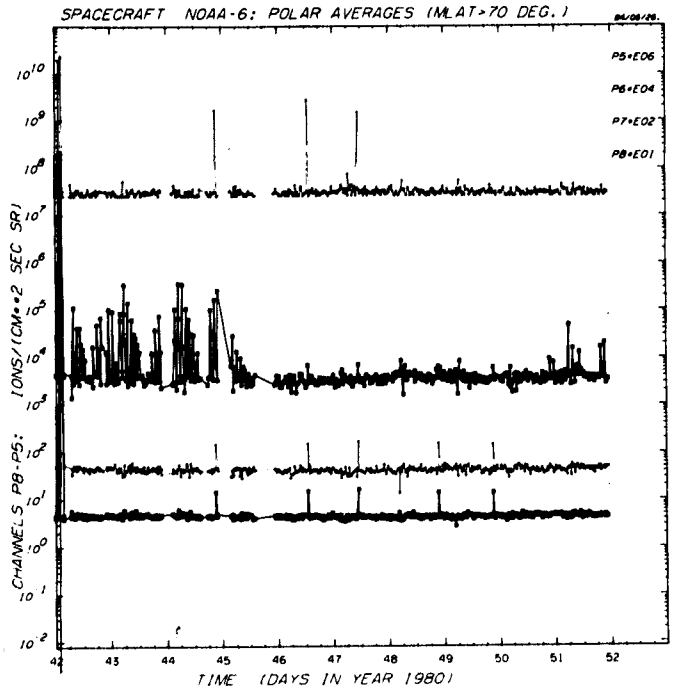


February 1, 1980





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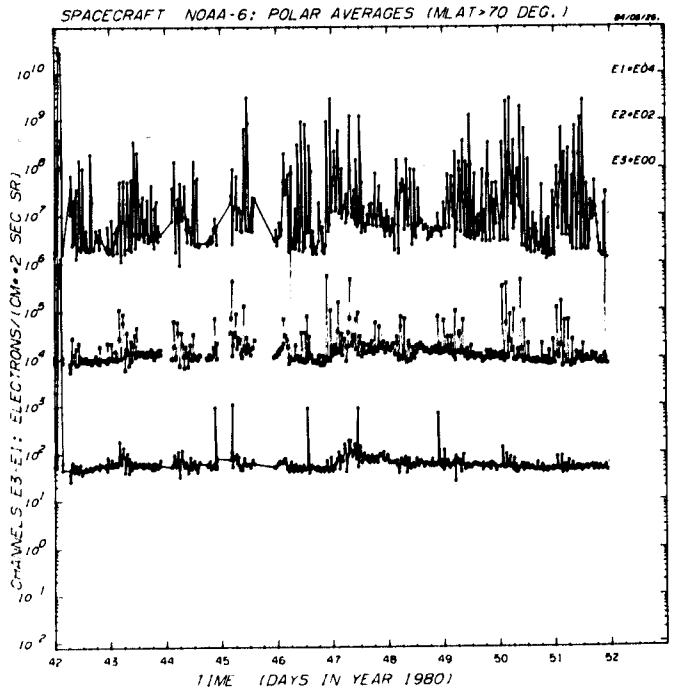
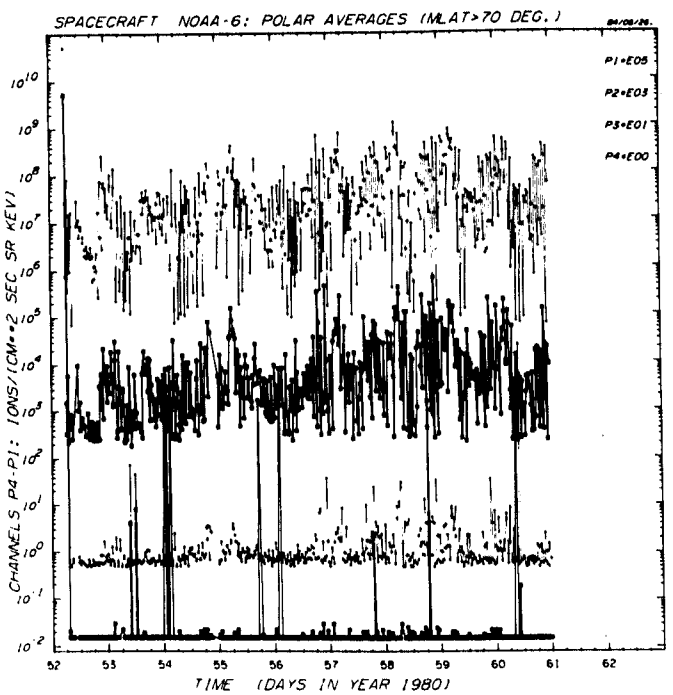
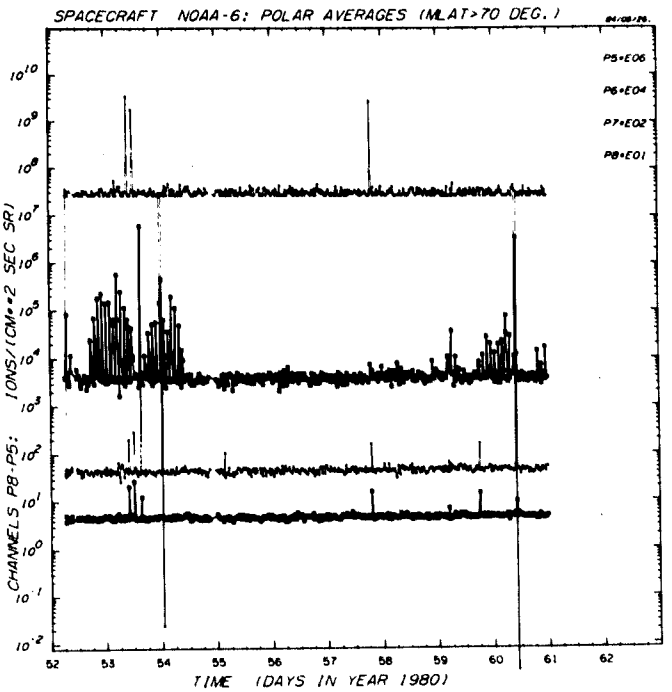


February 11, 1980





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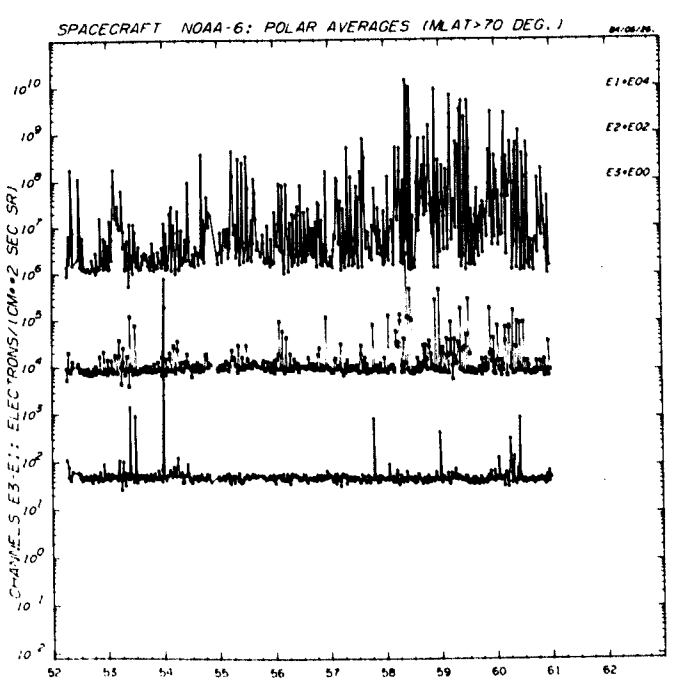
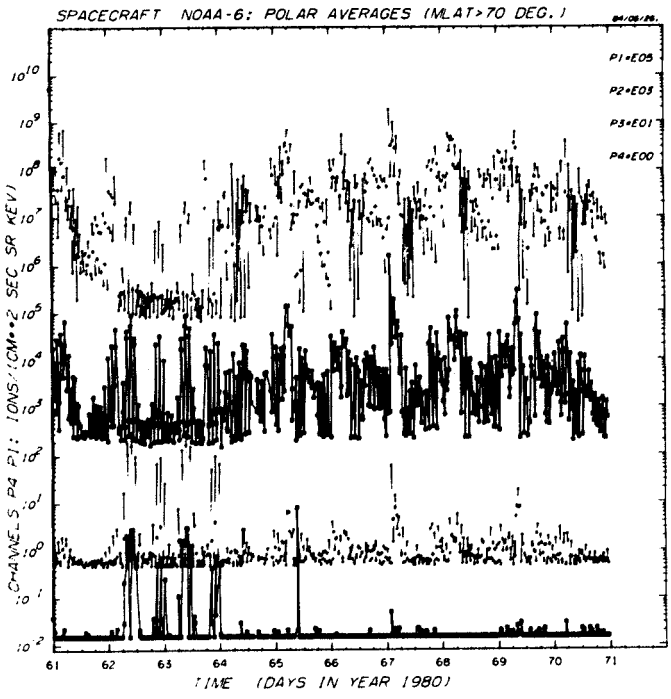
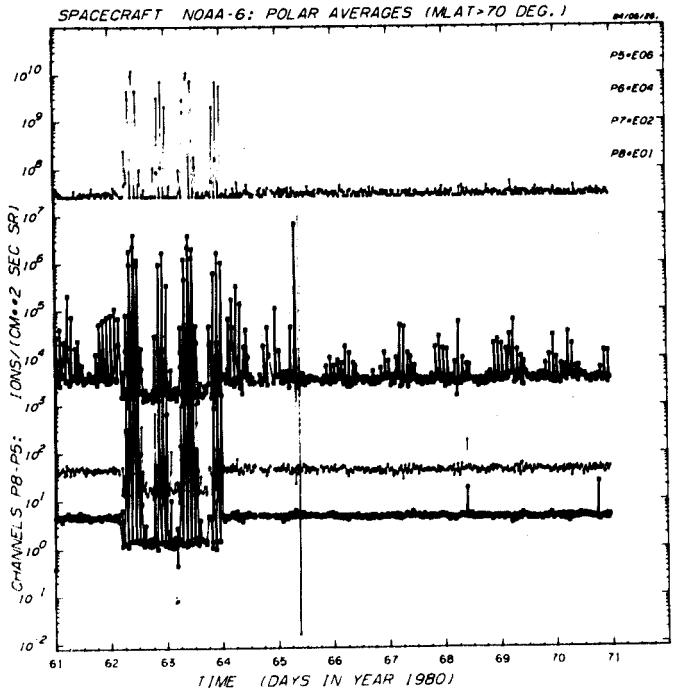


February 21, 1980





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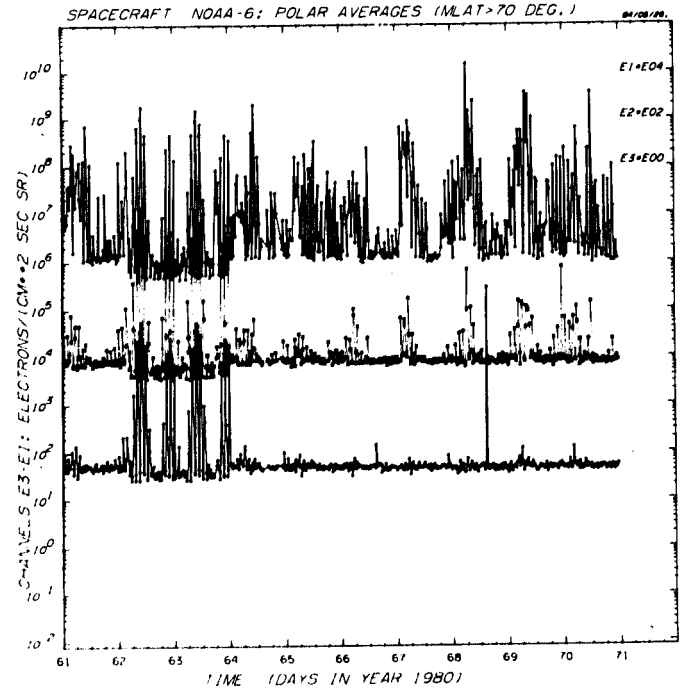
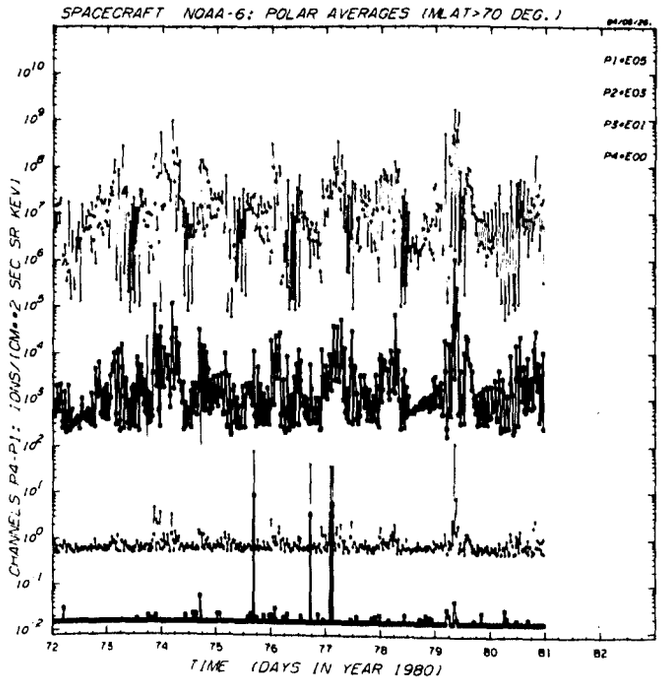
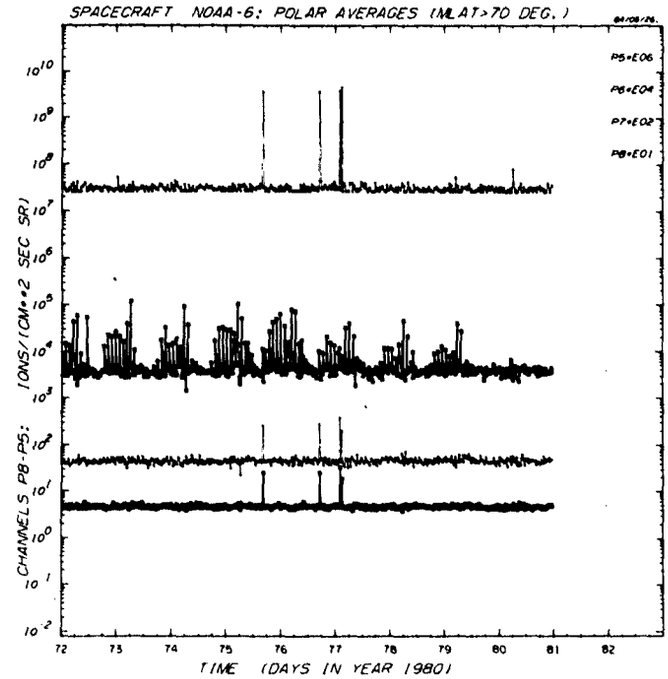


March 1, 1980





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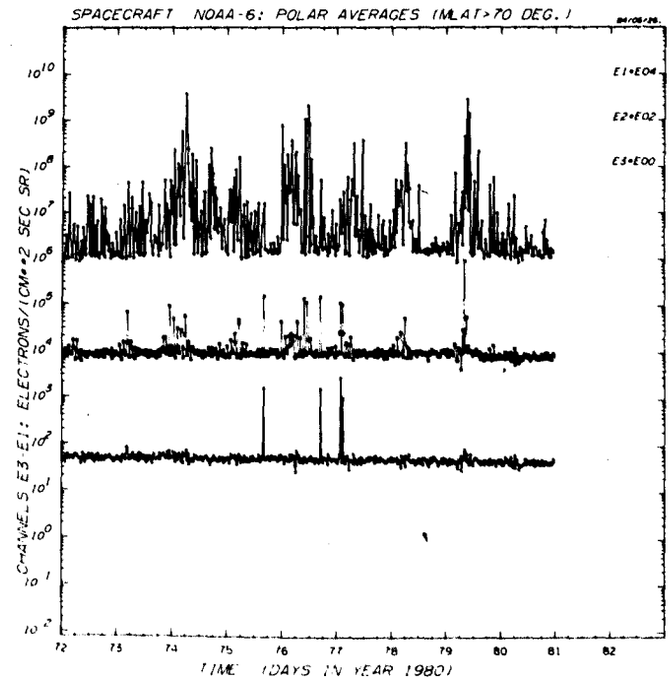
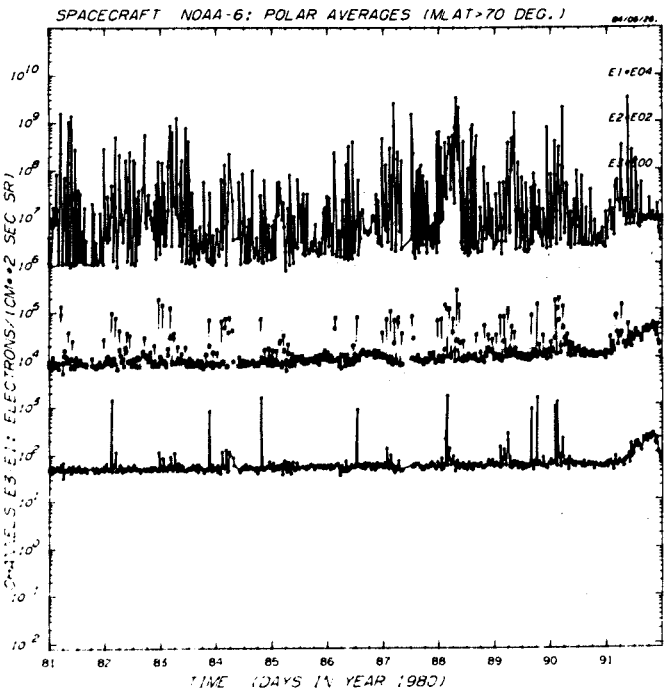
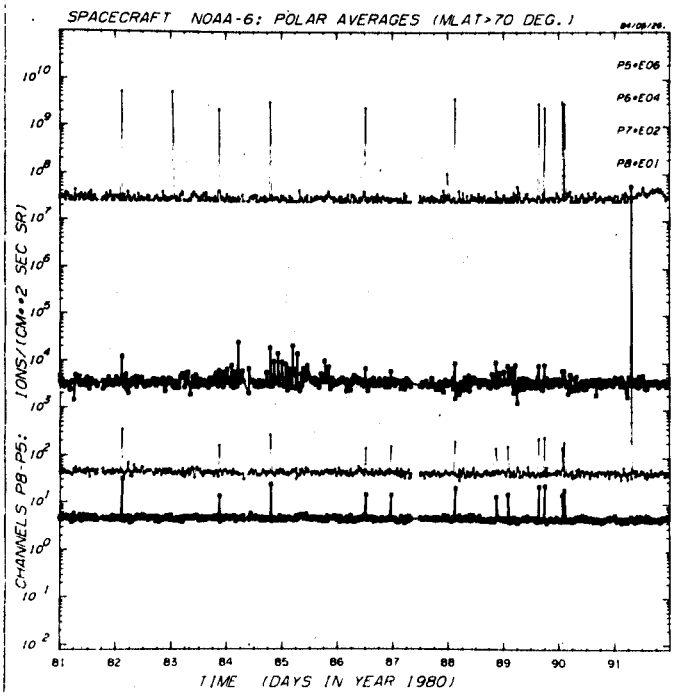


March 12, 1980





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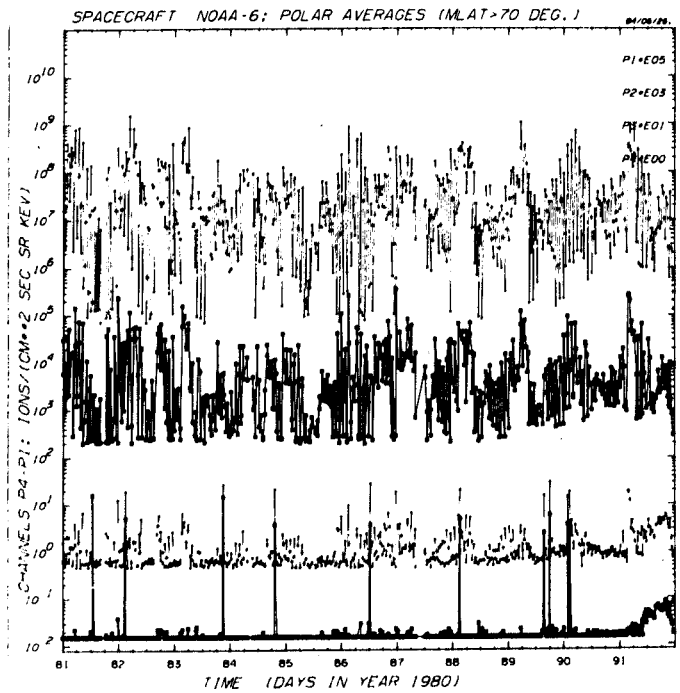
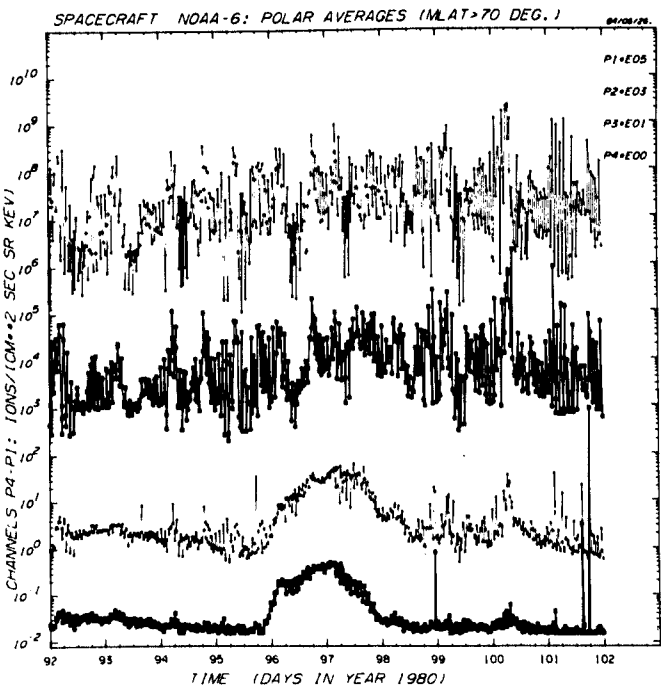
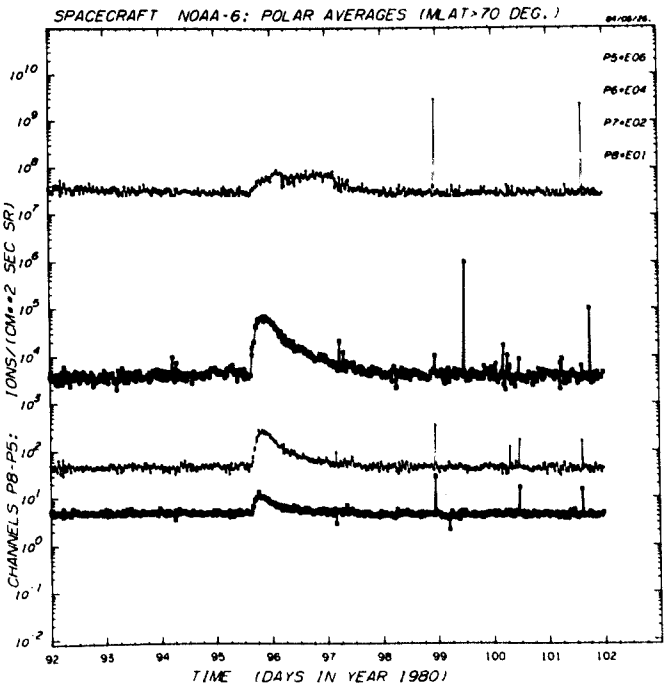


March 21, 1980





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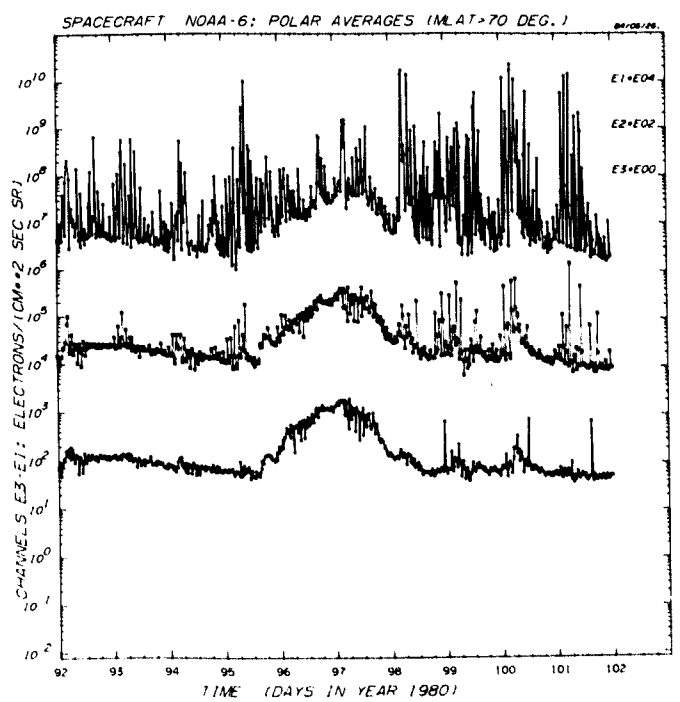
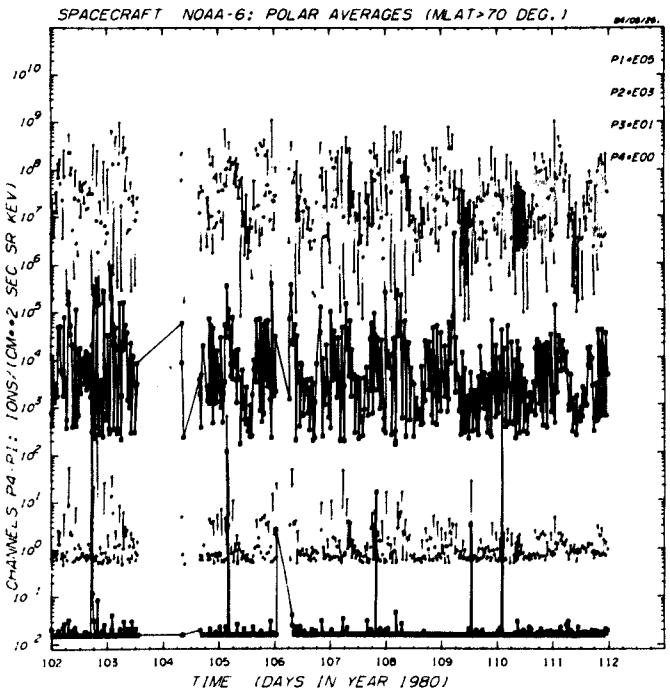
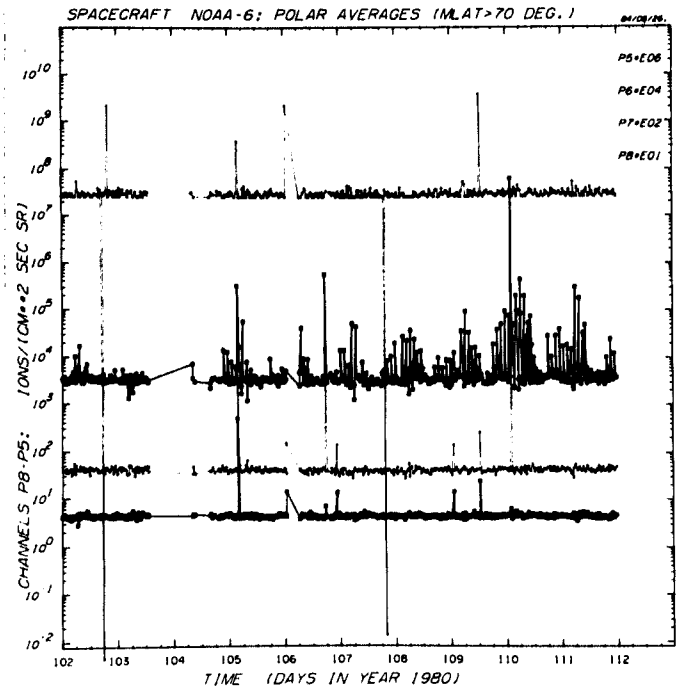


April 1, 1980





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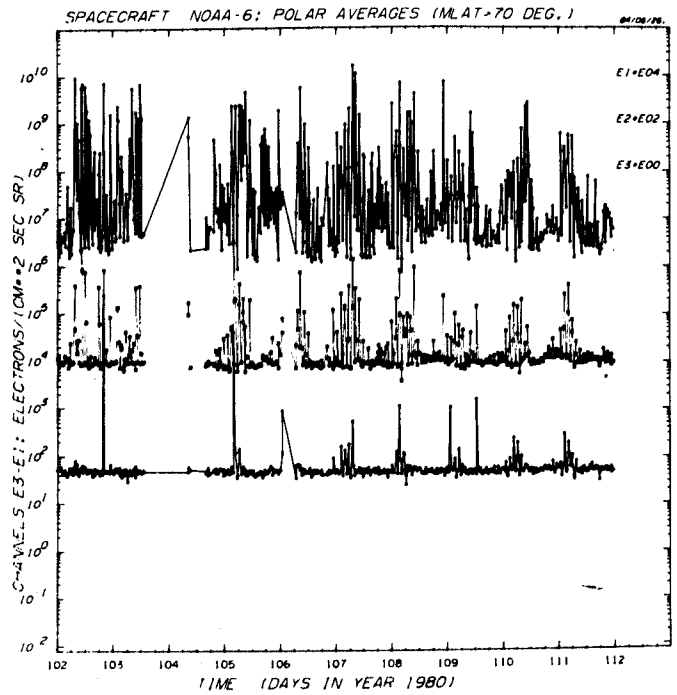
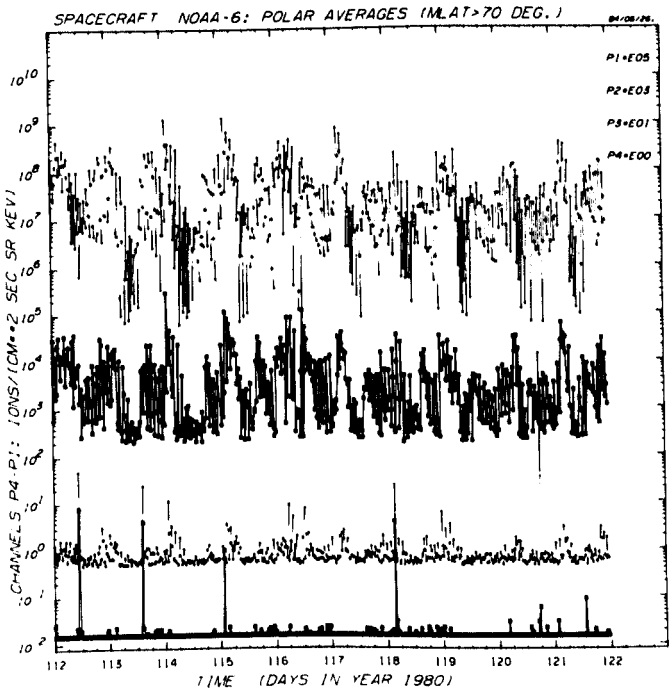
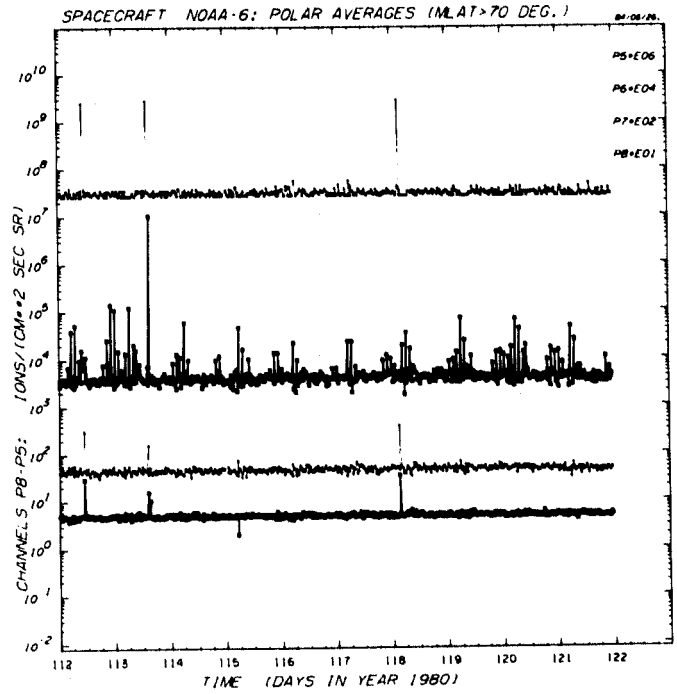


April 11, 1980





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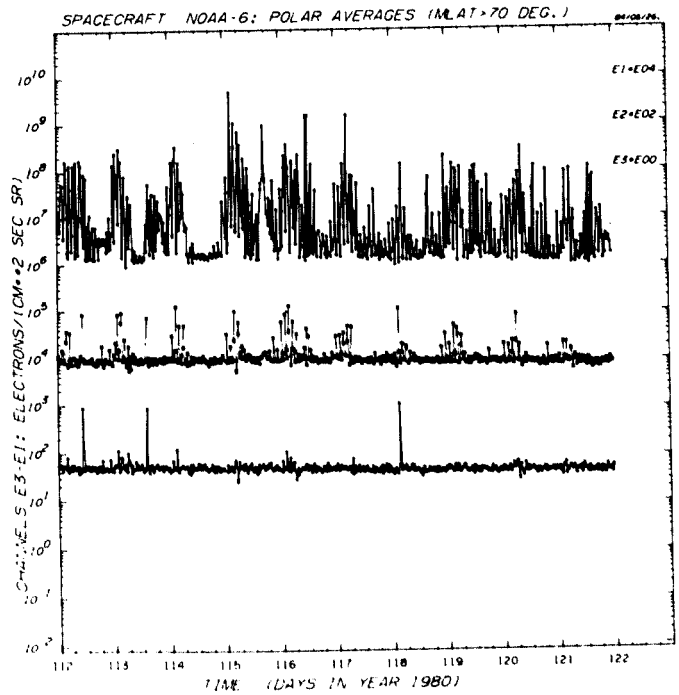
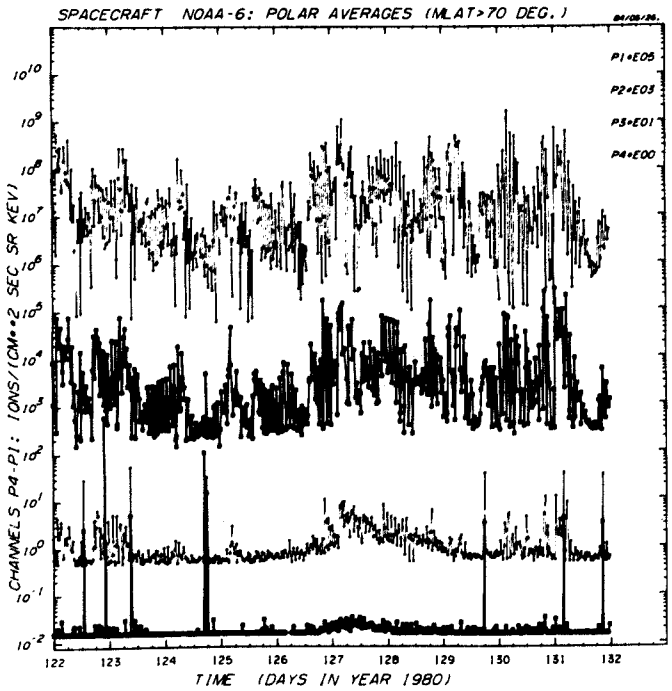
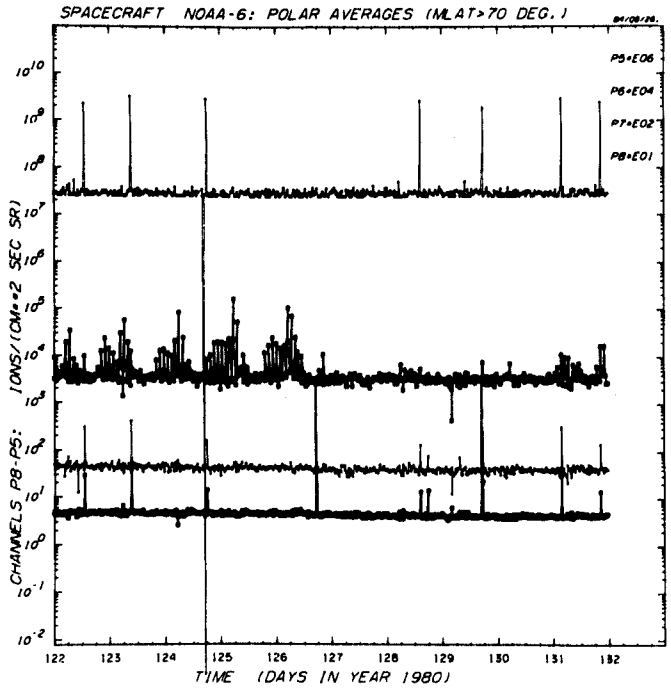


April 21, 1980





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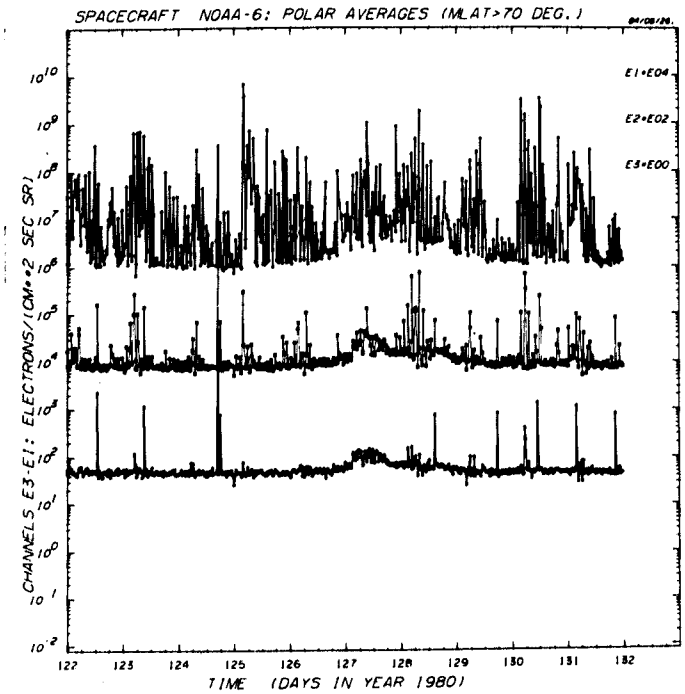
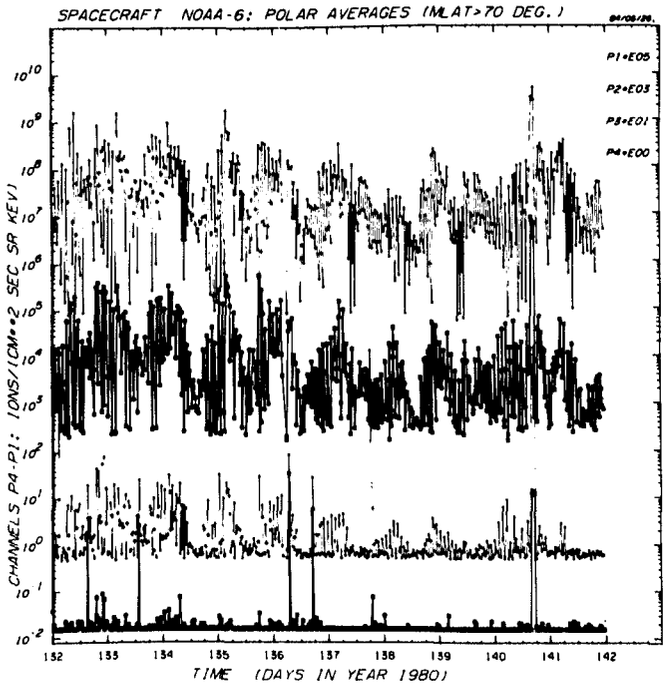
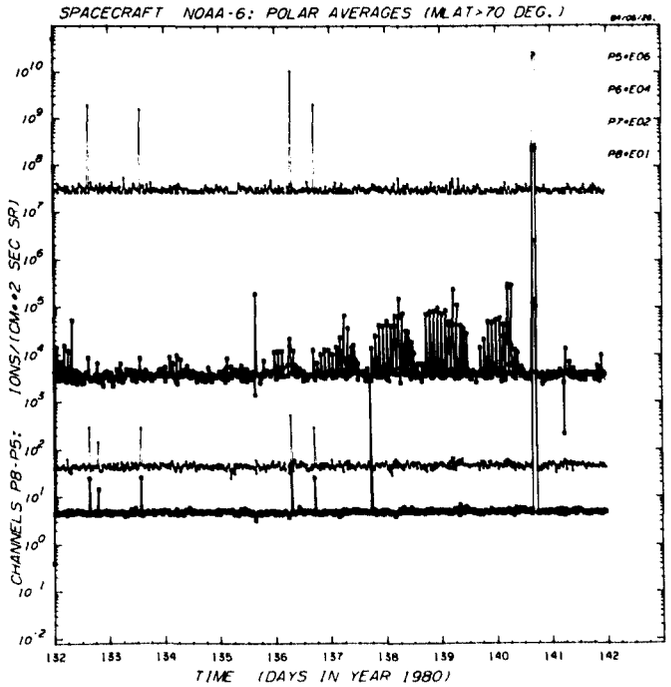


May 1, 1980





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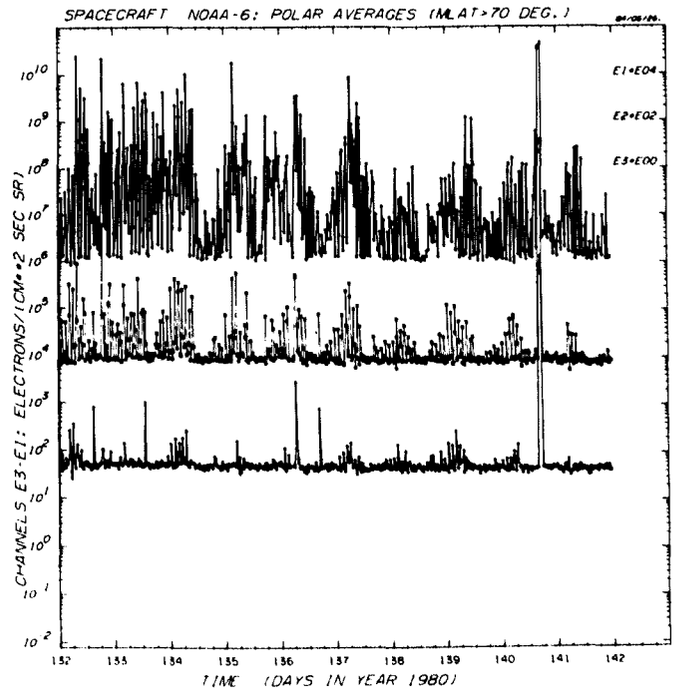

May 11, 1980

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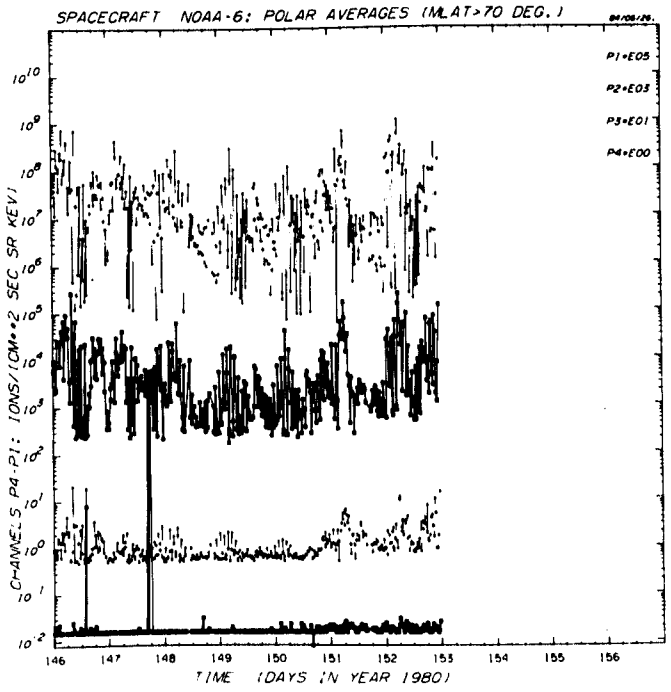
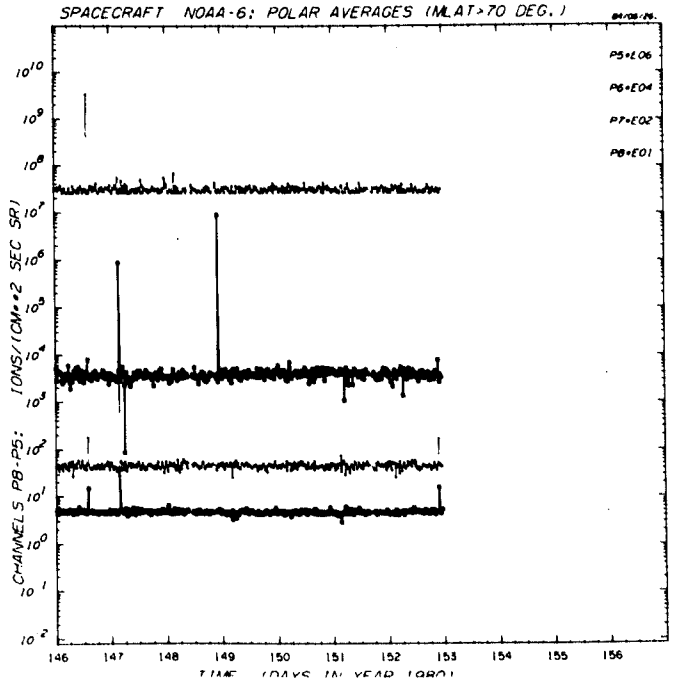
May 21, 1980

May 21, 1980





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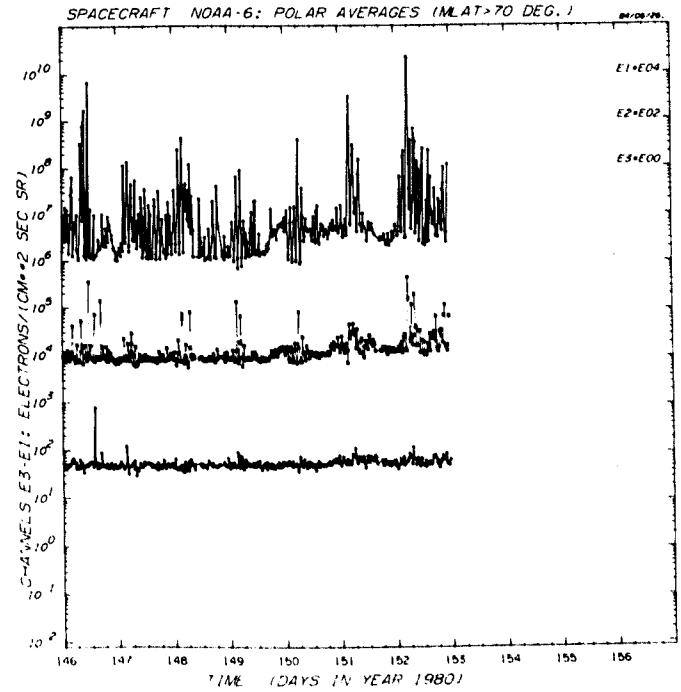
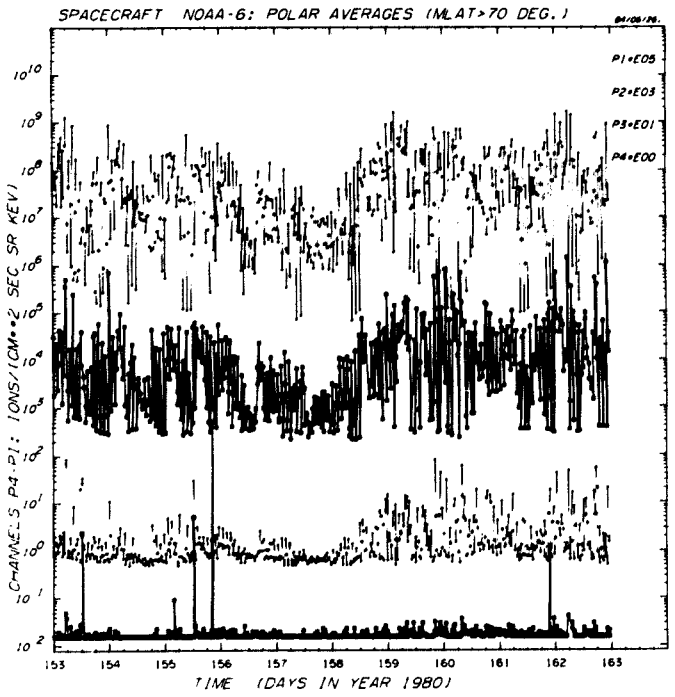
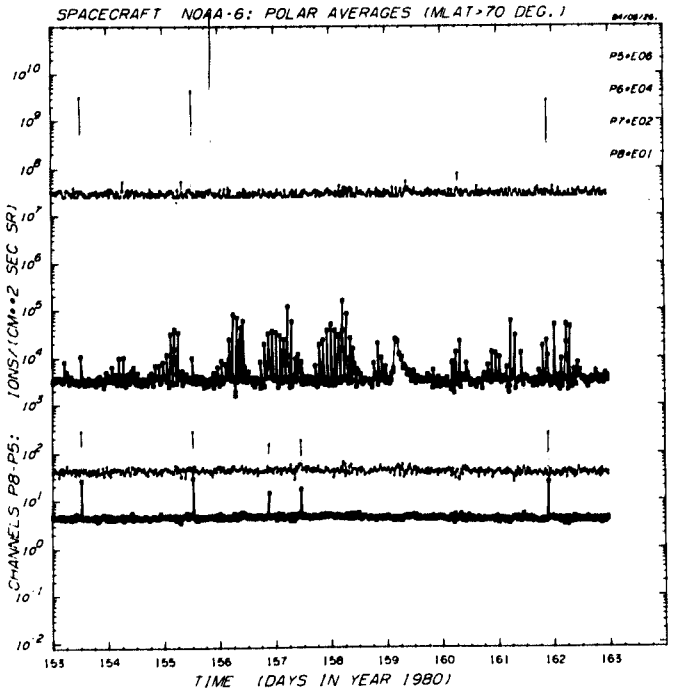


May 25, 1980





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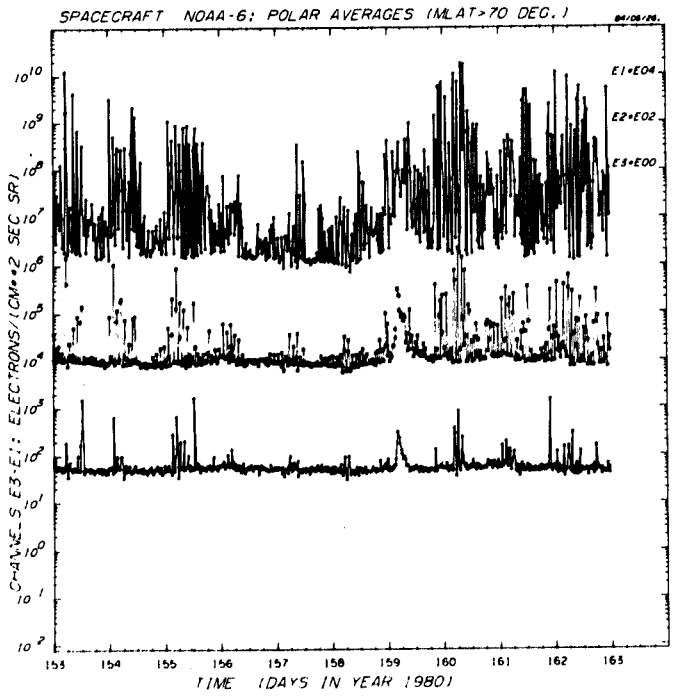
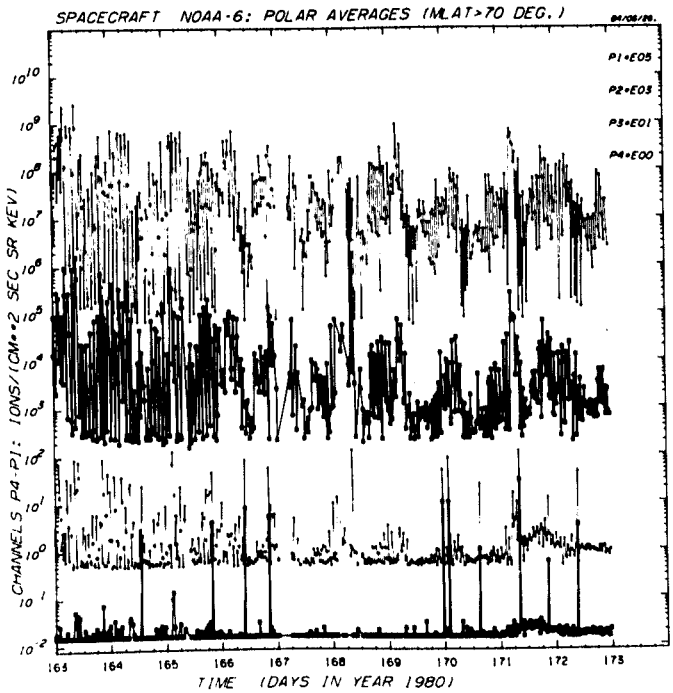
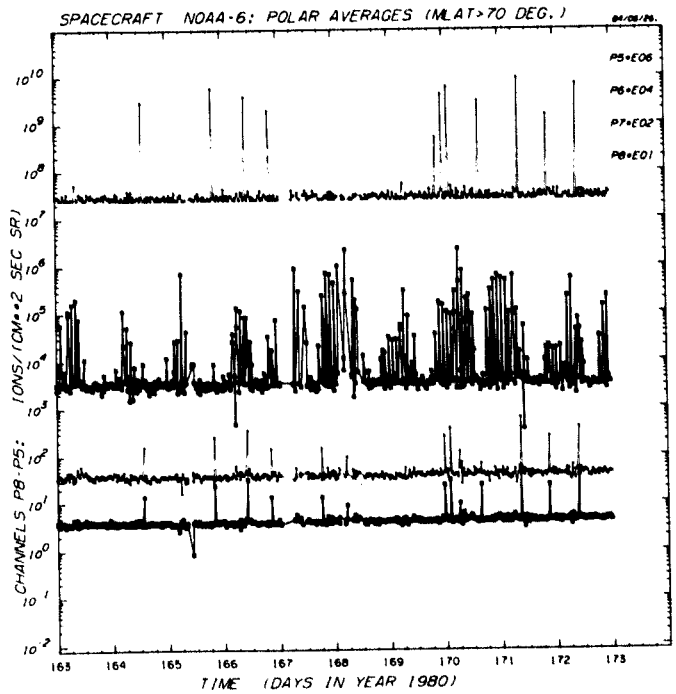


June 1, 1980





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P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
E2: E > 100 KEV
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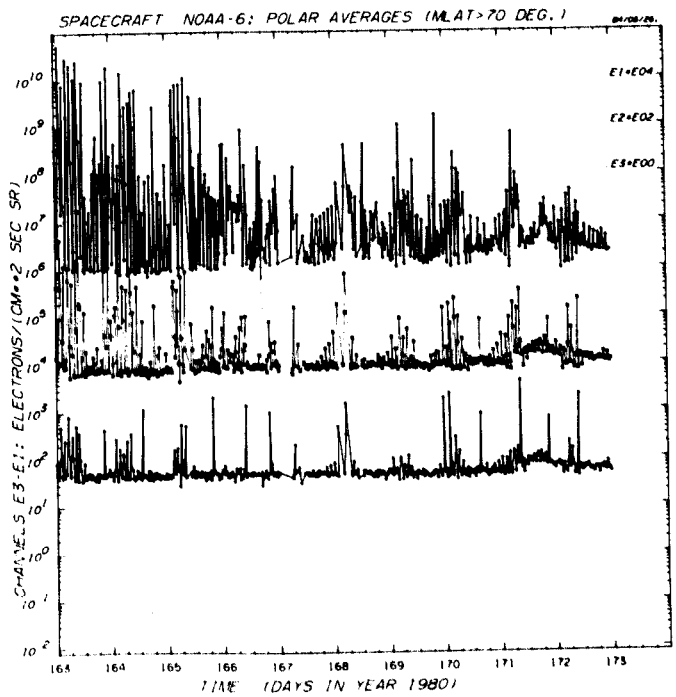

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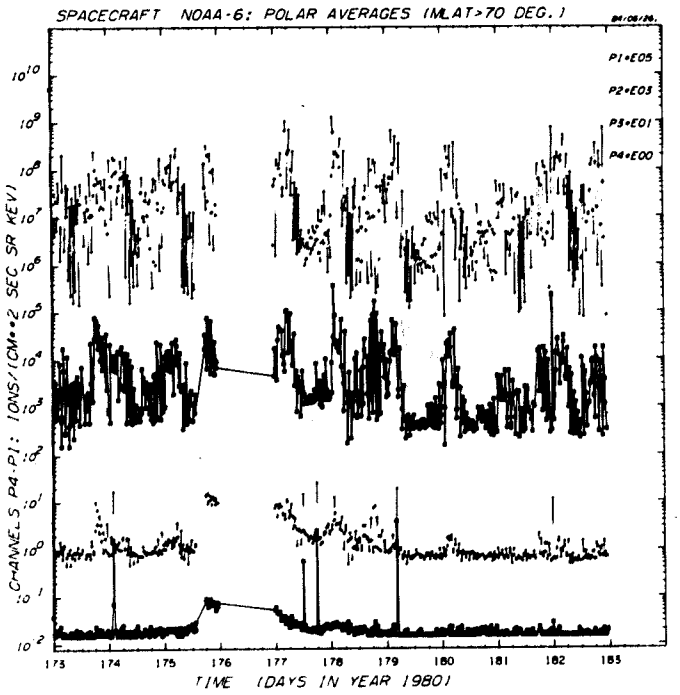

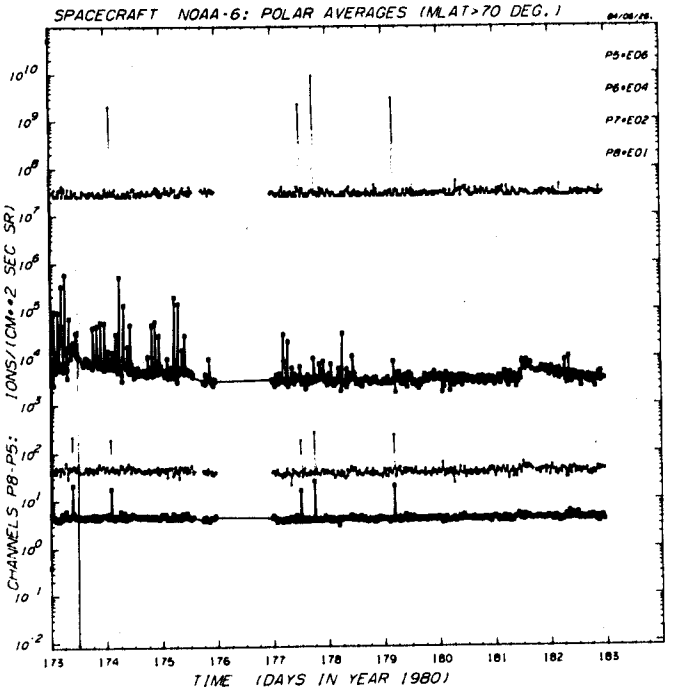

ENERGY CHANNELS:

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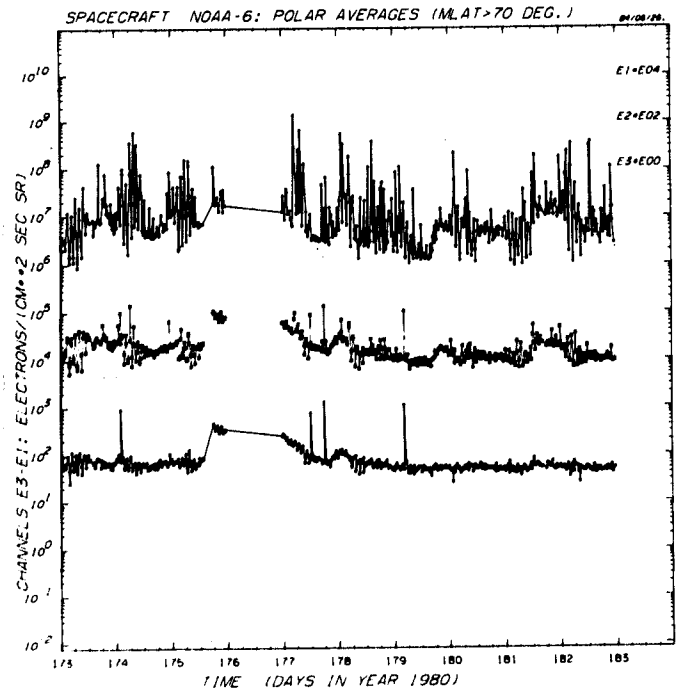

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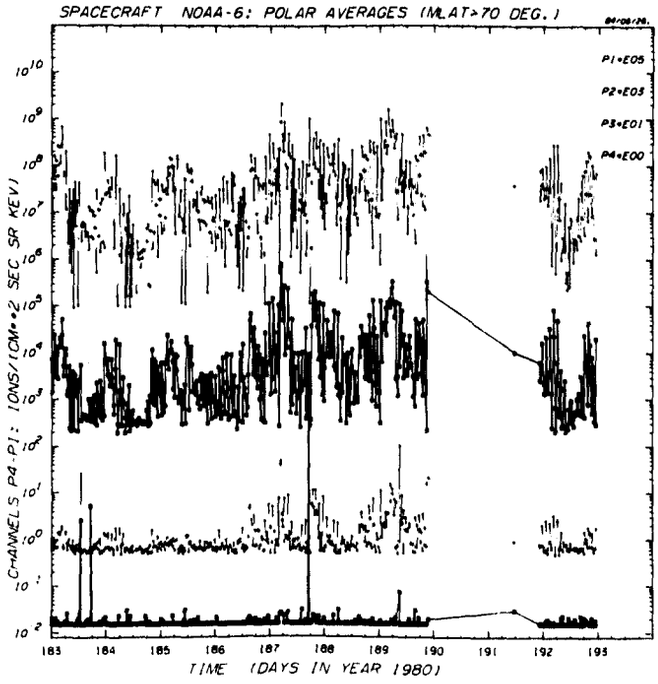

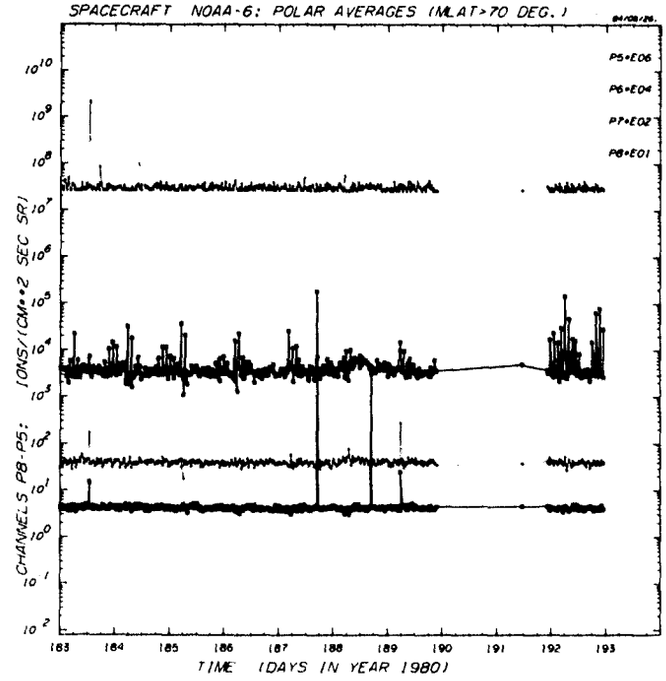

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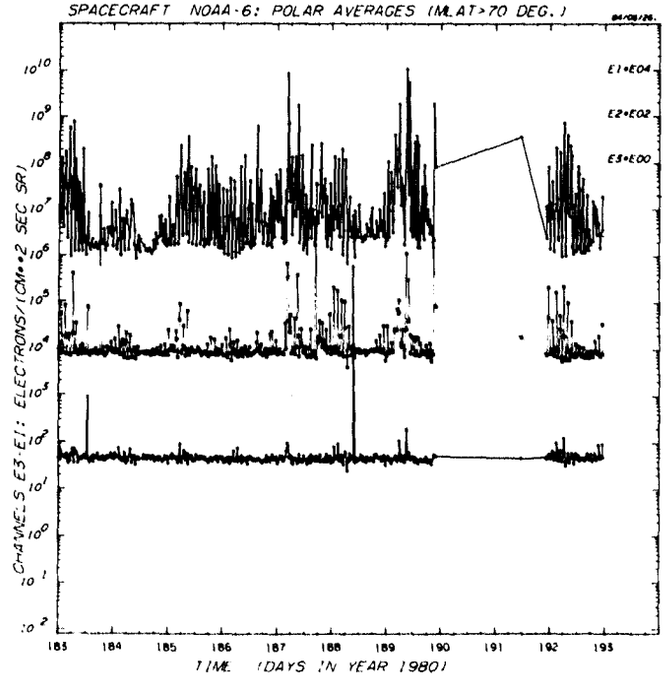

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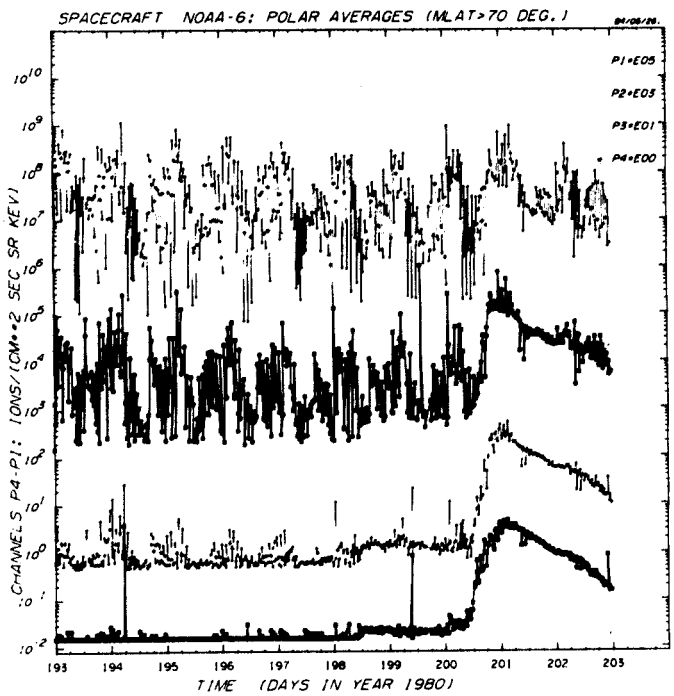

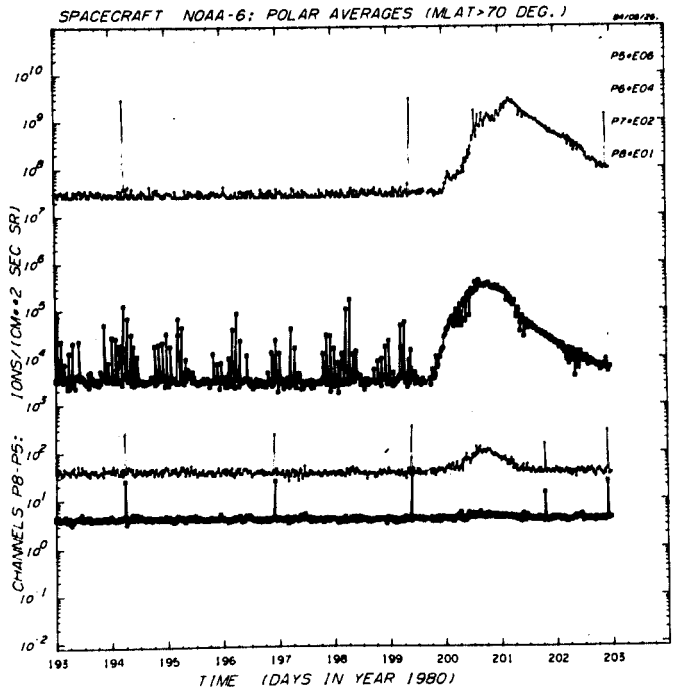

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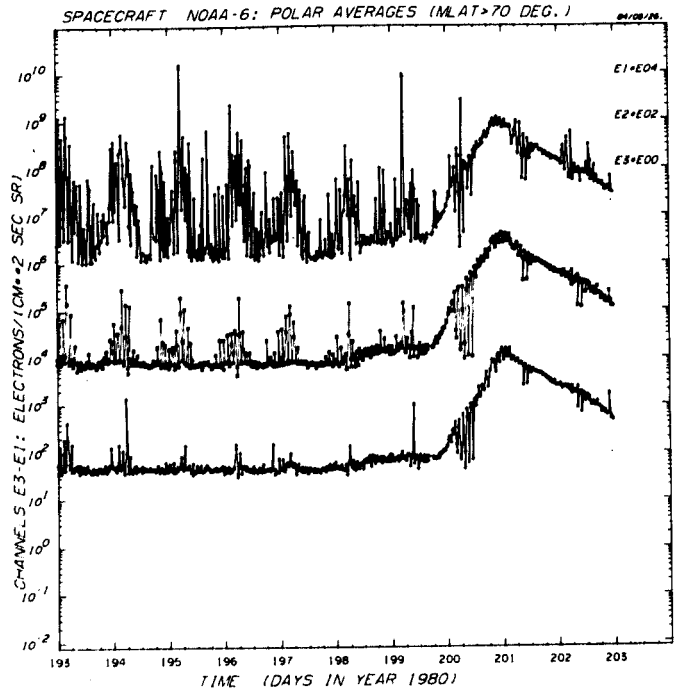

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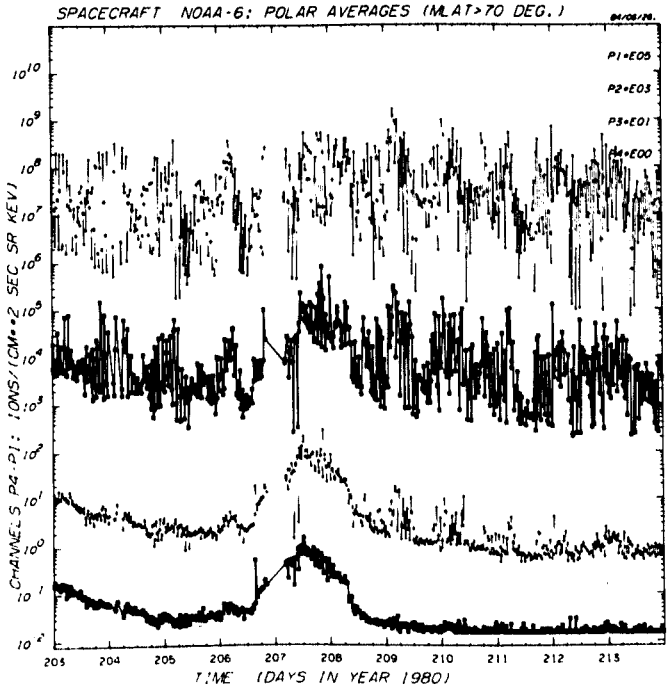

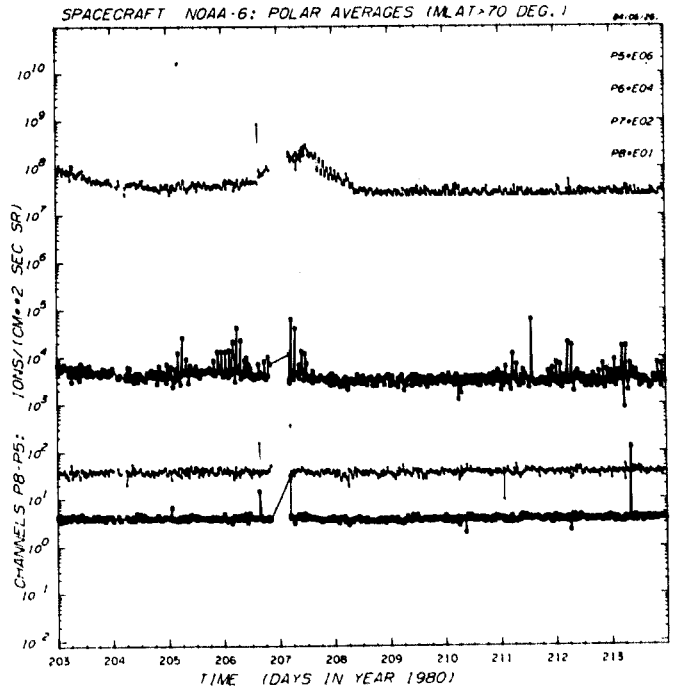

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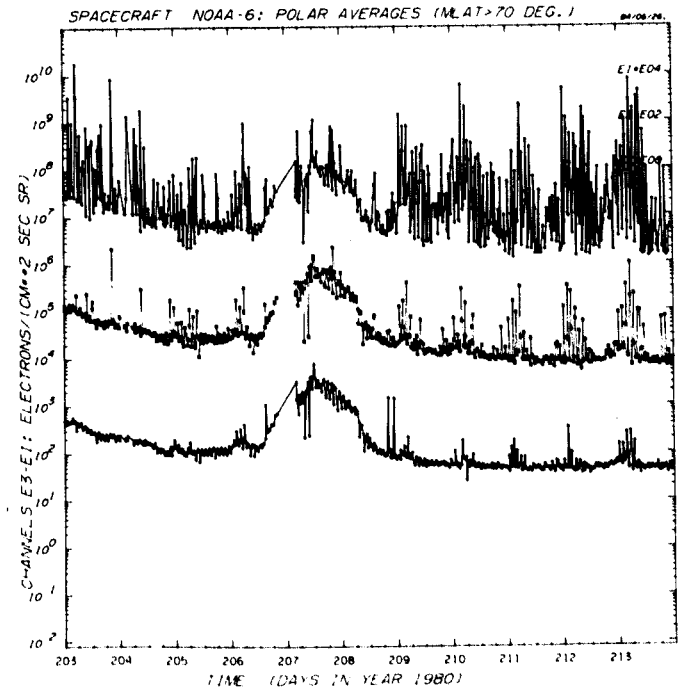
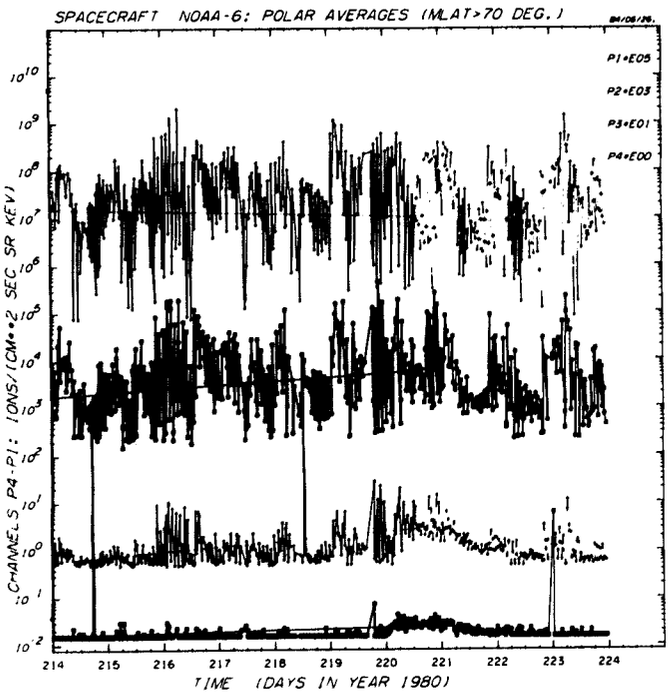
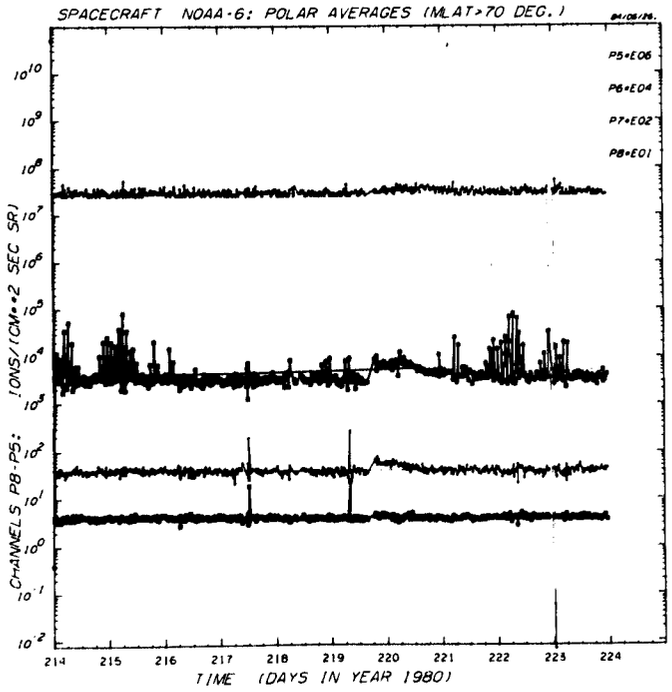


July 21, 1980





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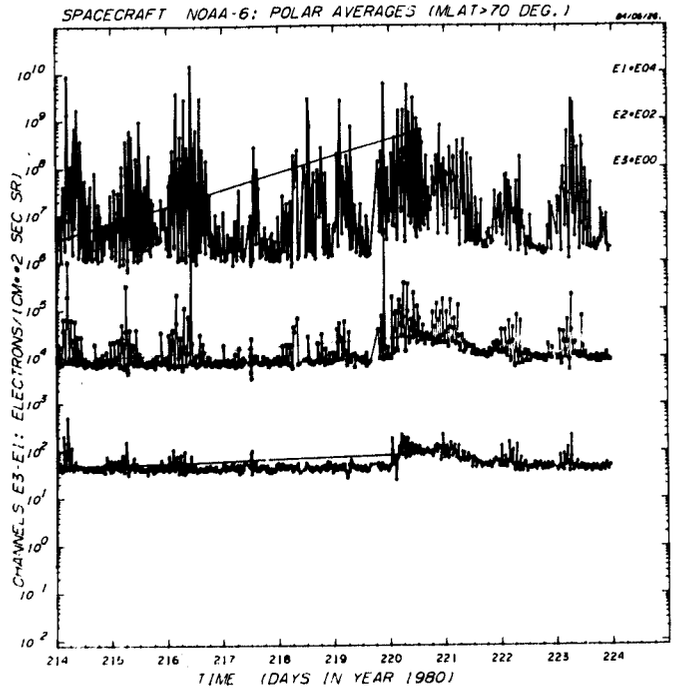
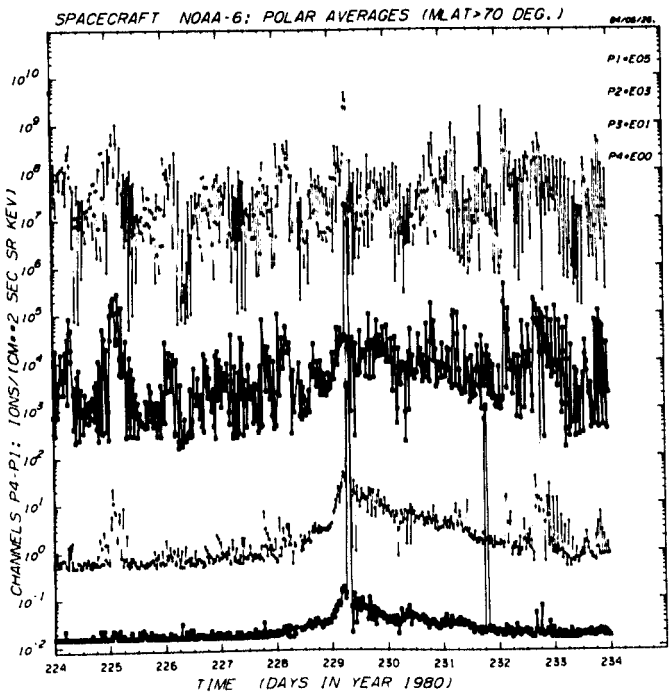
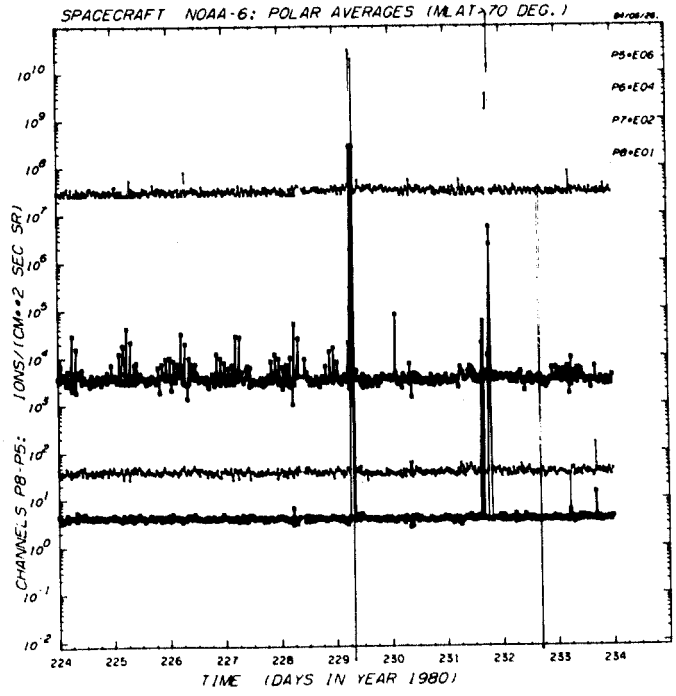


August 1, 1980





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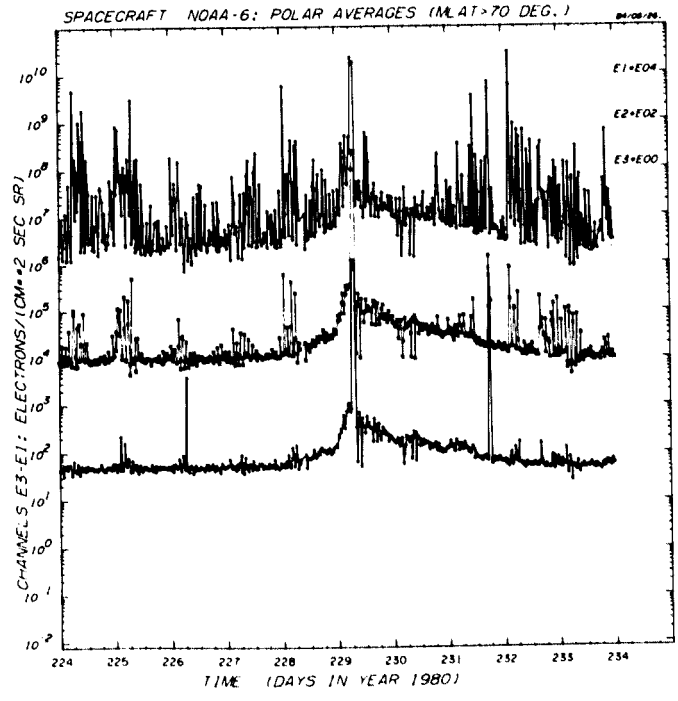
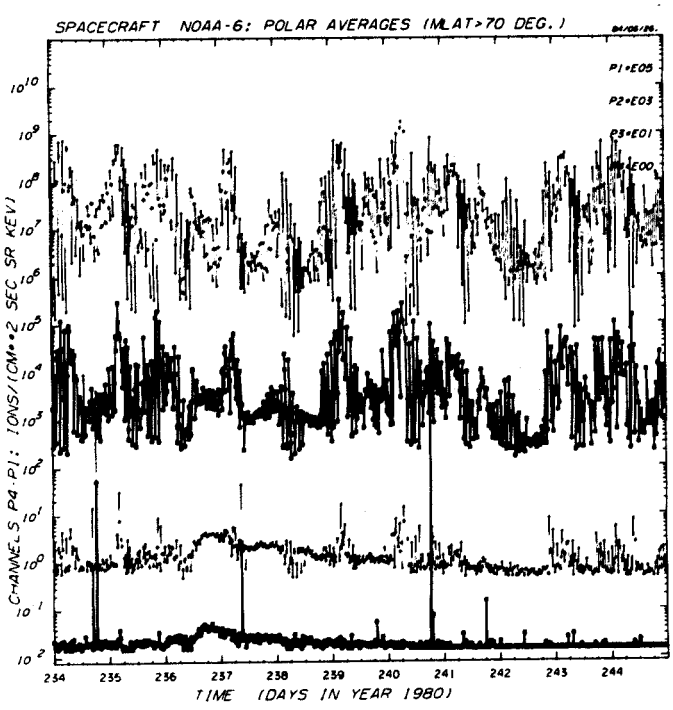
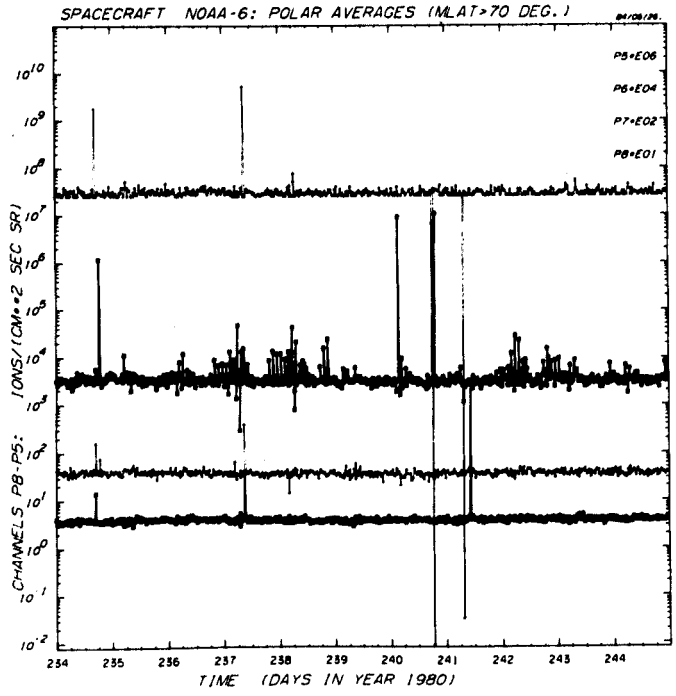


August 11, 1980





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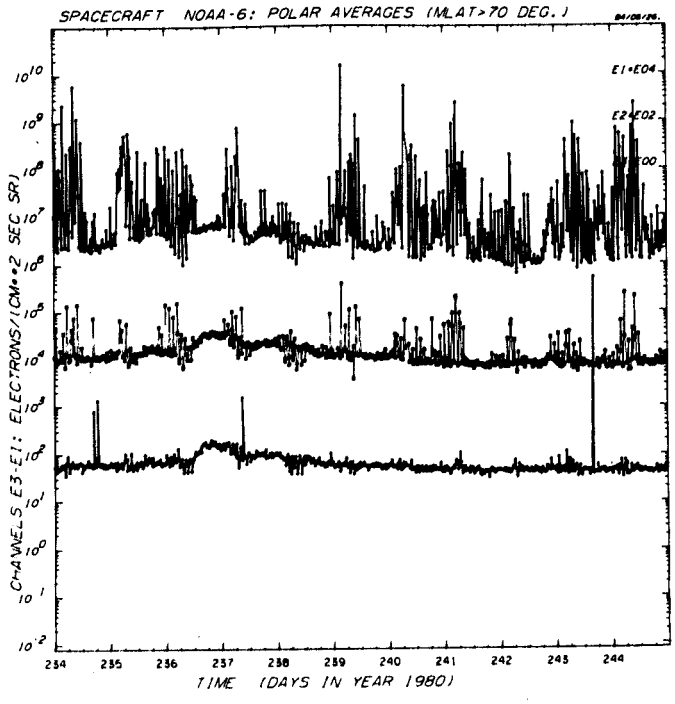
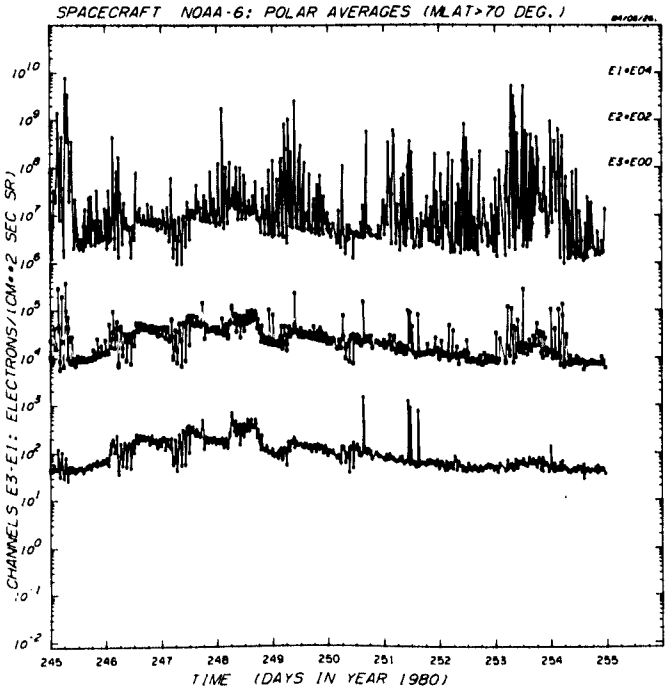
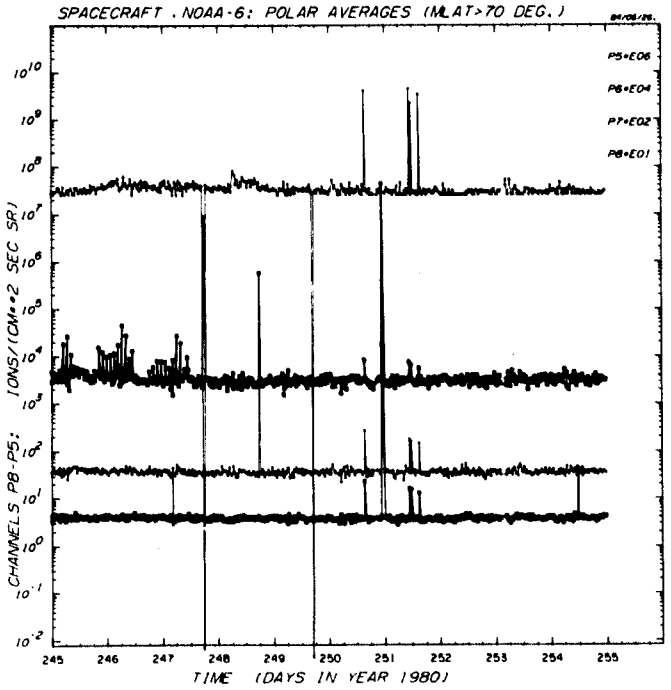


August 21, 1980





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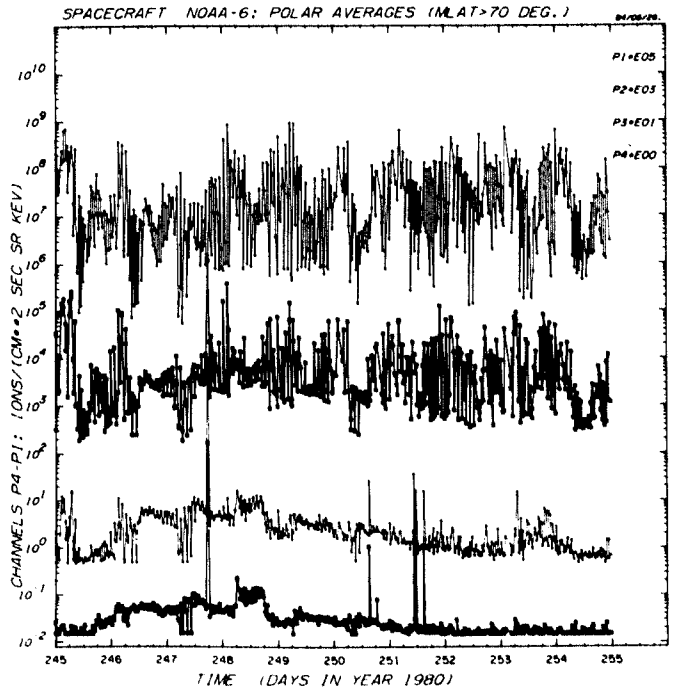
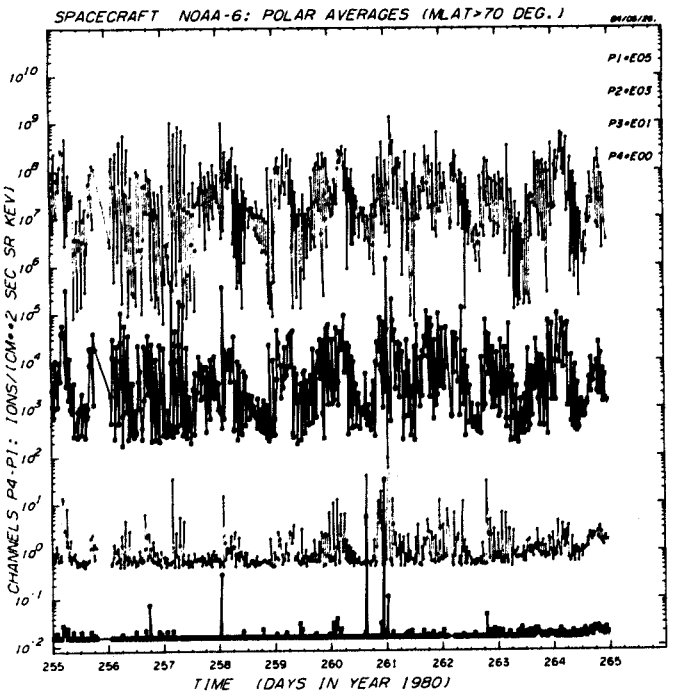
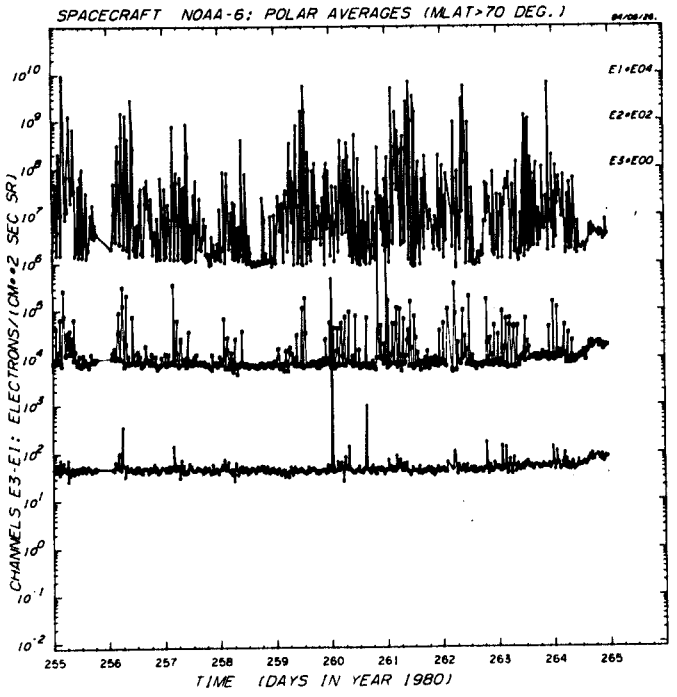


September 1, 1980





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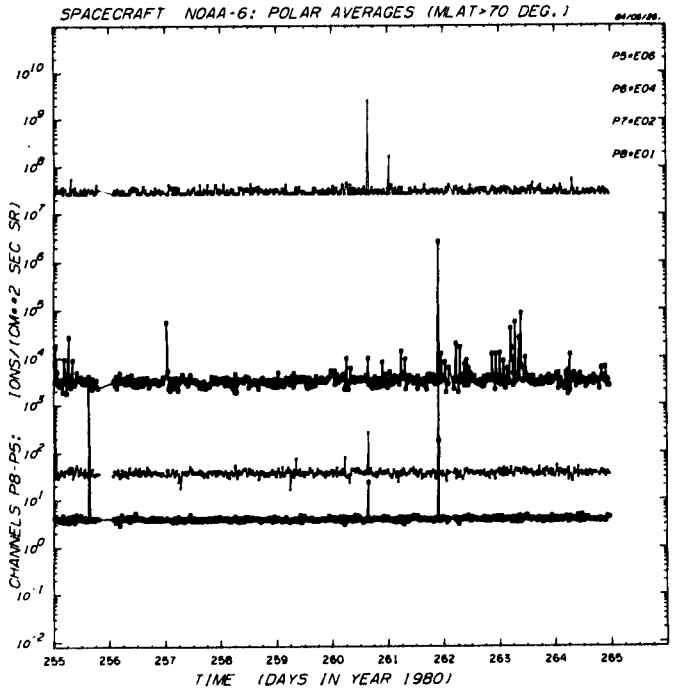

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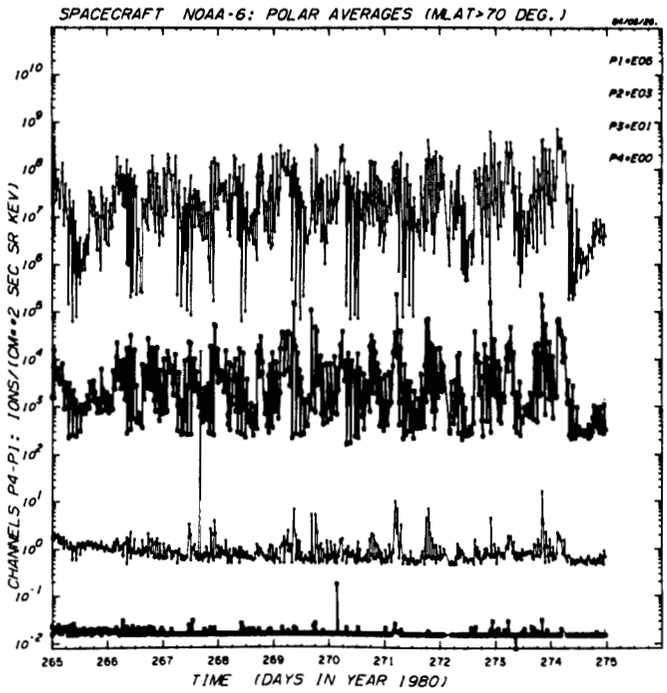

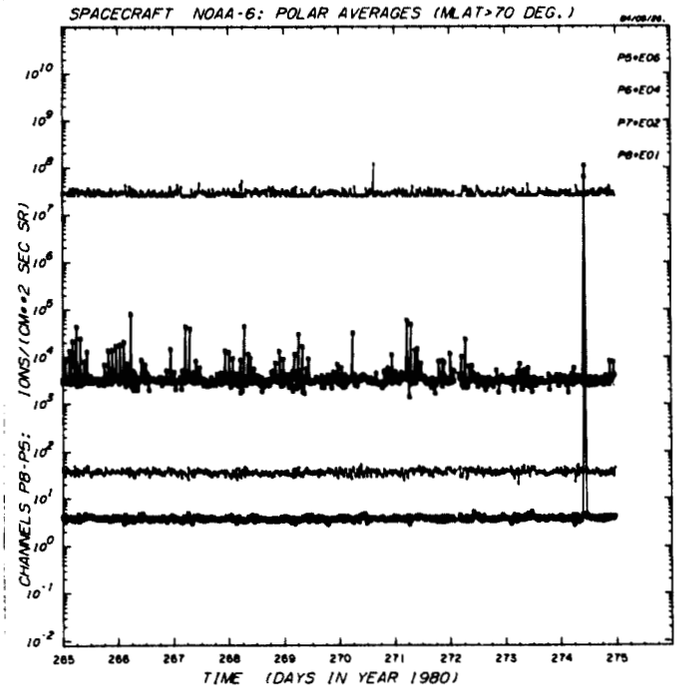

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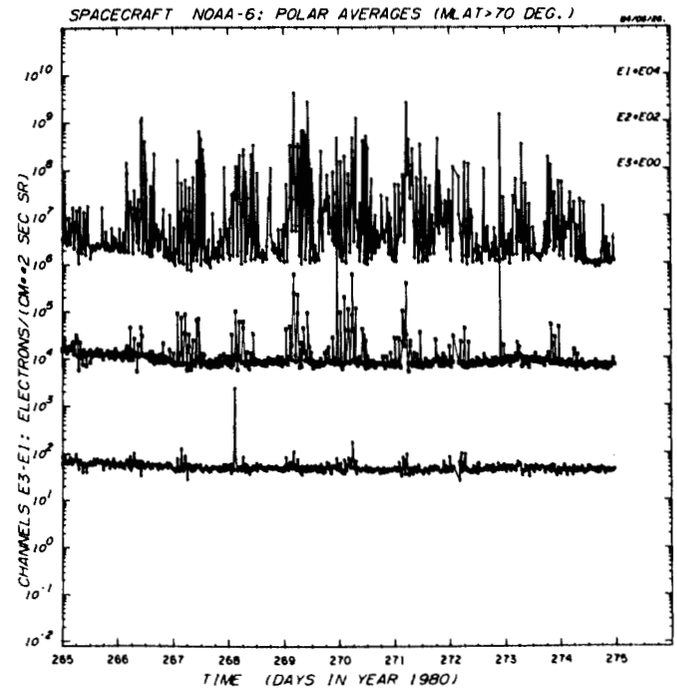

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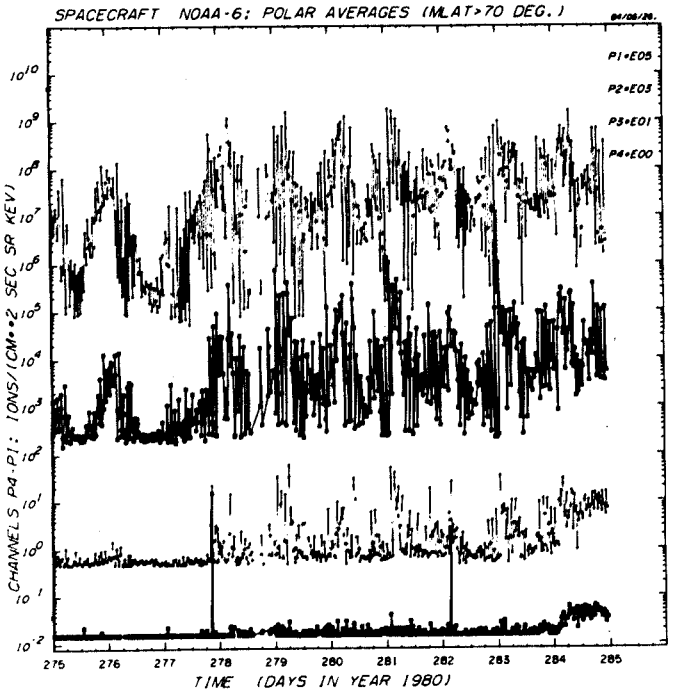

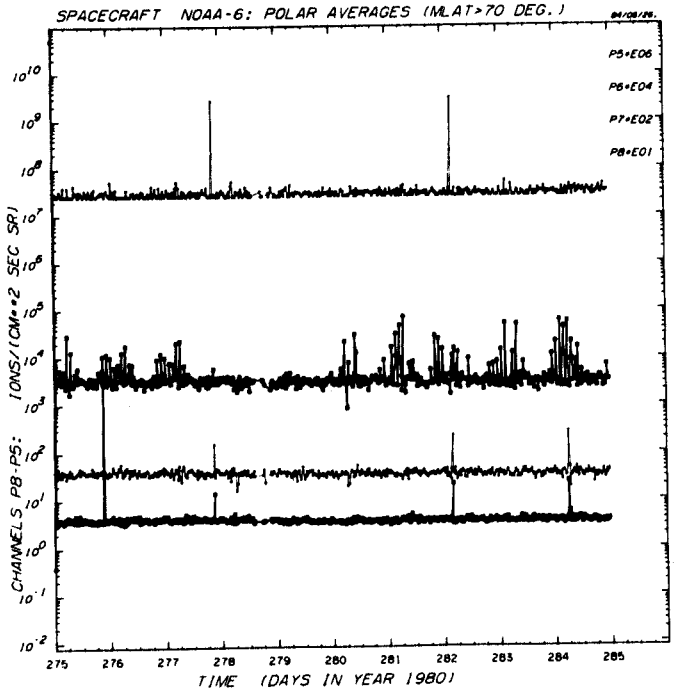

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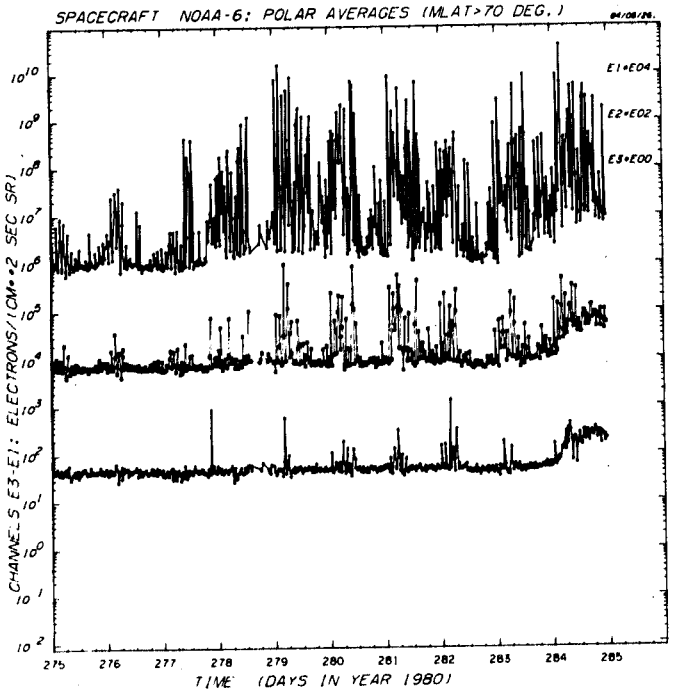

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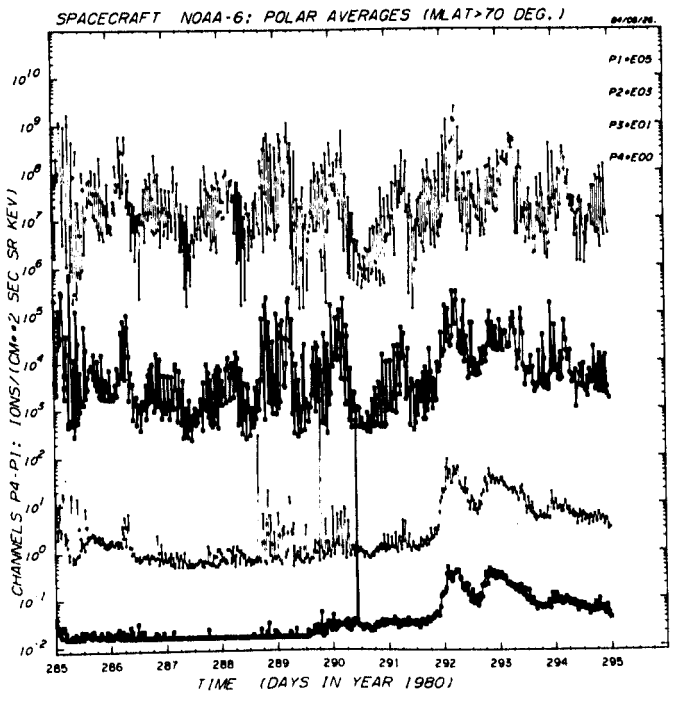

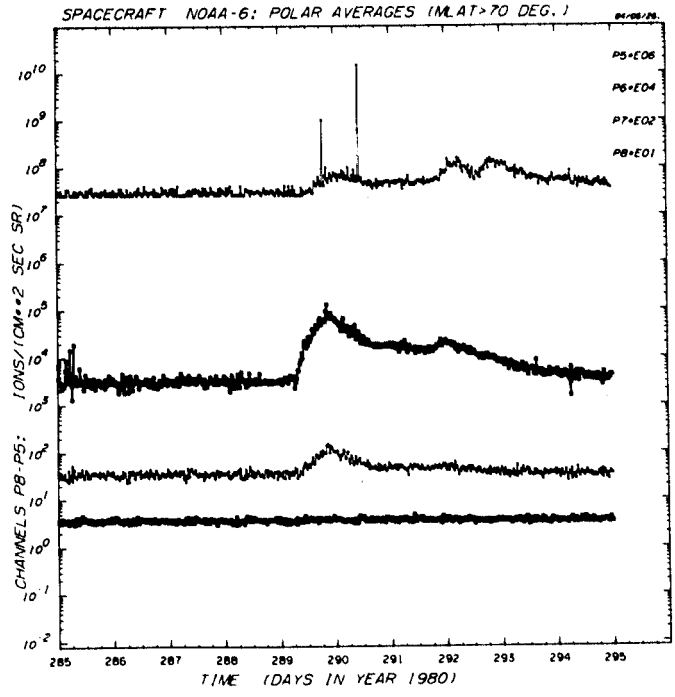

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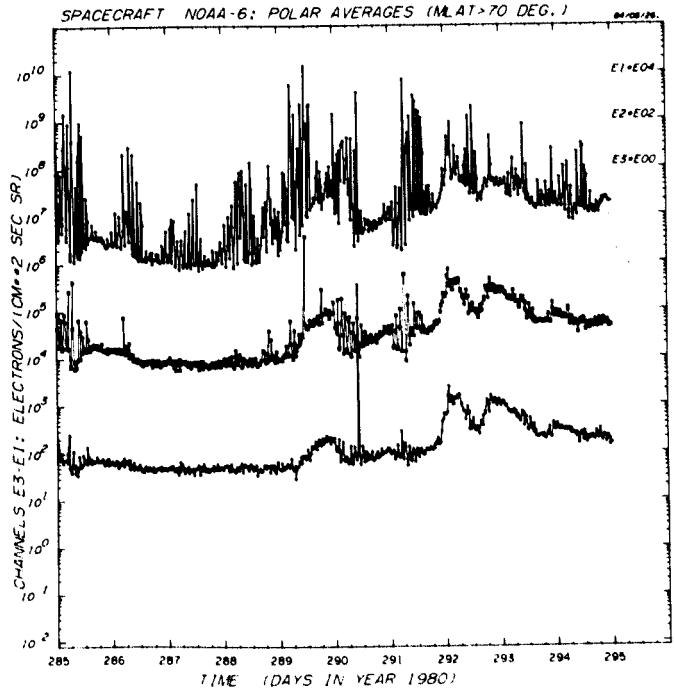

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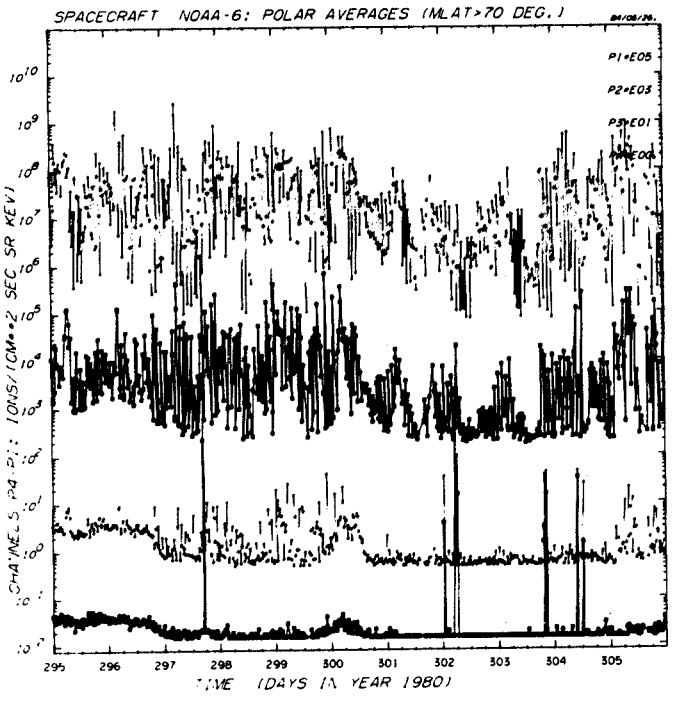

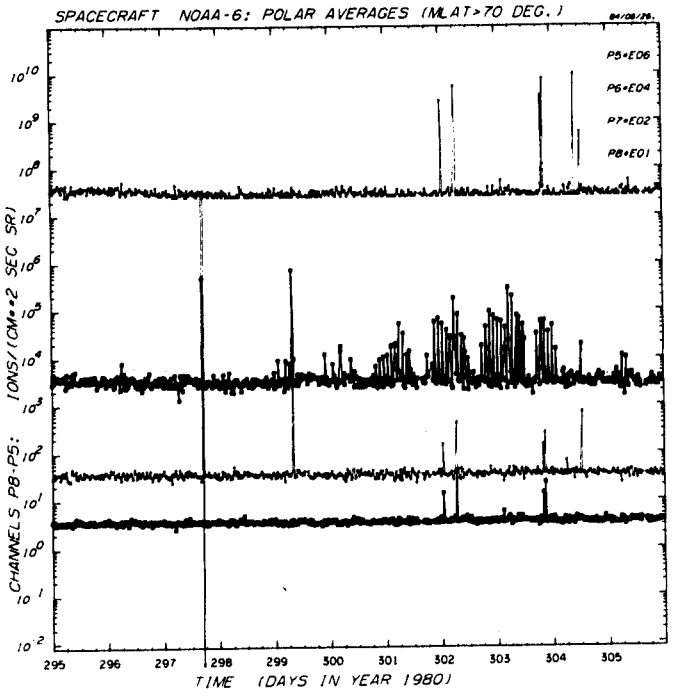

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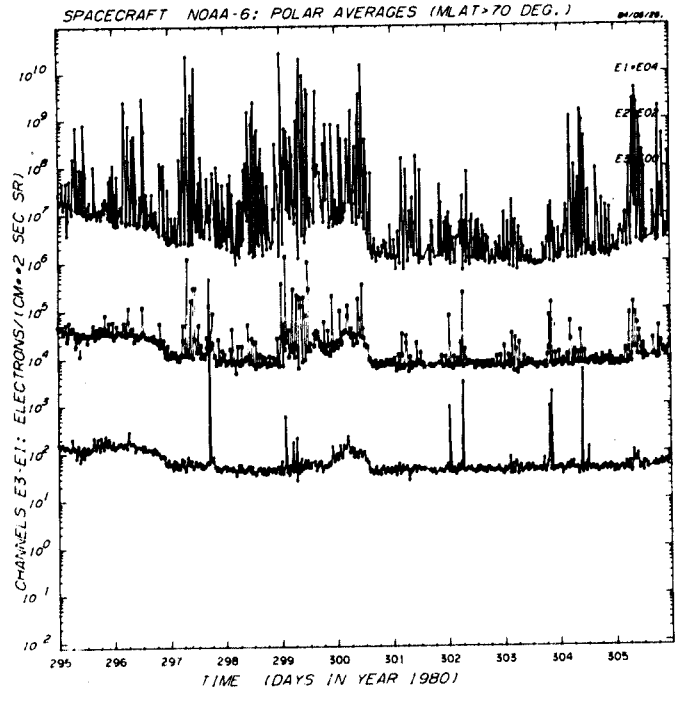

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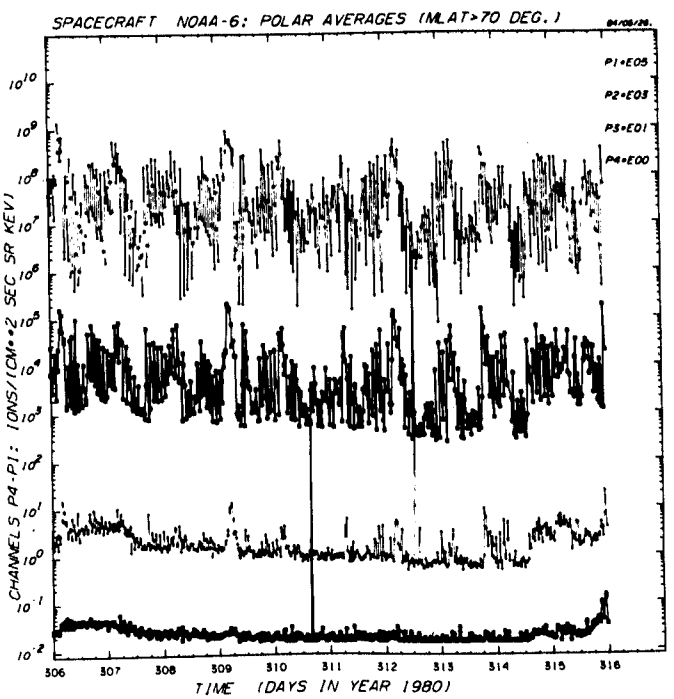

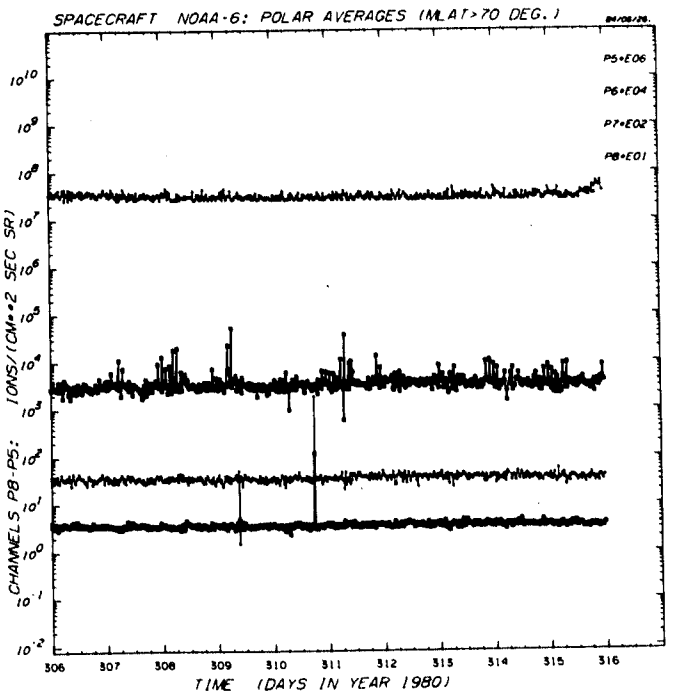

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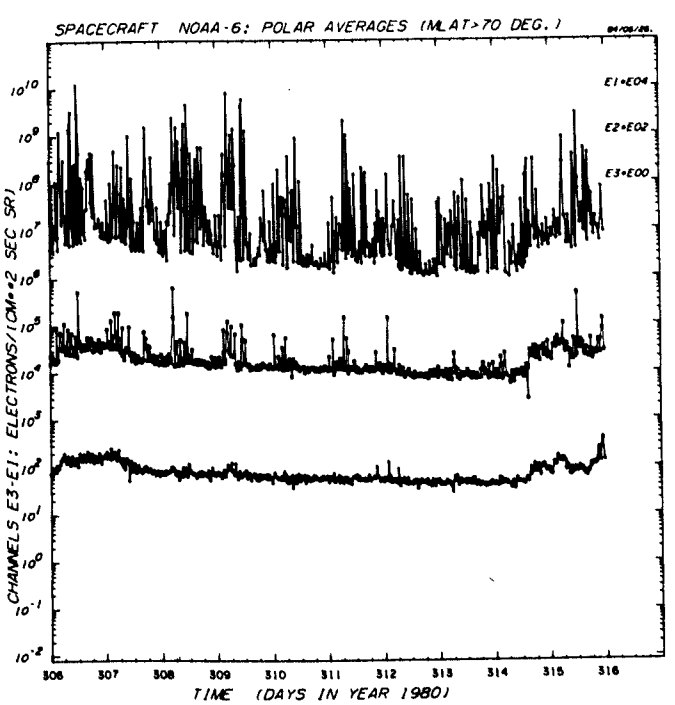
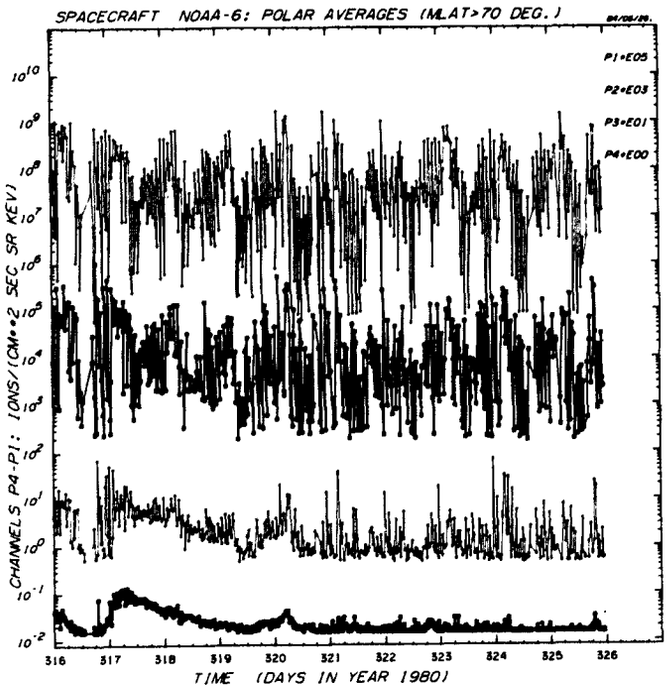
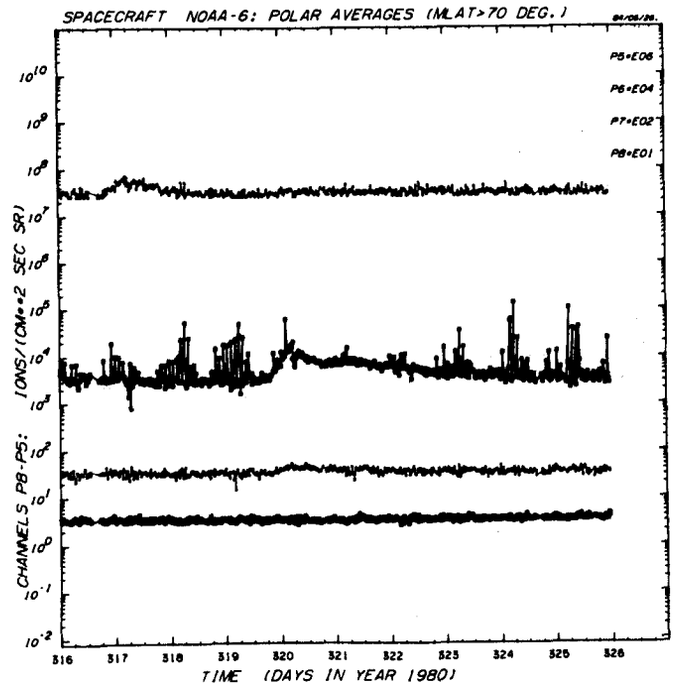


November 1, 1980





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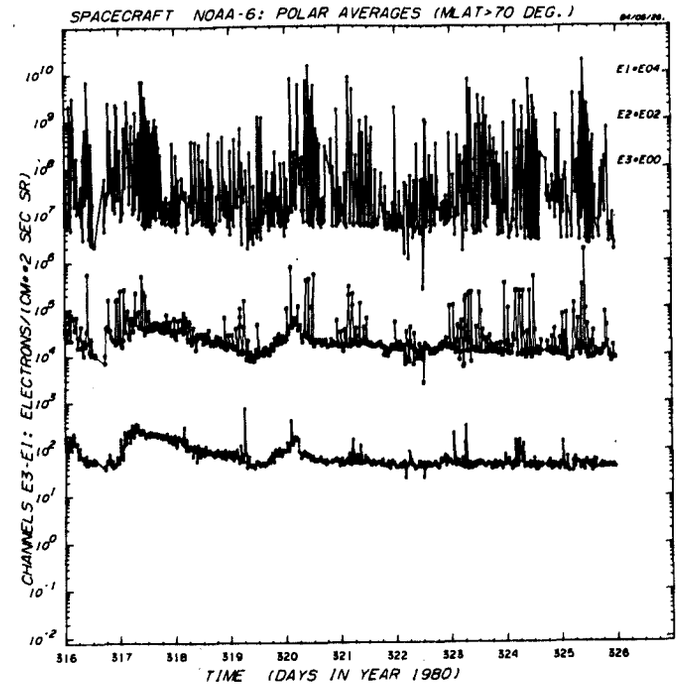
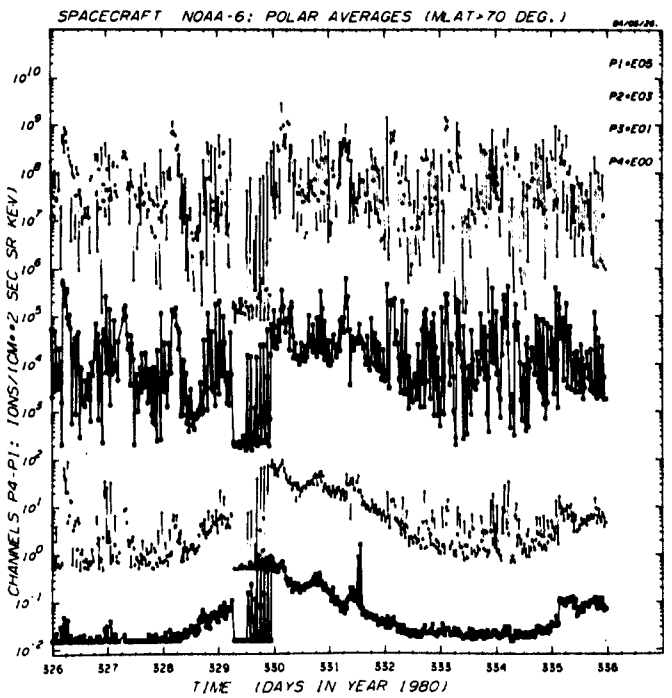
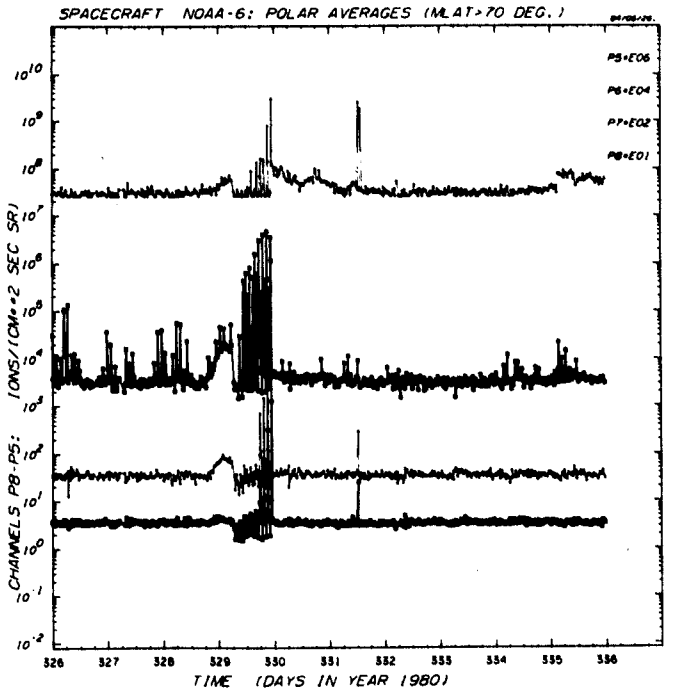


November 11, 1980





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
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P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
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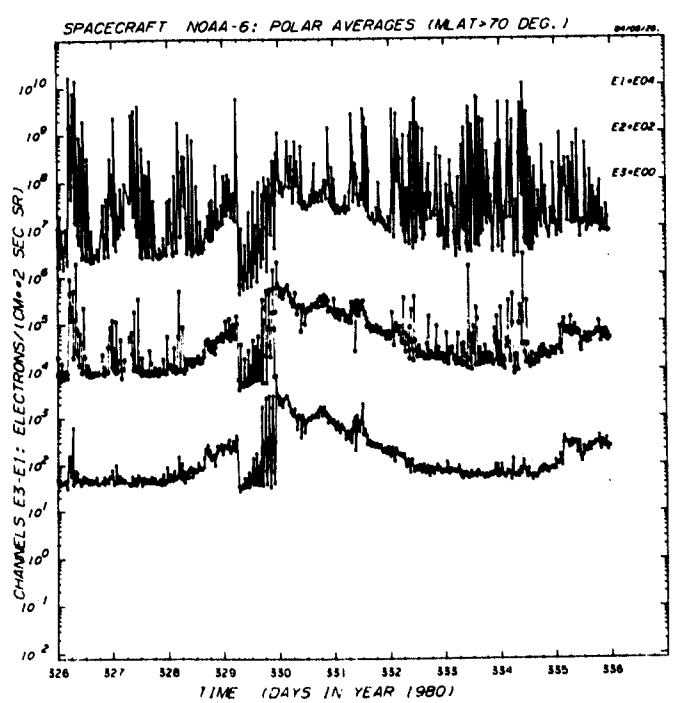
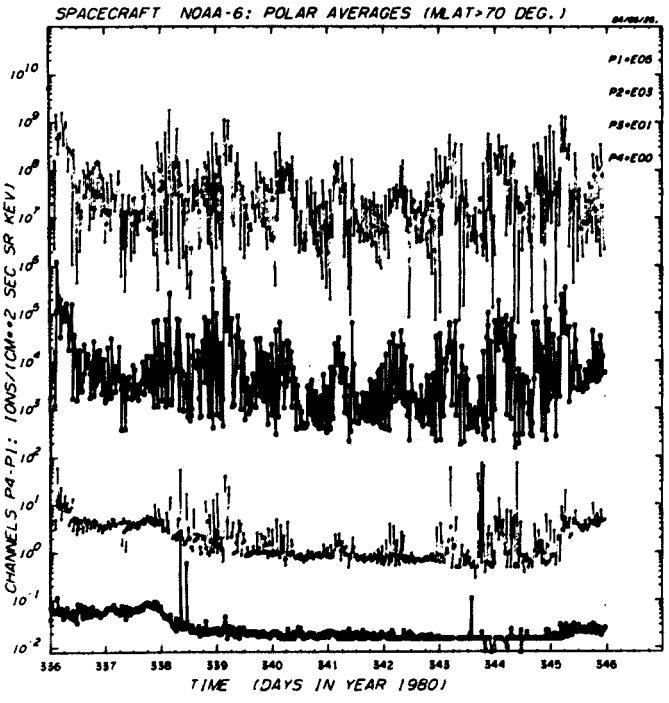
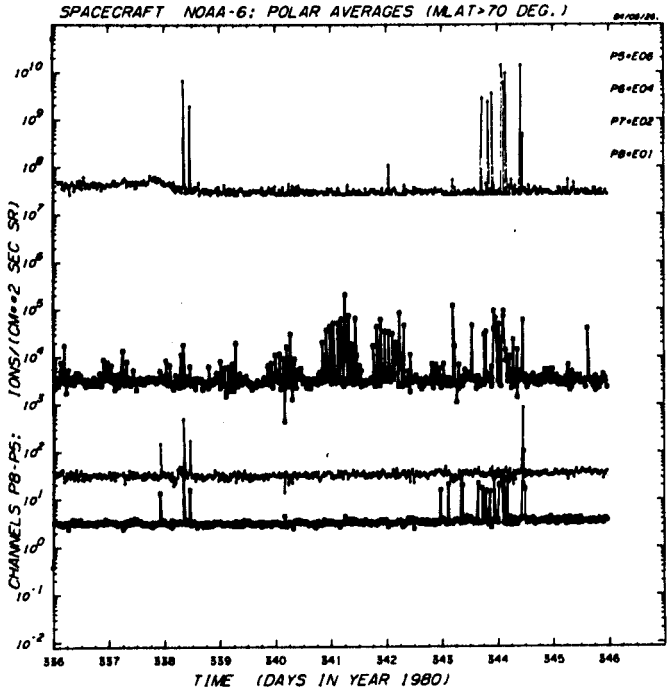


November 21, 1980





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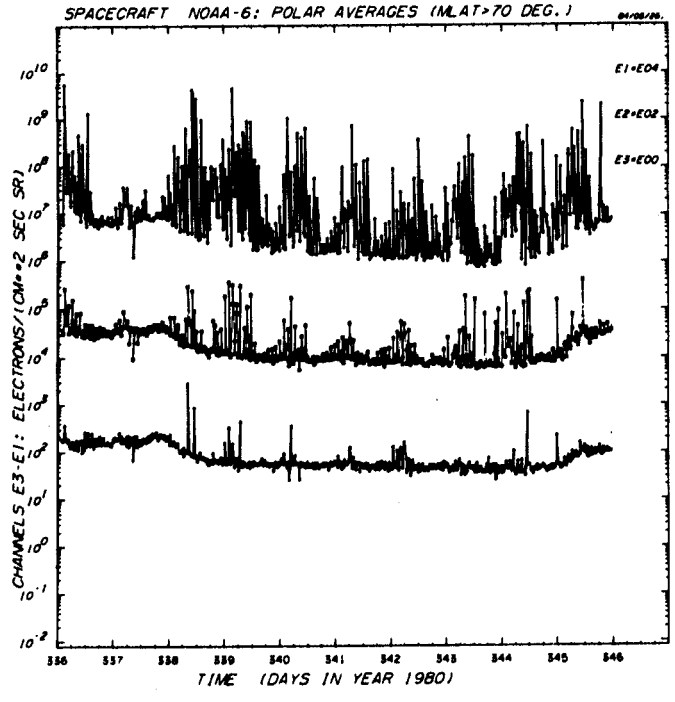
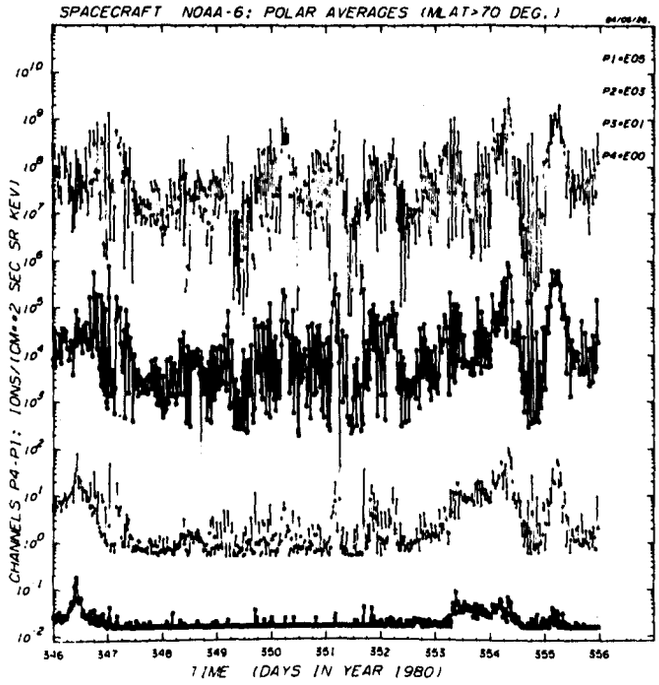
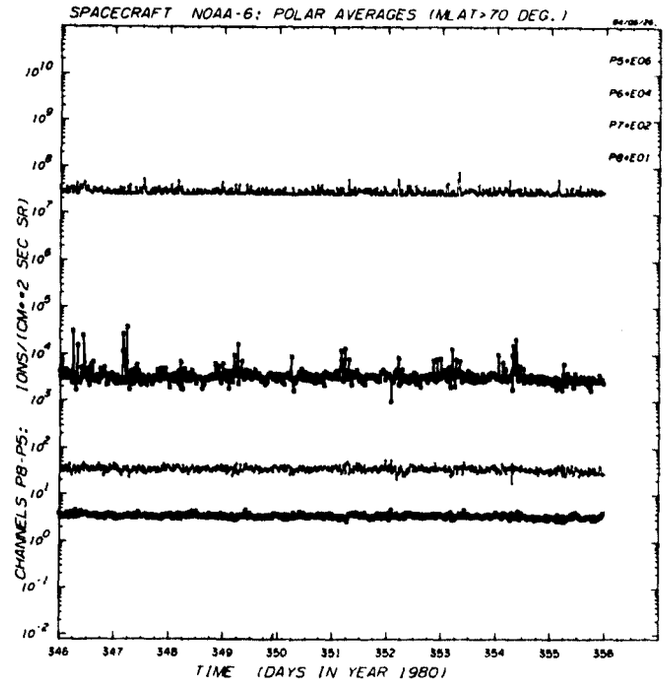


December 1, 1980





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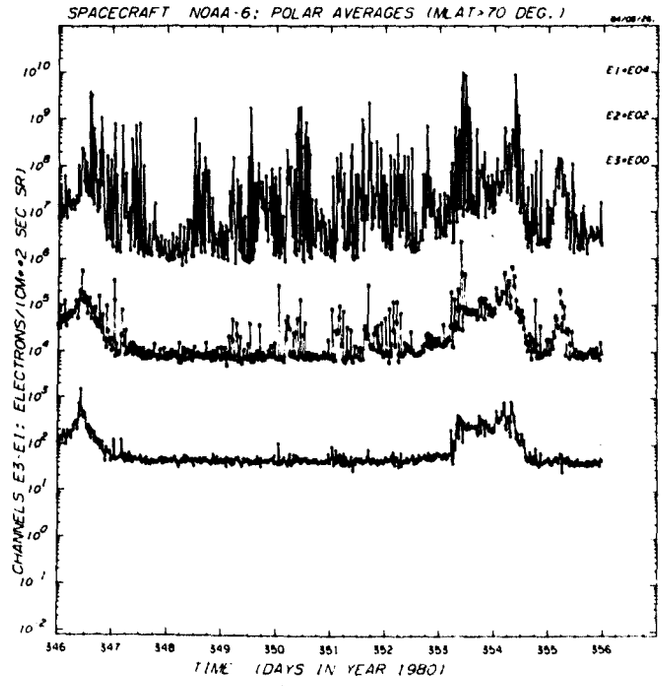
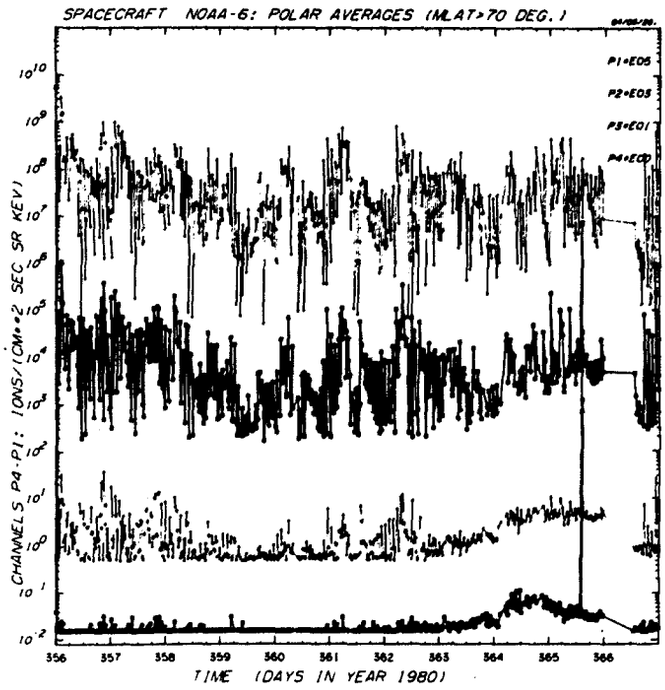
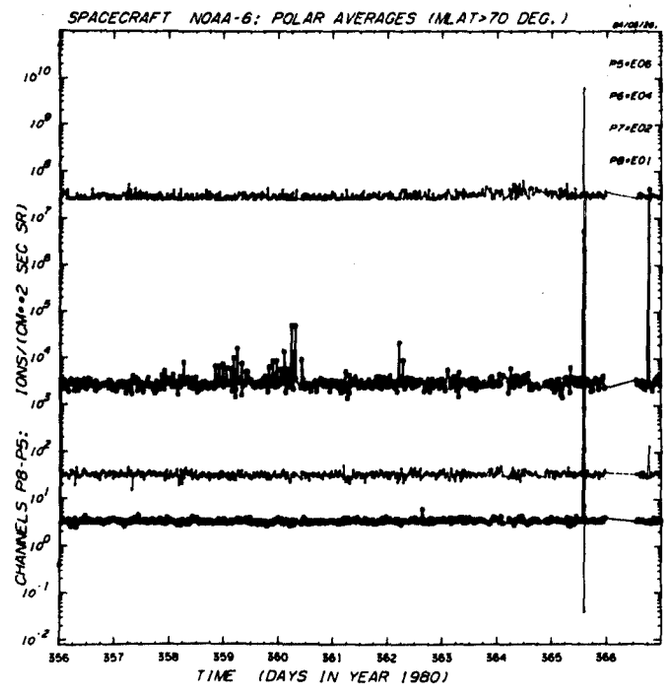


December 11, 1980





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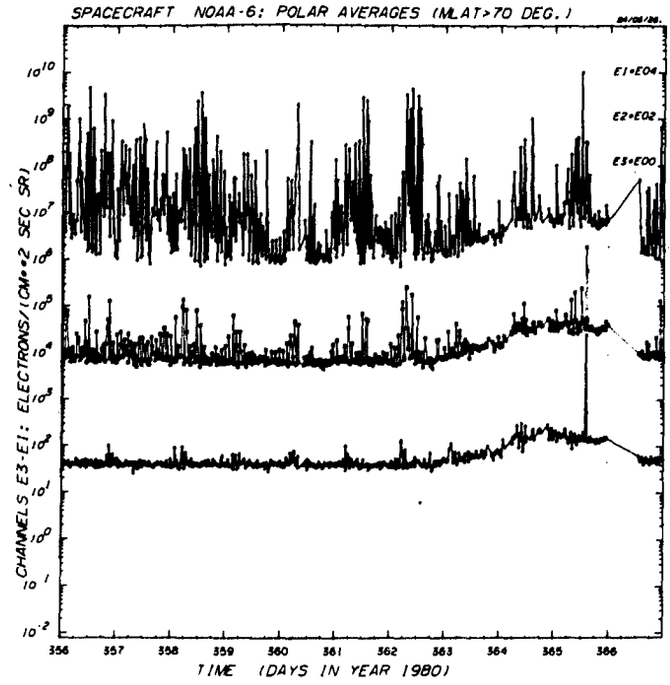
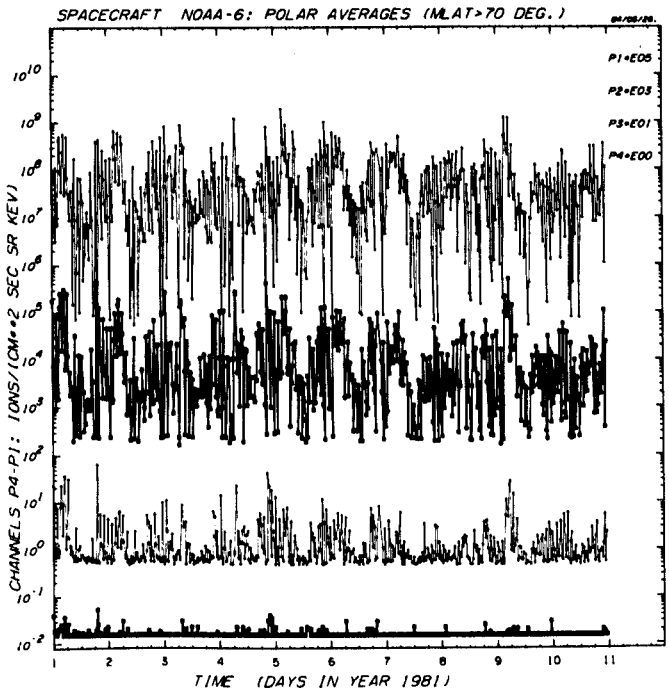
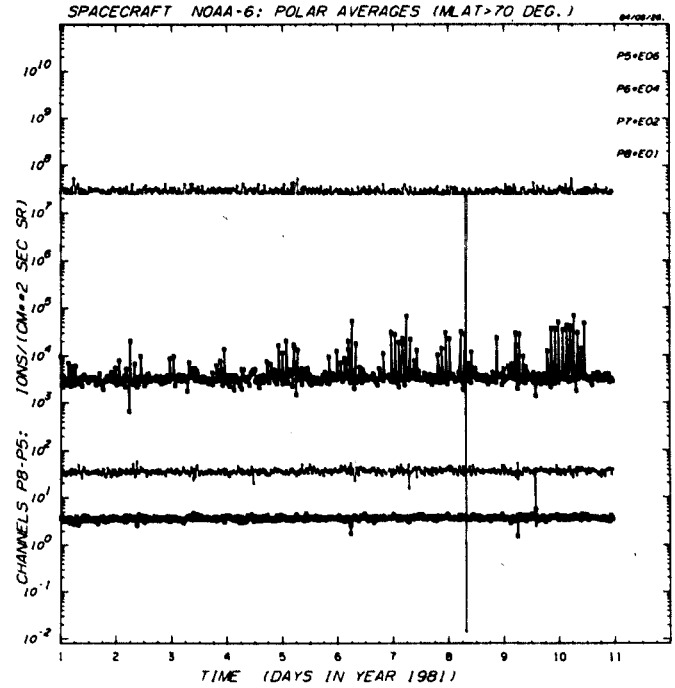


December 21, 1980





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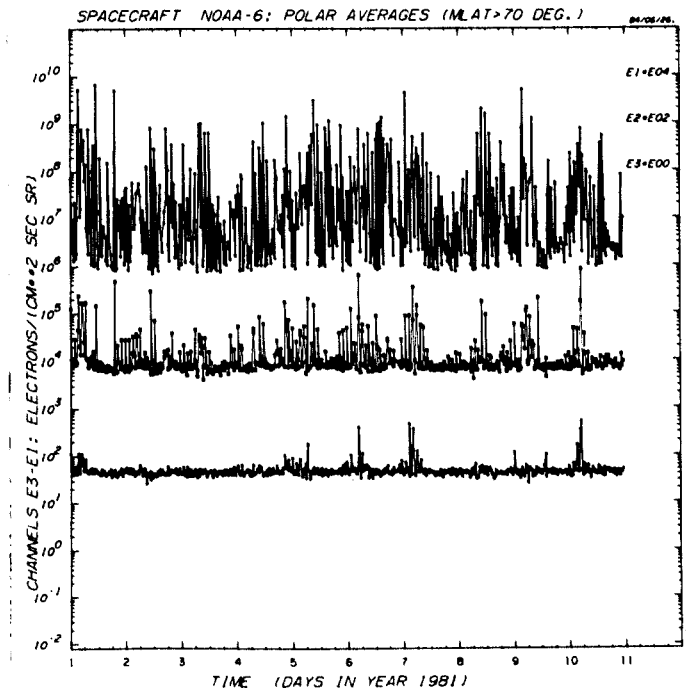
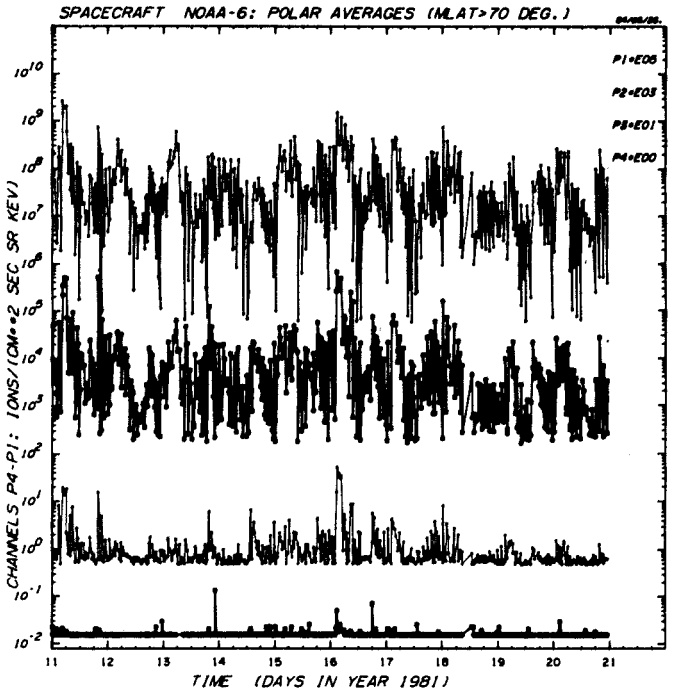
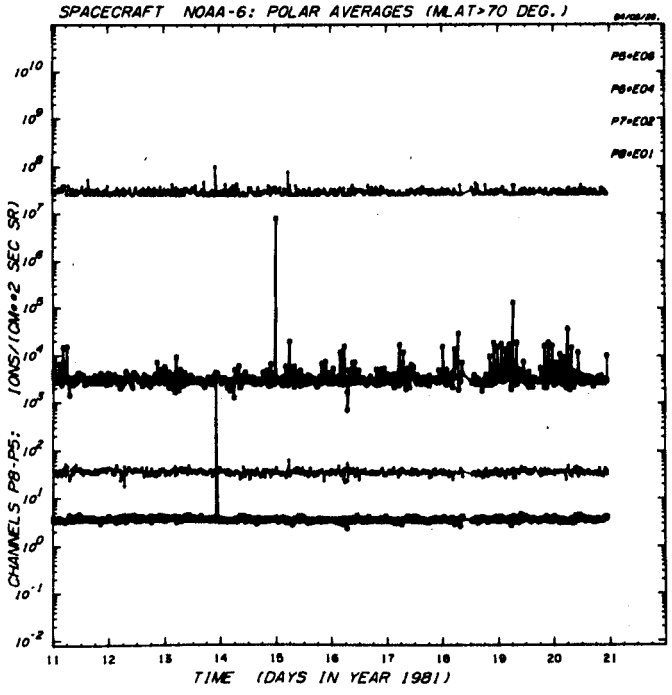


January 1, 1981





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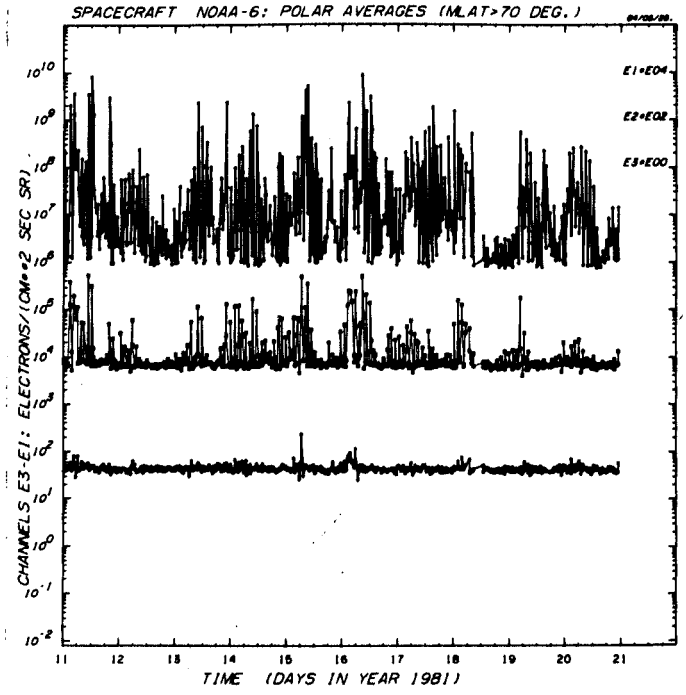
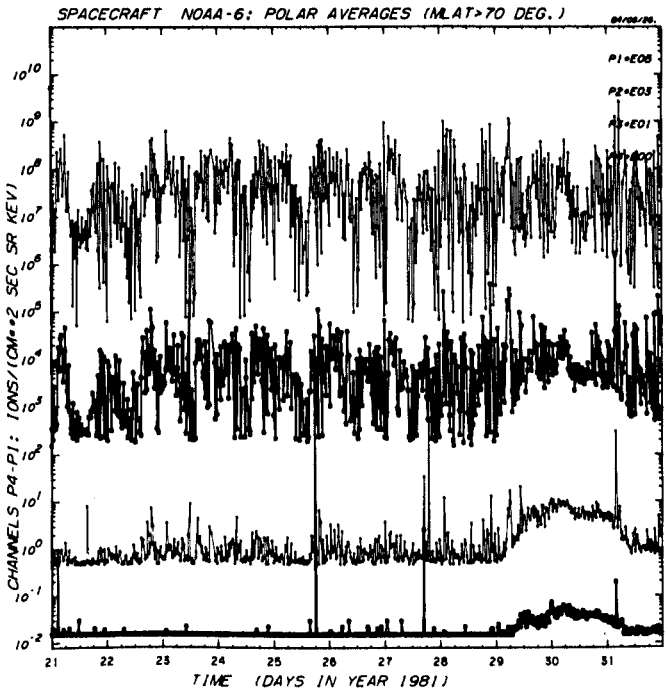
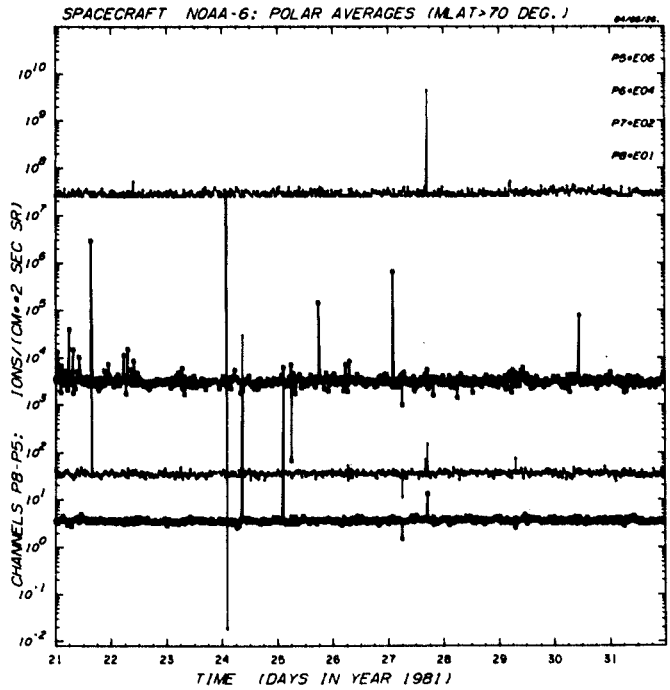


January 11, 1981





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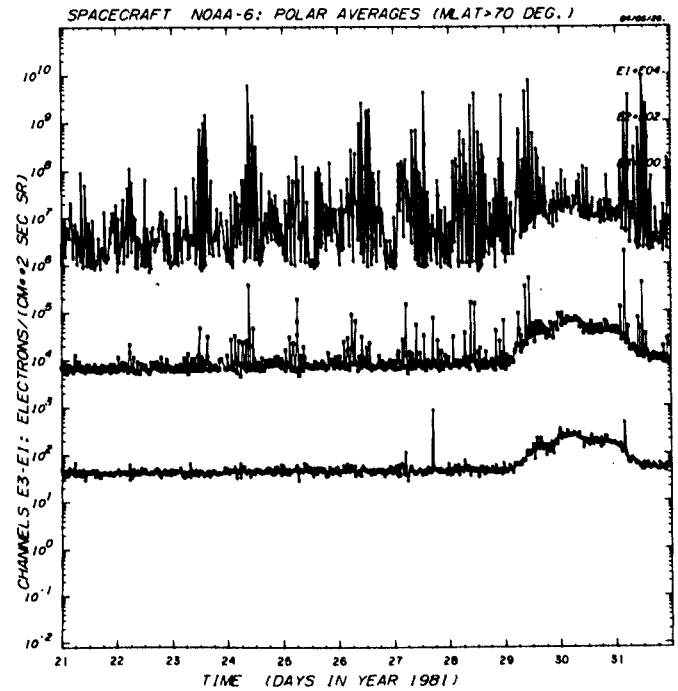
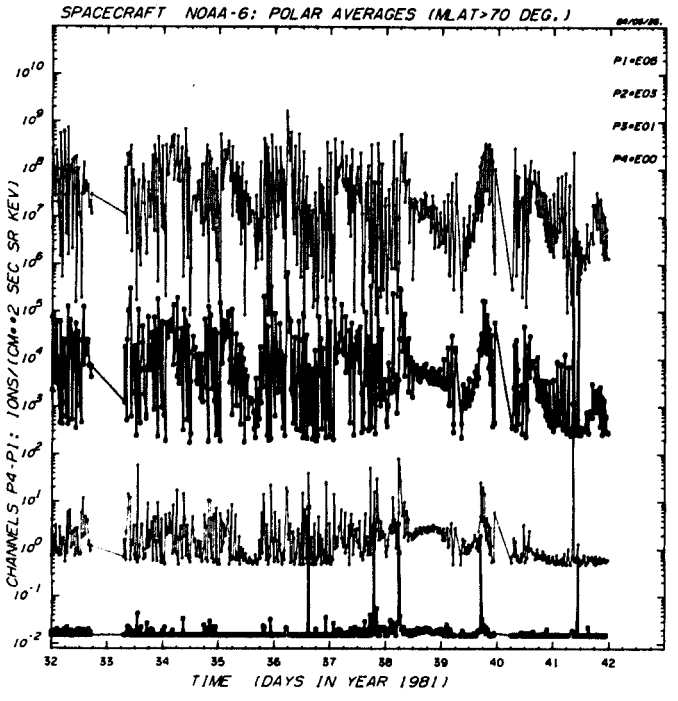
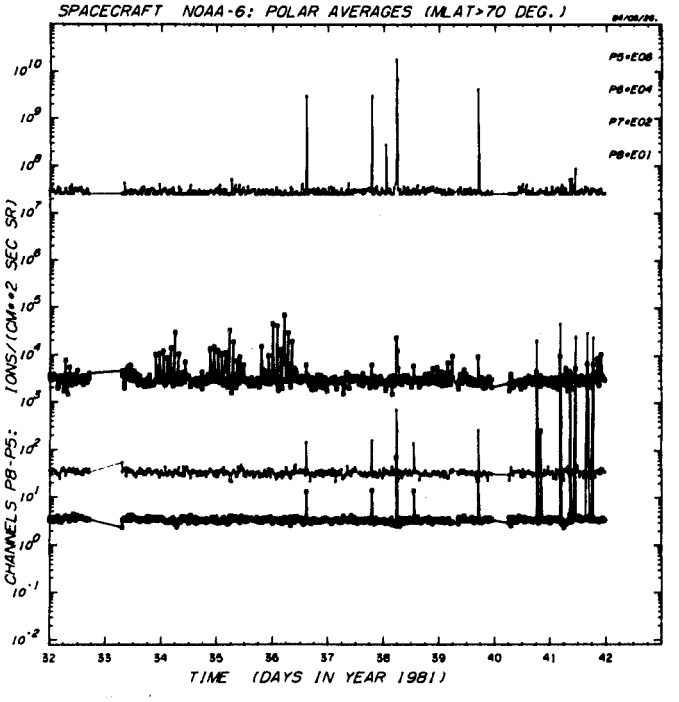


January 21, 1981





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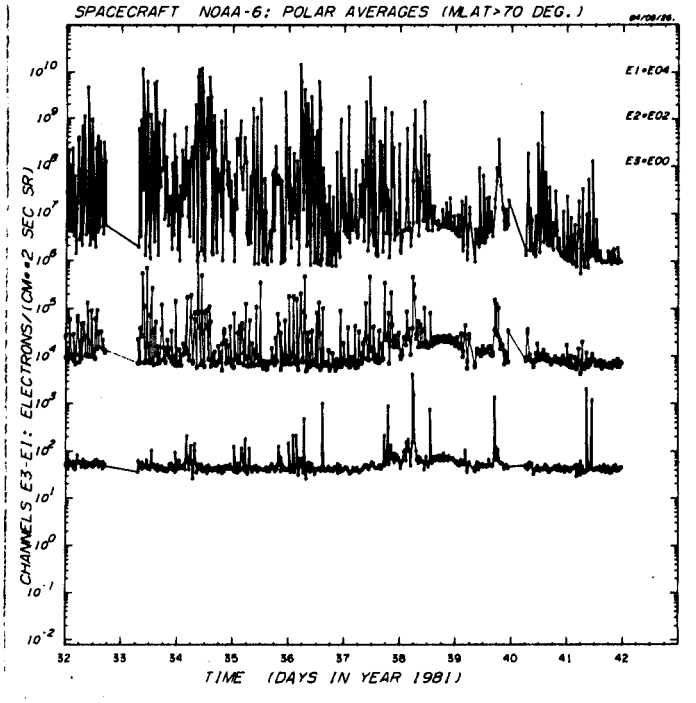
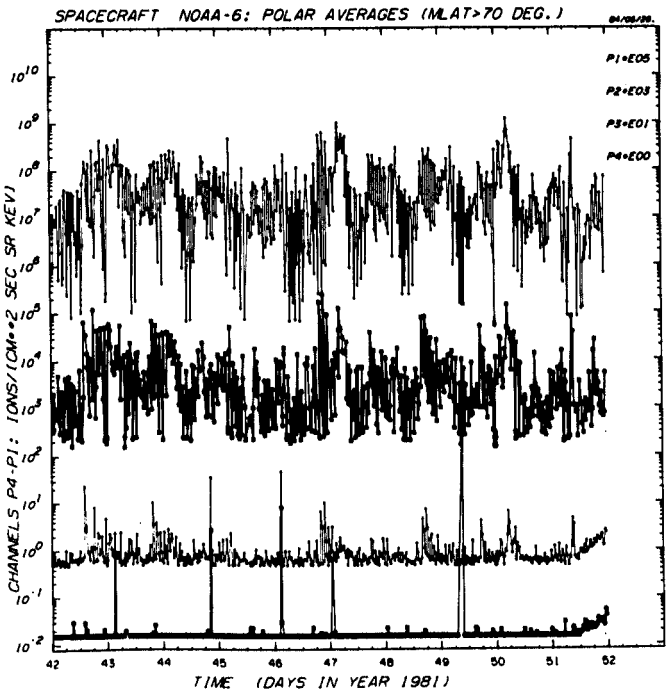
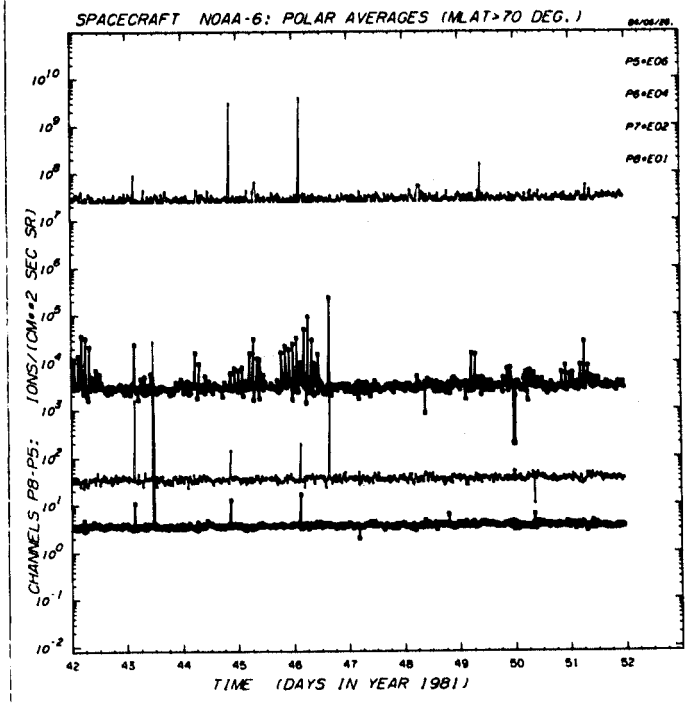


February 1, 1981





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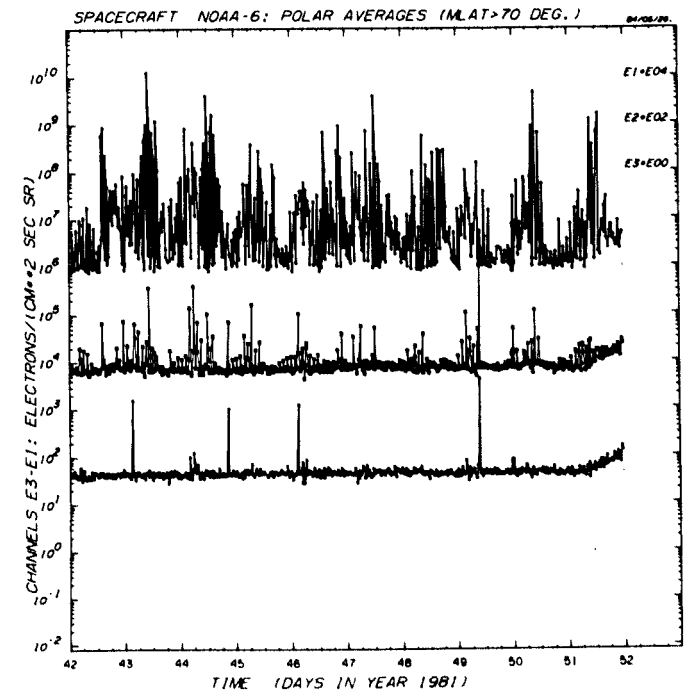
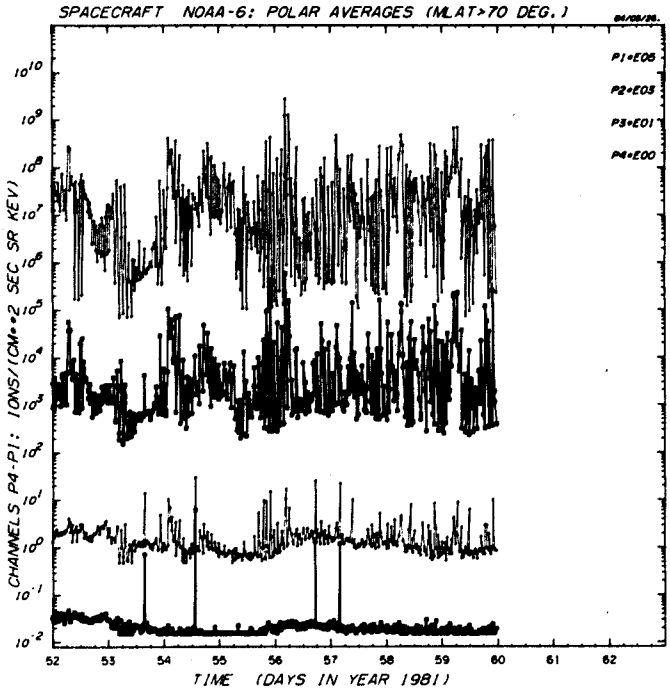
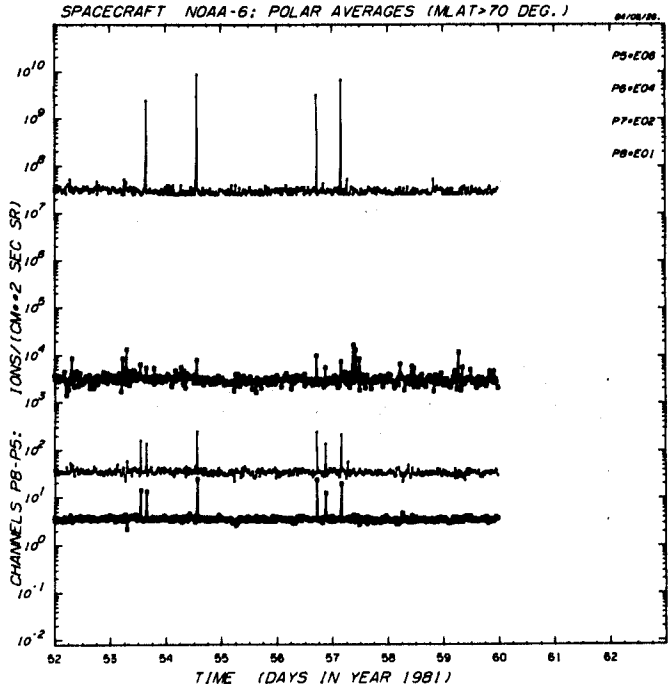


February 11, 1981





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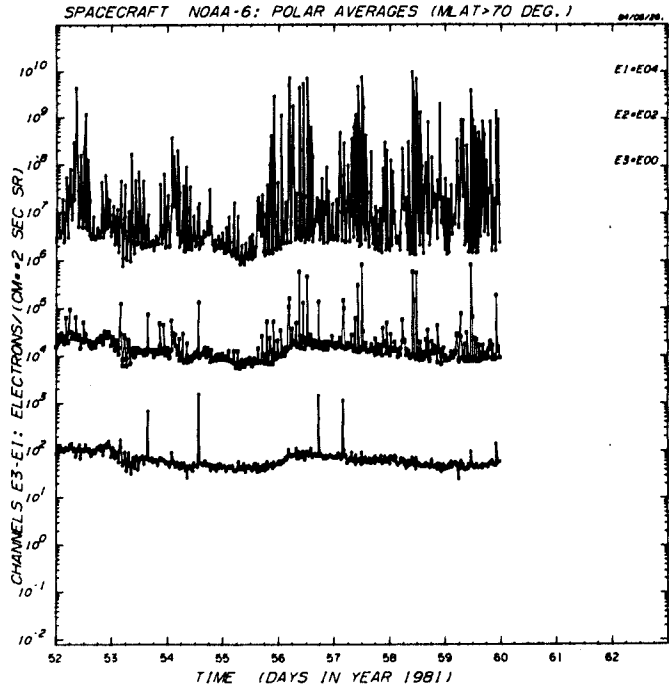
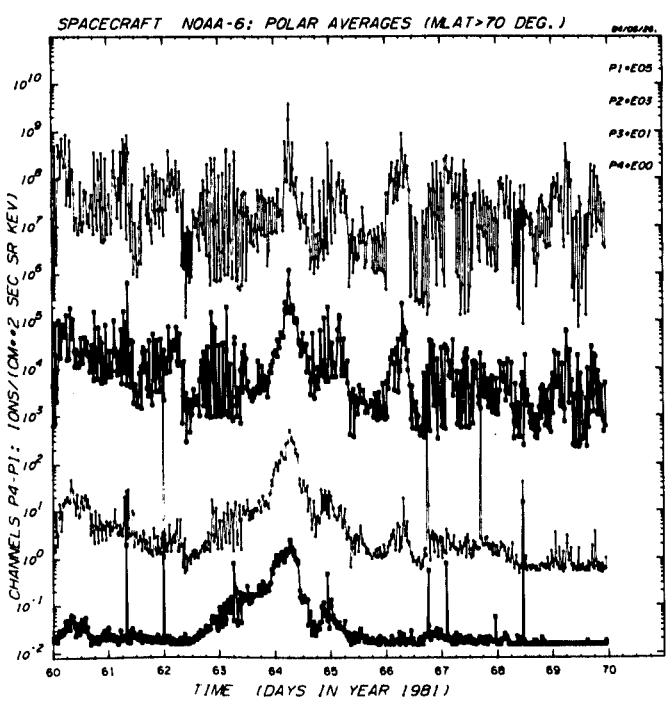
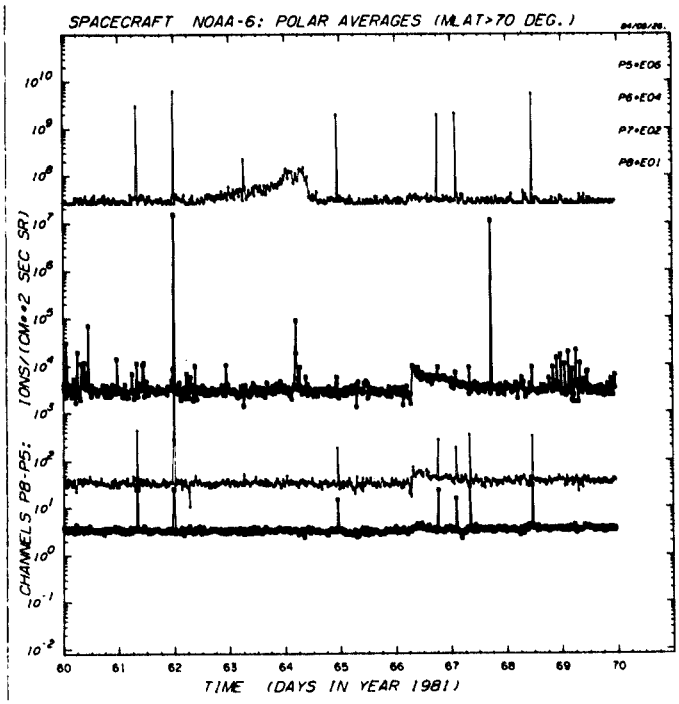


February 21, 1981





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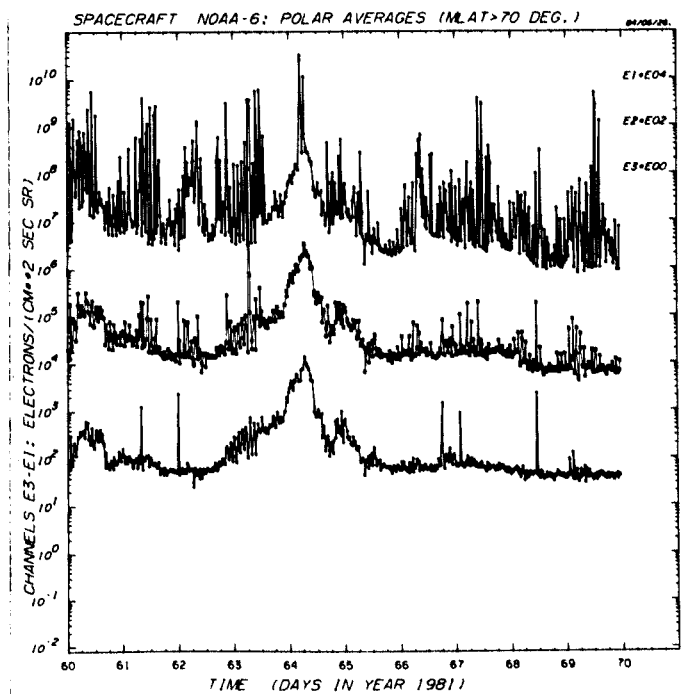
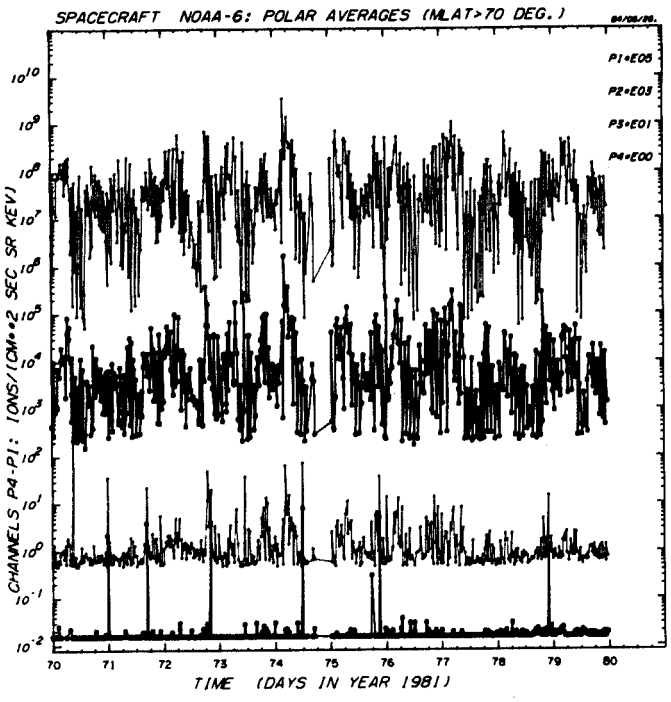
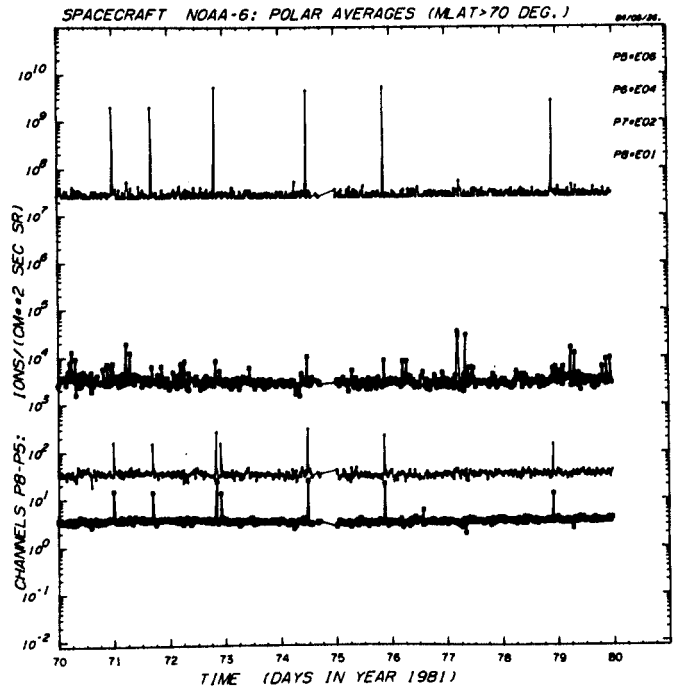


March 1, 1981





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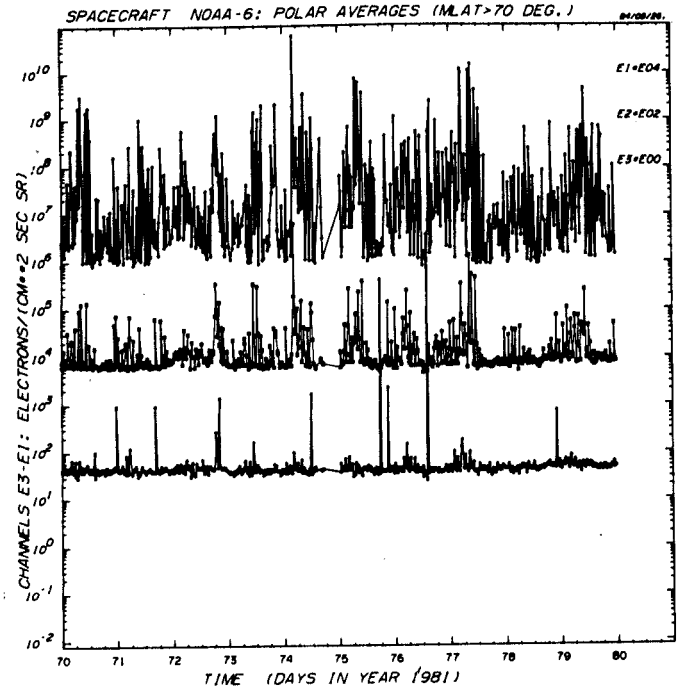

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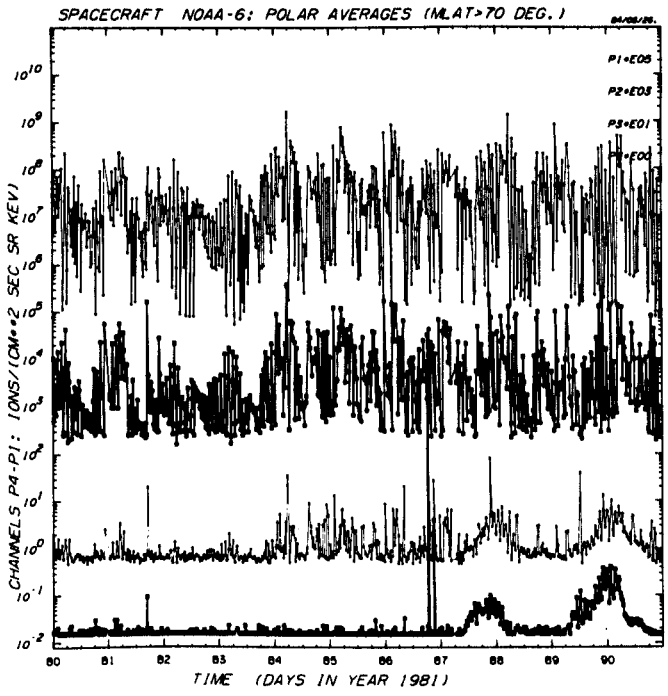

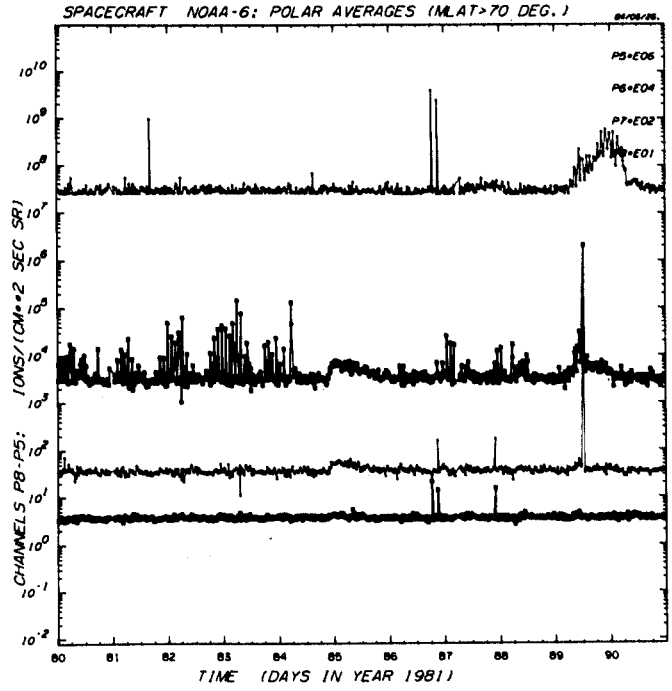

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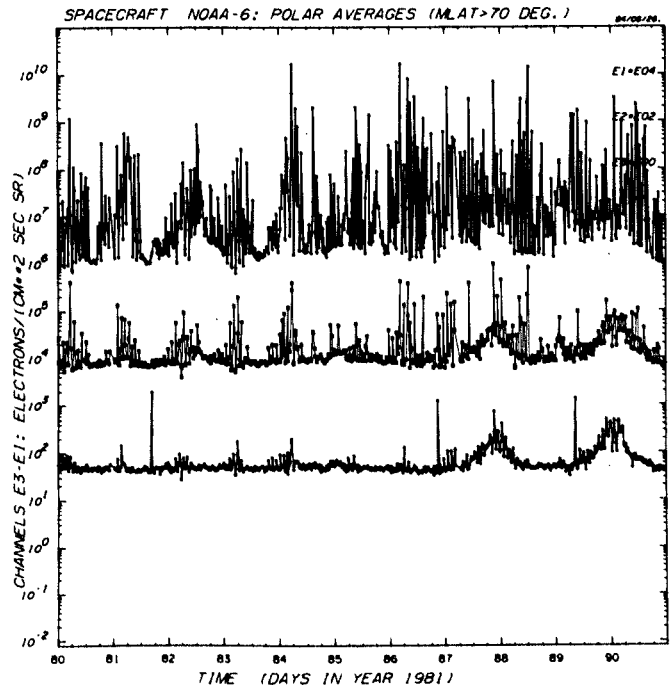

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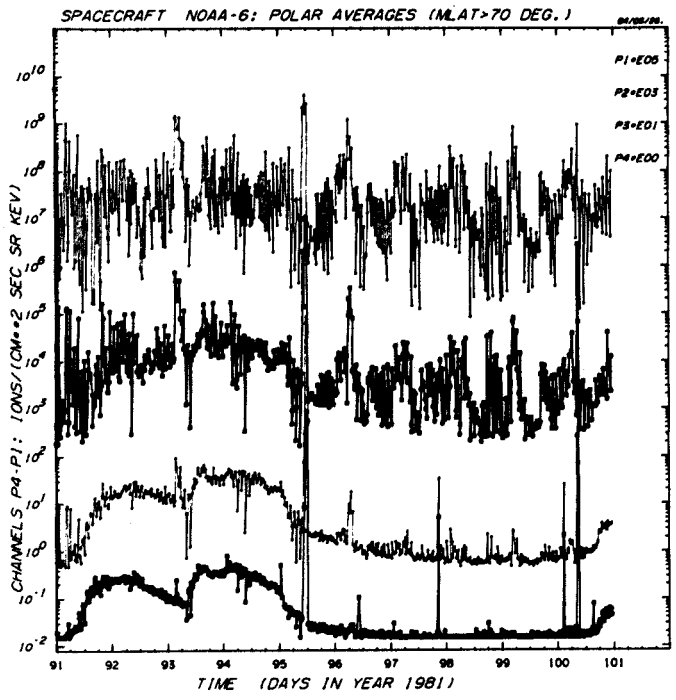

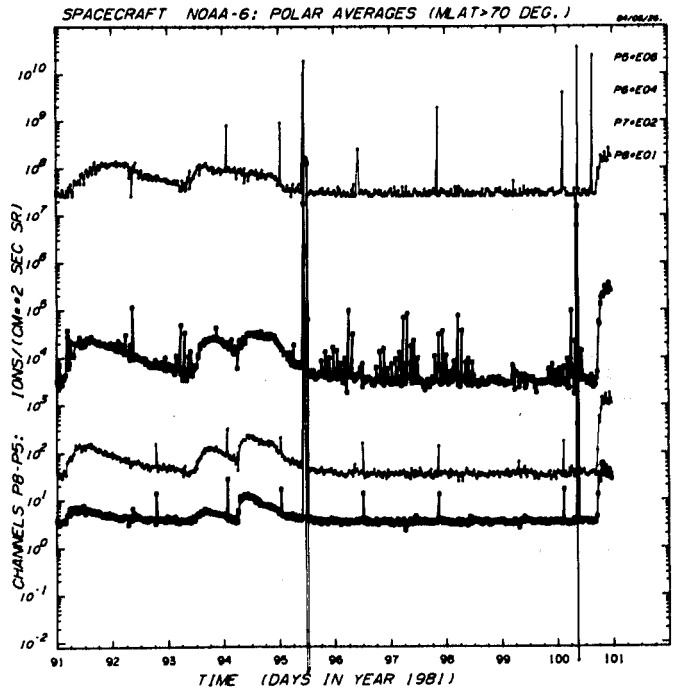

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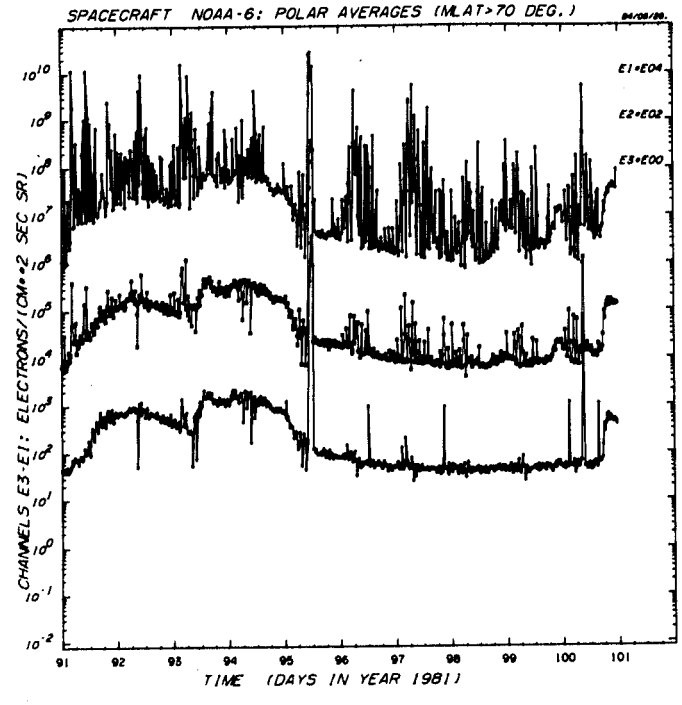
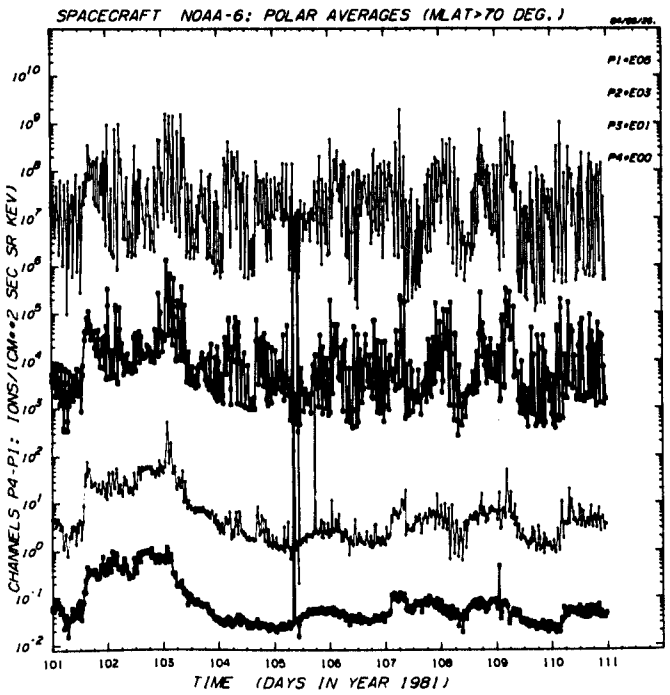
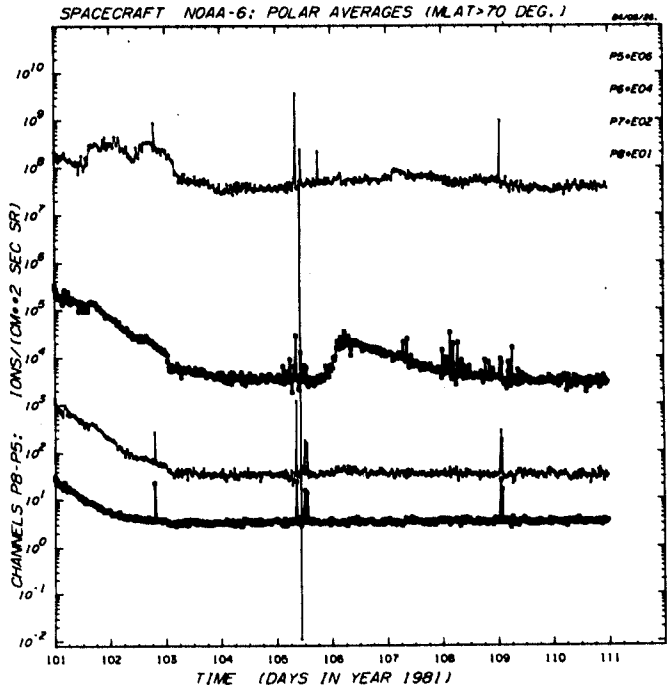


April 1, 1981





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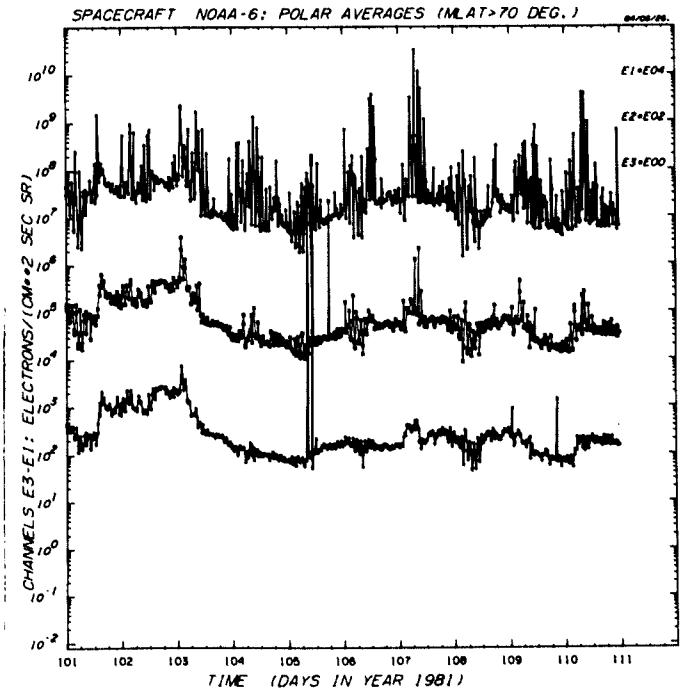
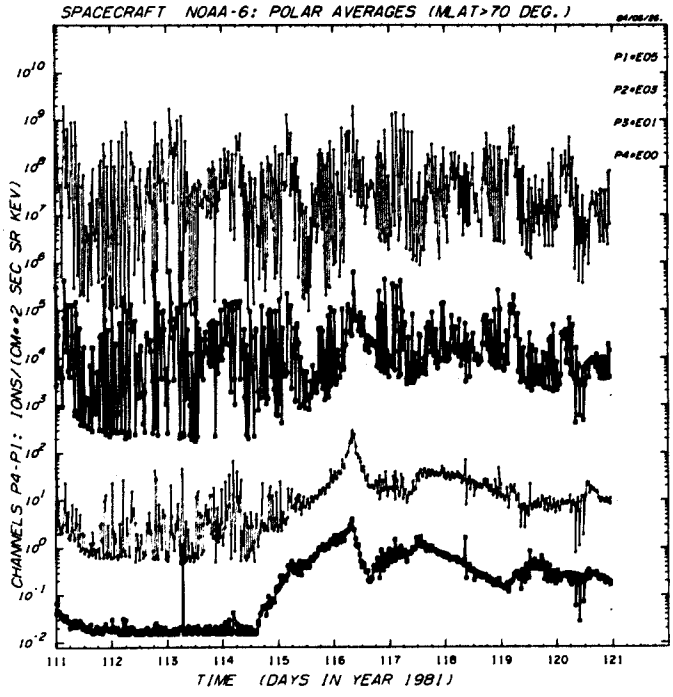
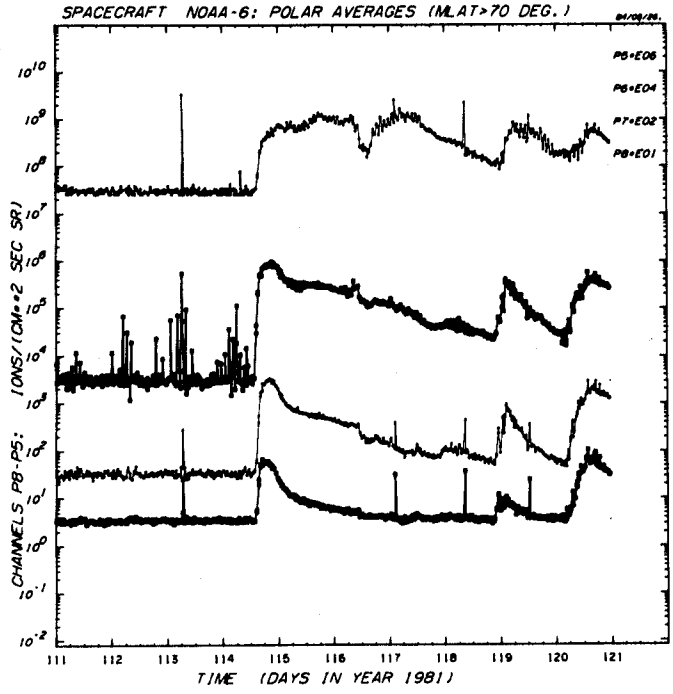


April 11, 1981





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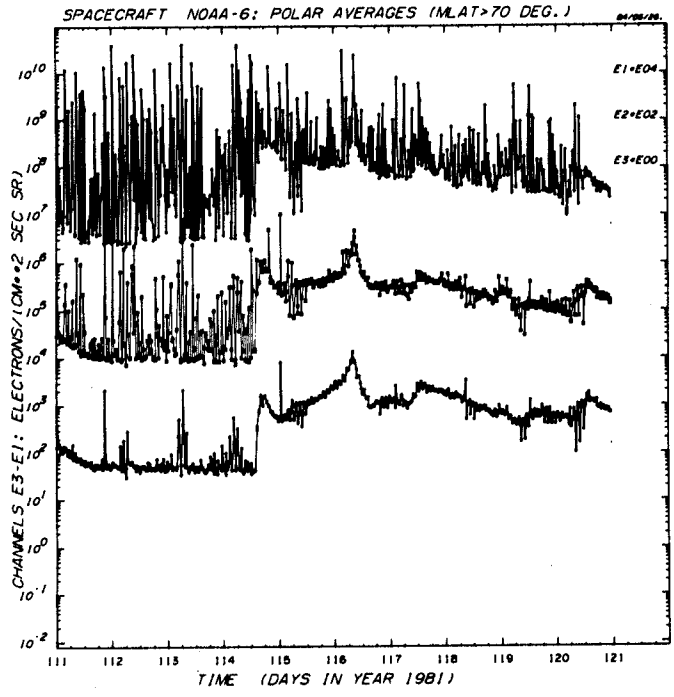
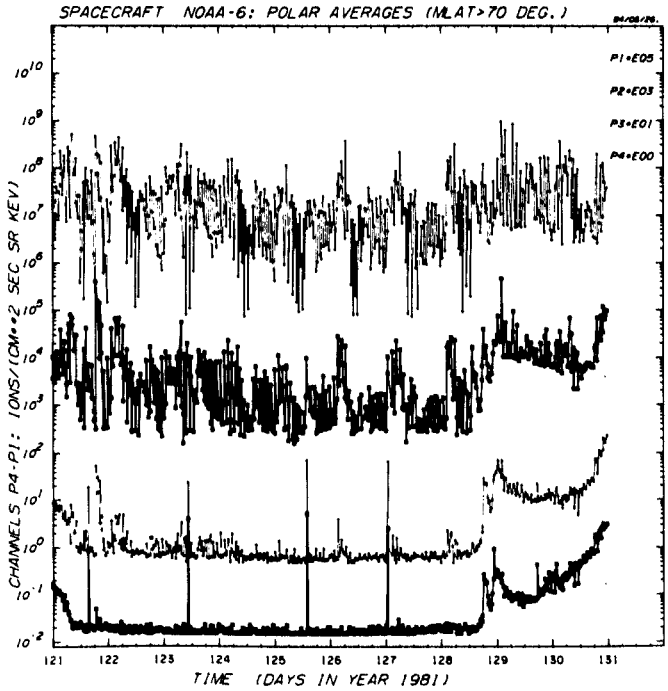
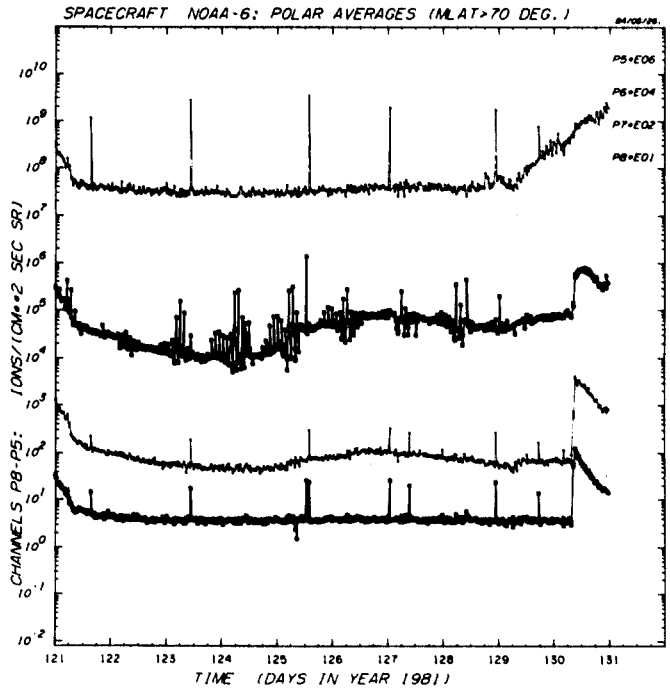
P6: E > 16000 KEV
P7: E > 36000 KEV
P8: E > 80000 KEV
E1: E > 30 KEV
E2: E > 100 KEV
E3: E > 300 KEV



April 21, 1981





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
P2: E= 80 - 250 KEV
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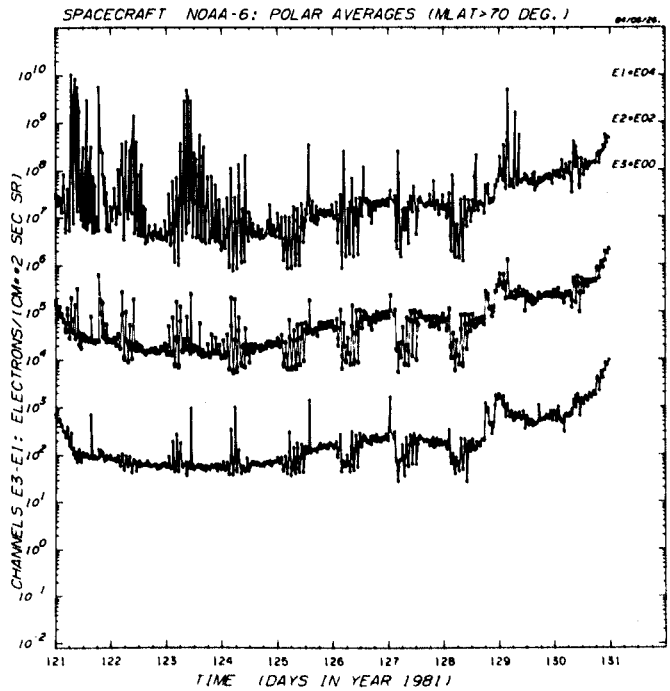
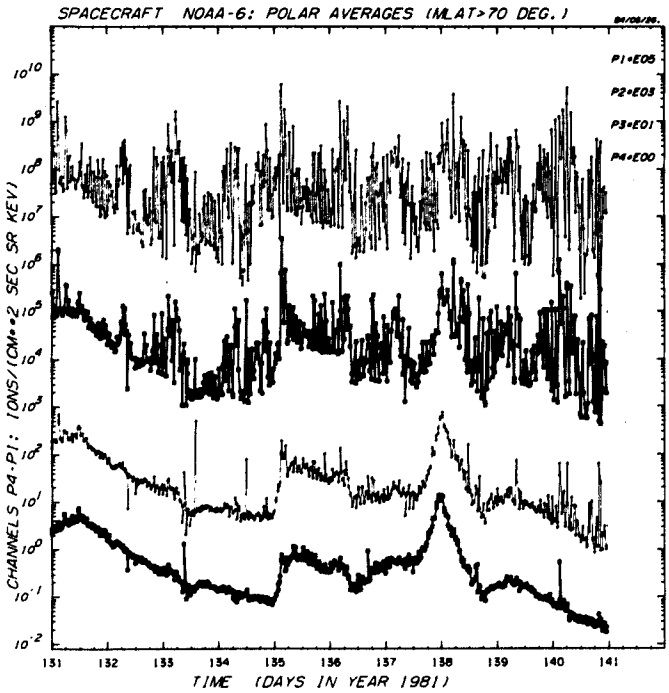
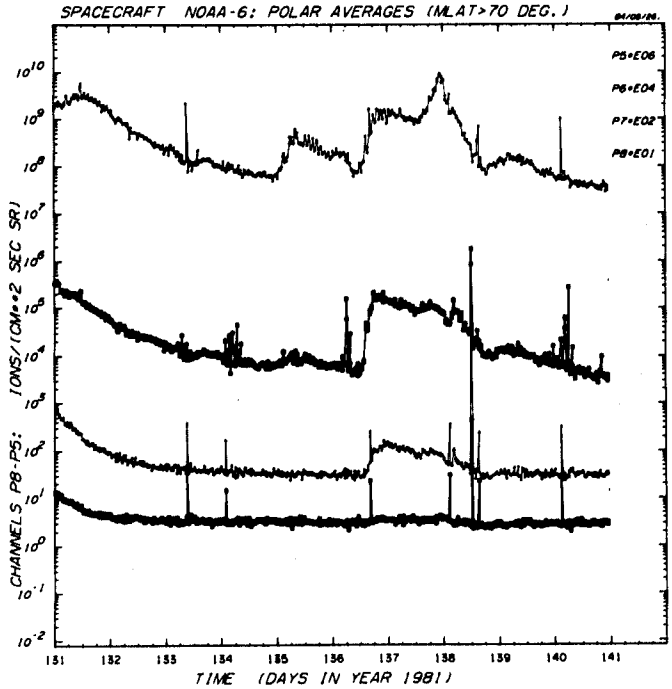


May 1, 1981





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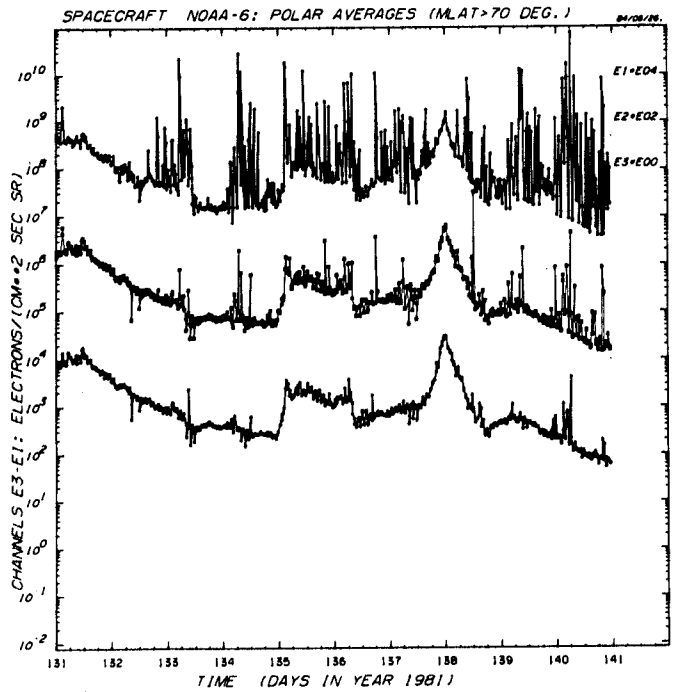
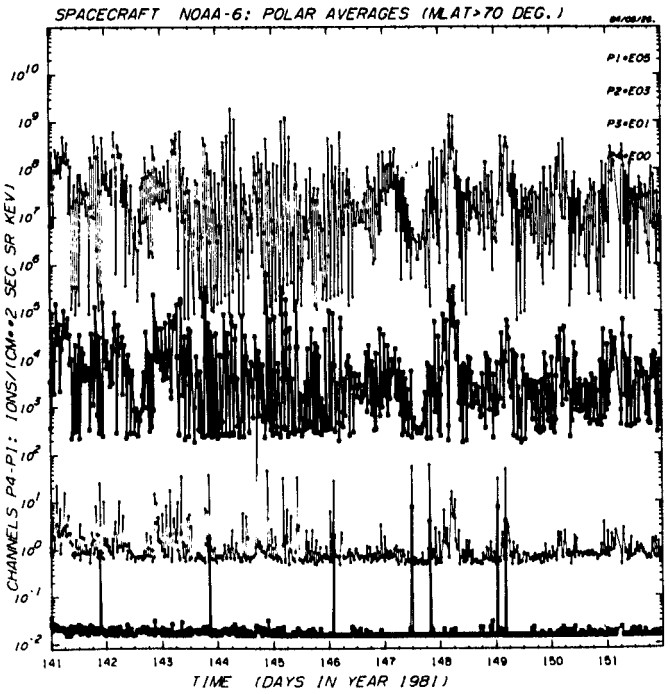
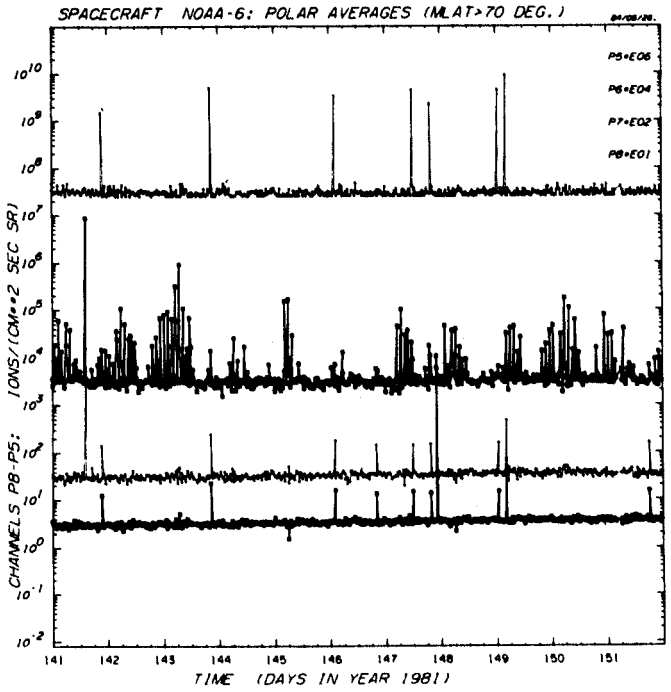


May 11, 1981





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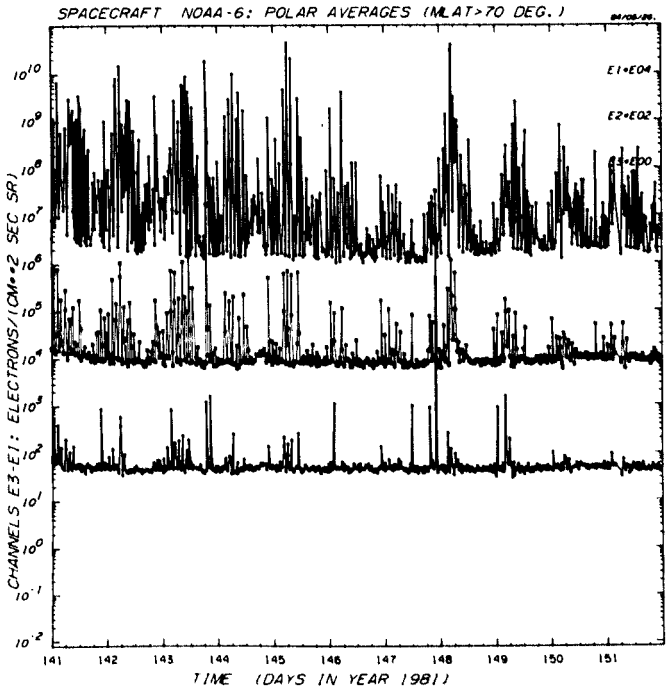
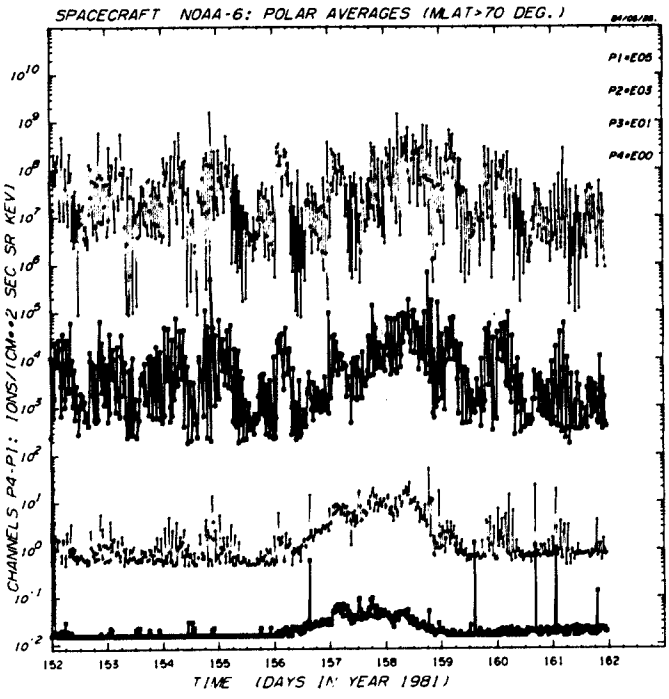
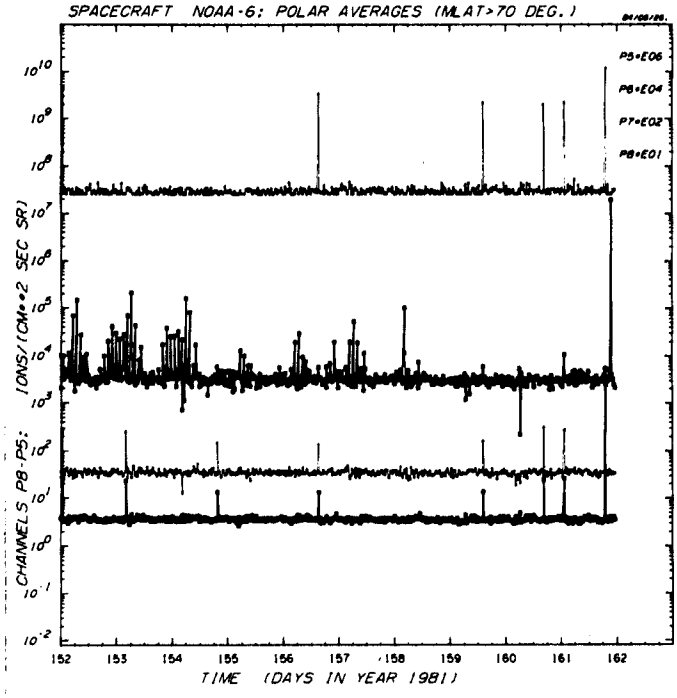


May 21, 1981





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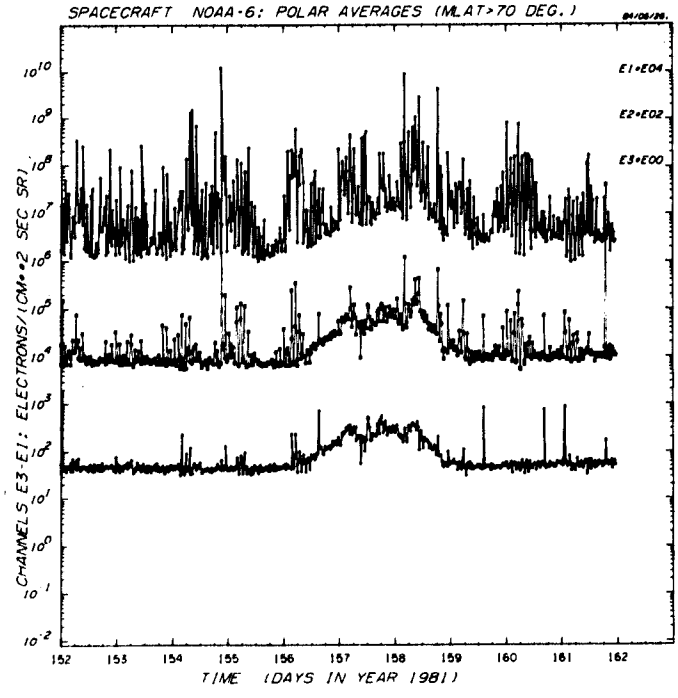
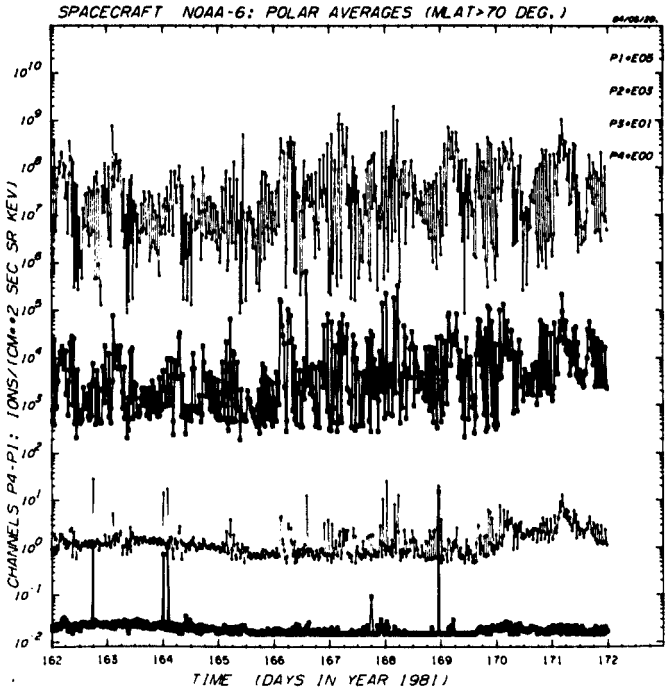
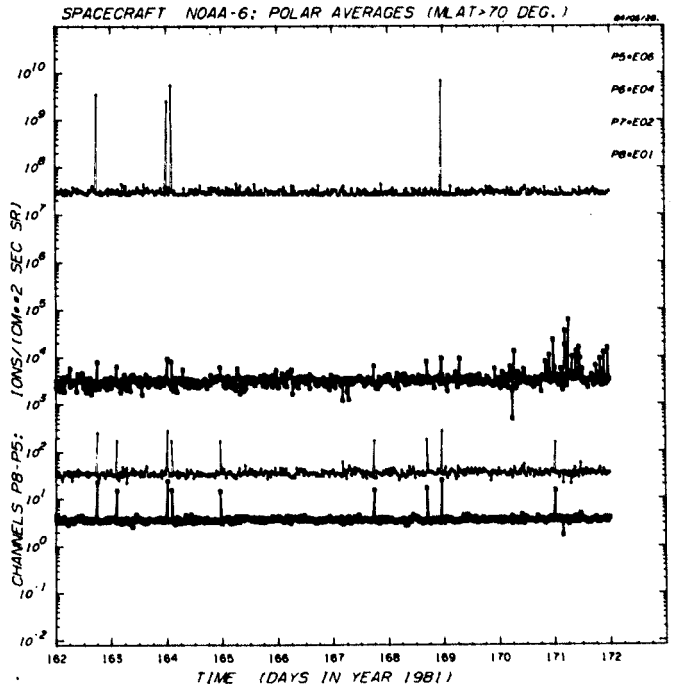


June 1, 1981





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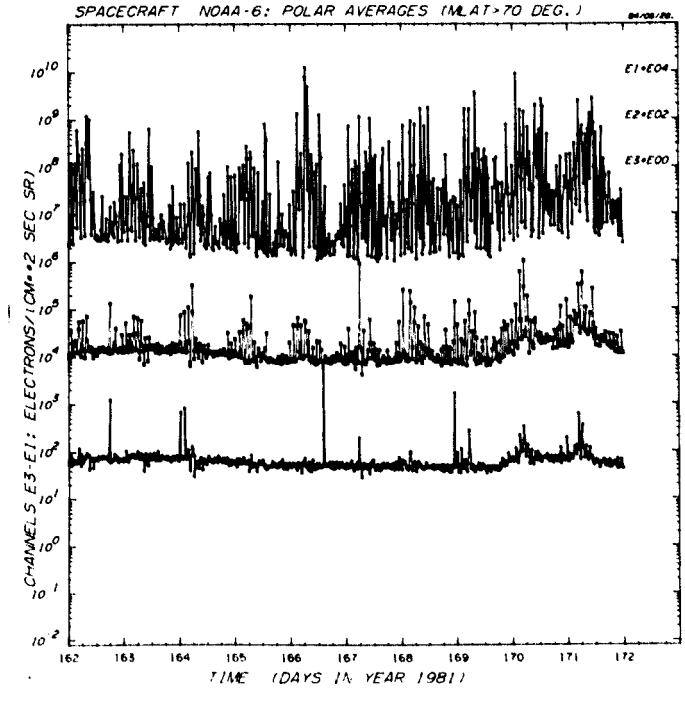
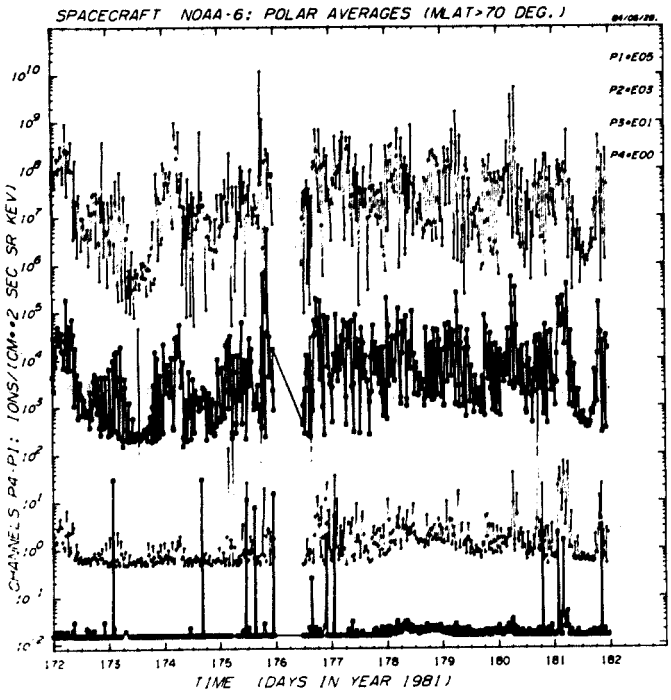
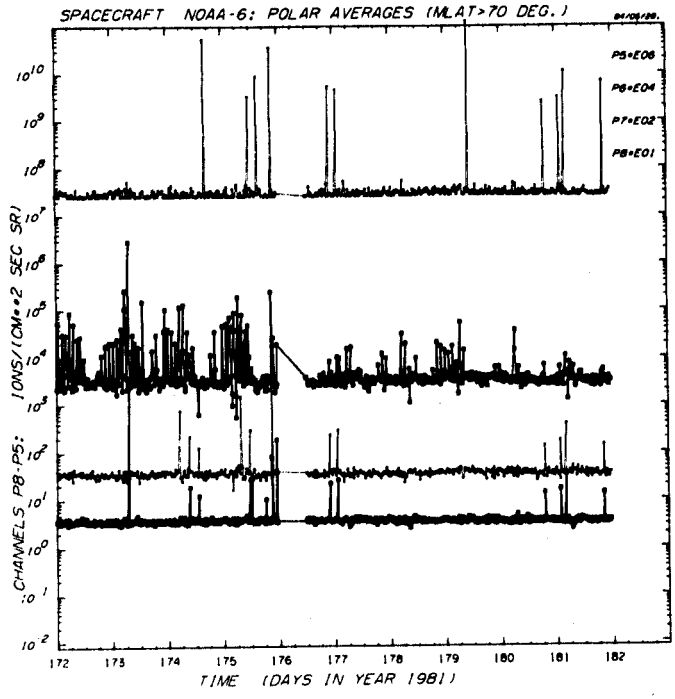


June 11, 1981





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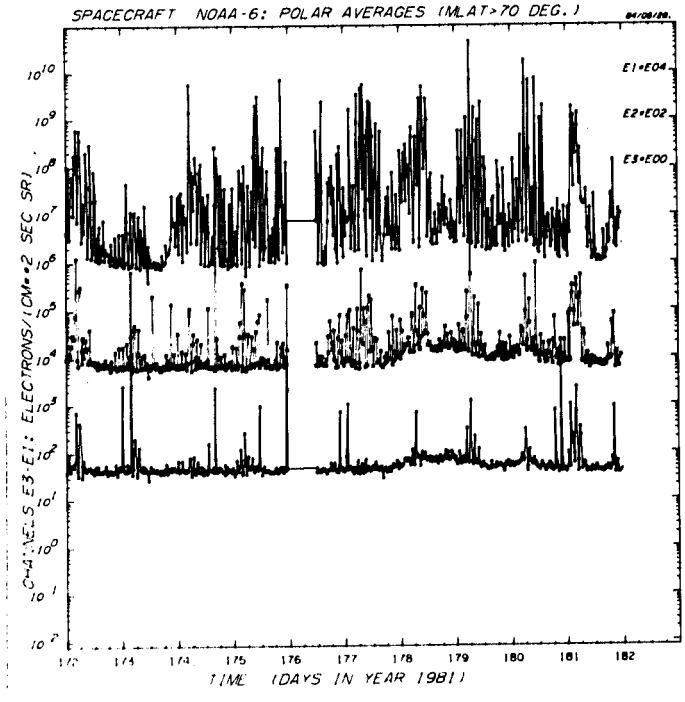
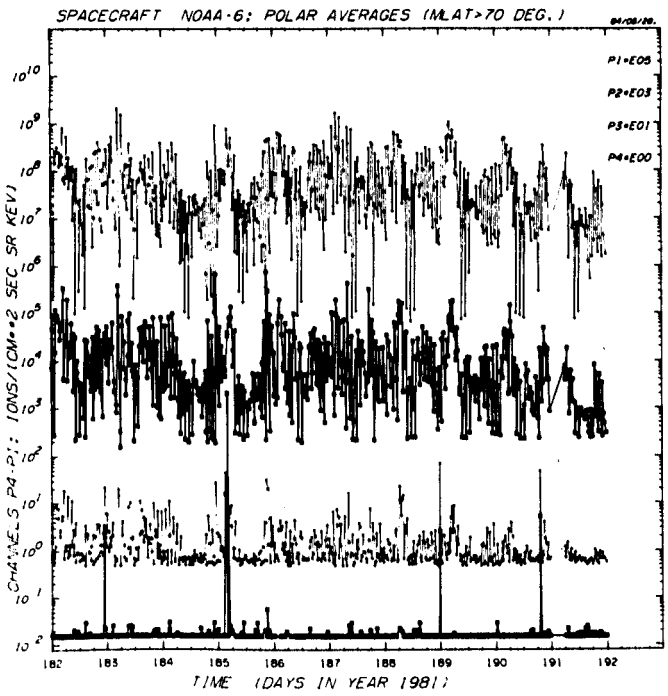
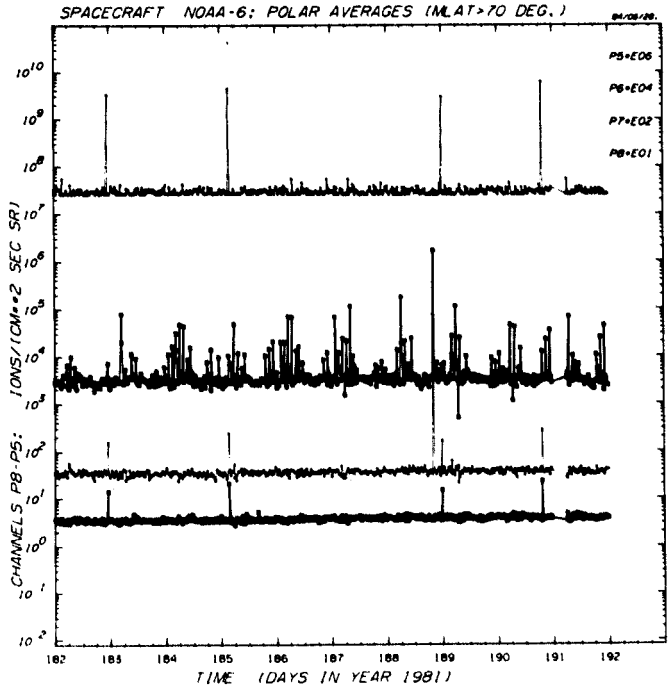


June 21, 1981





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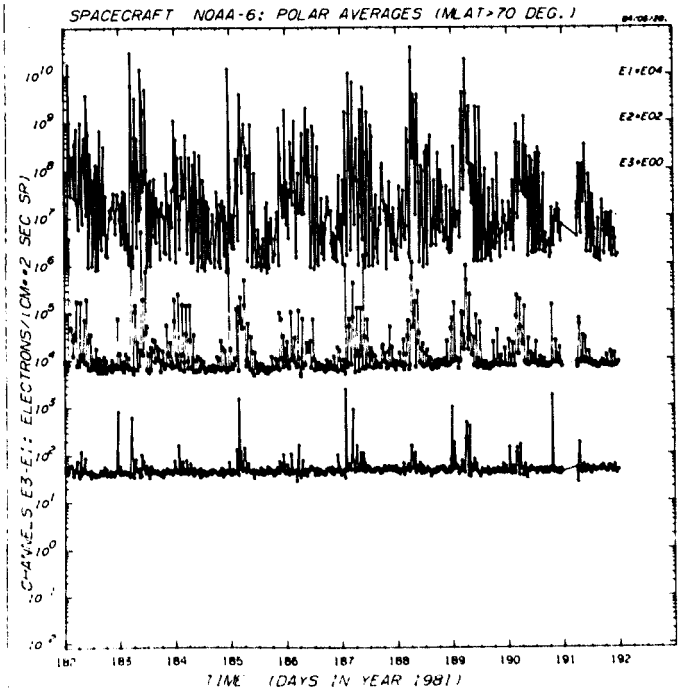
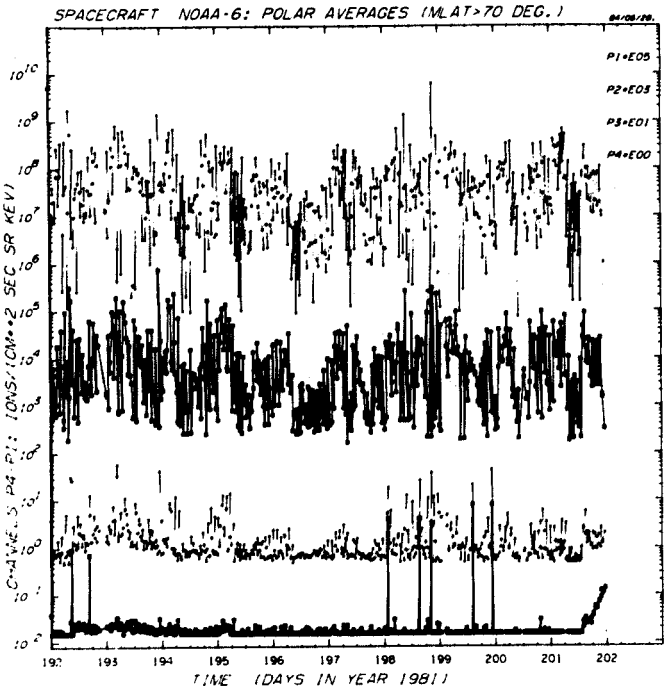
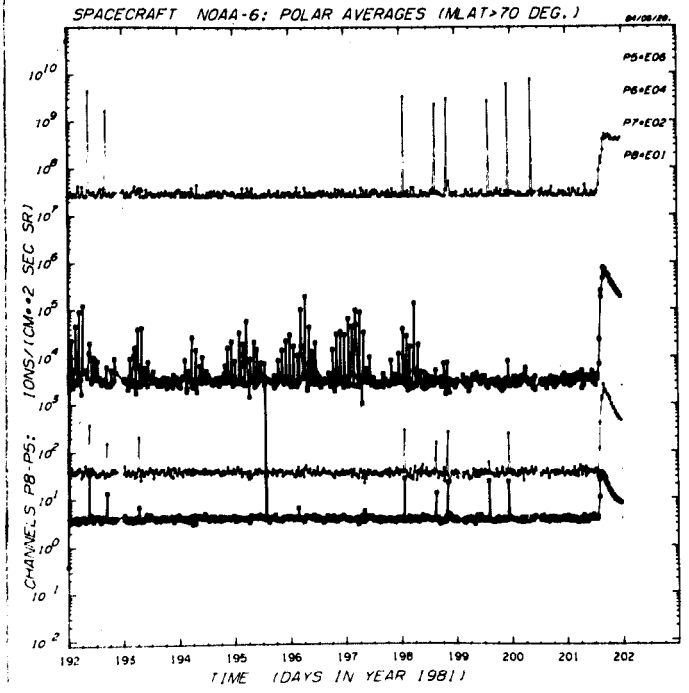


July 1, 1981





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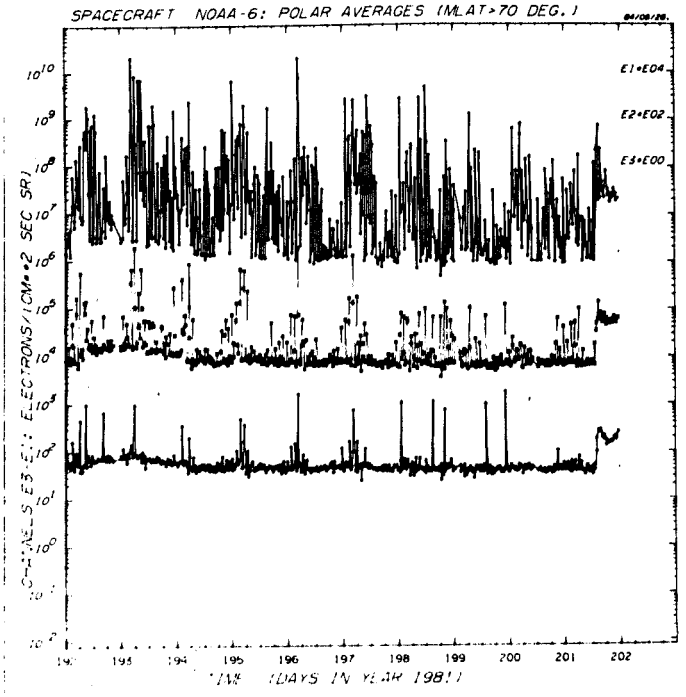
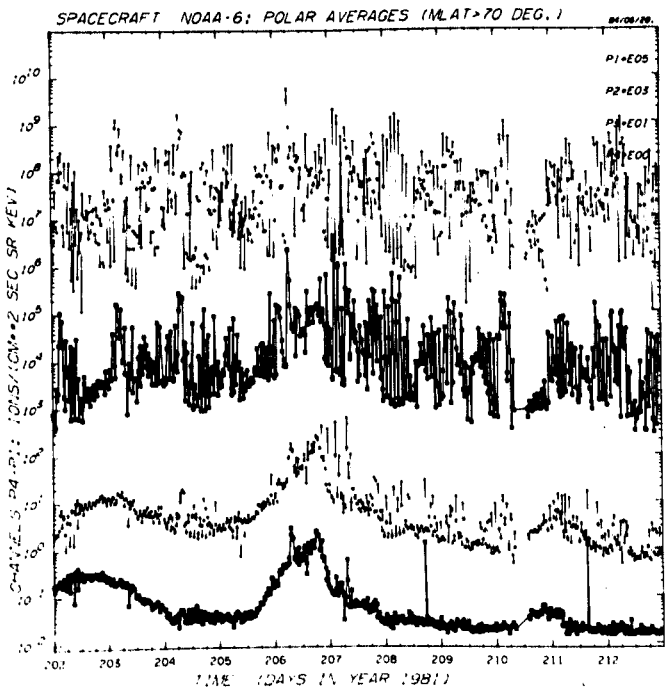
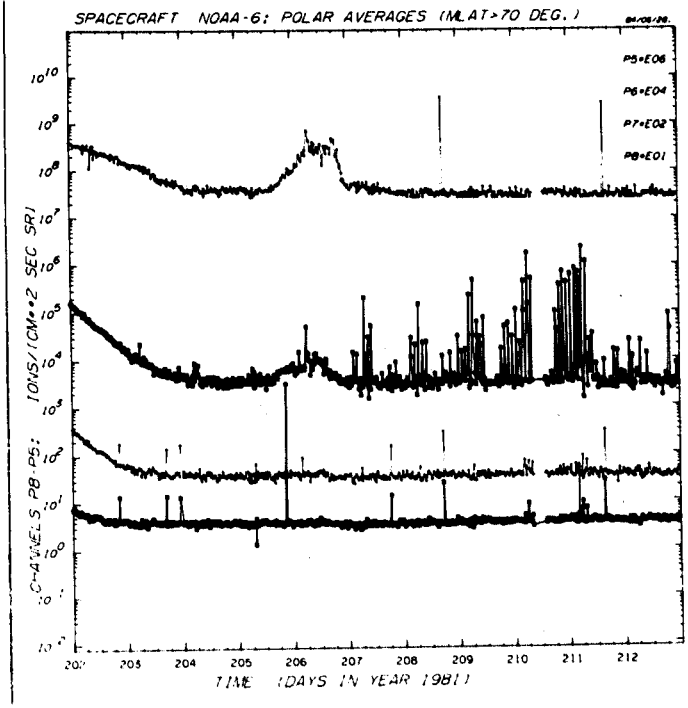


July 11, 1981





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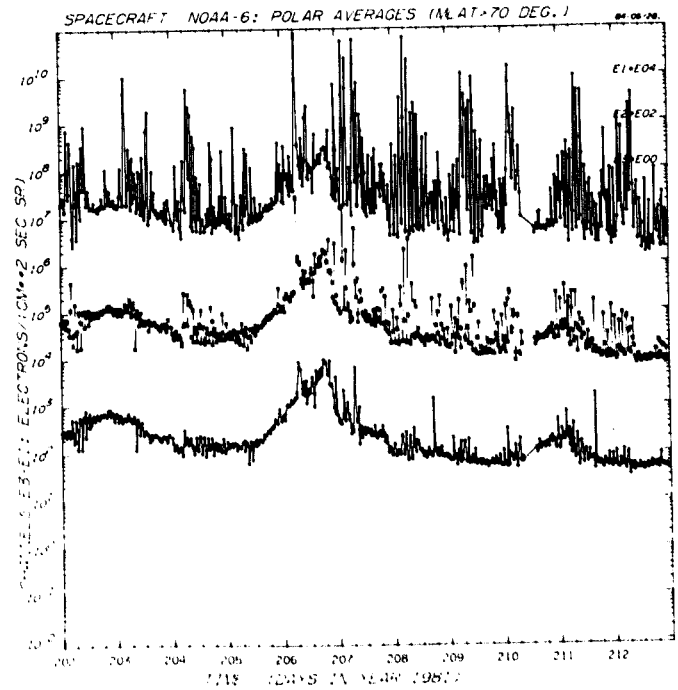
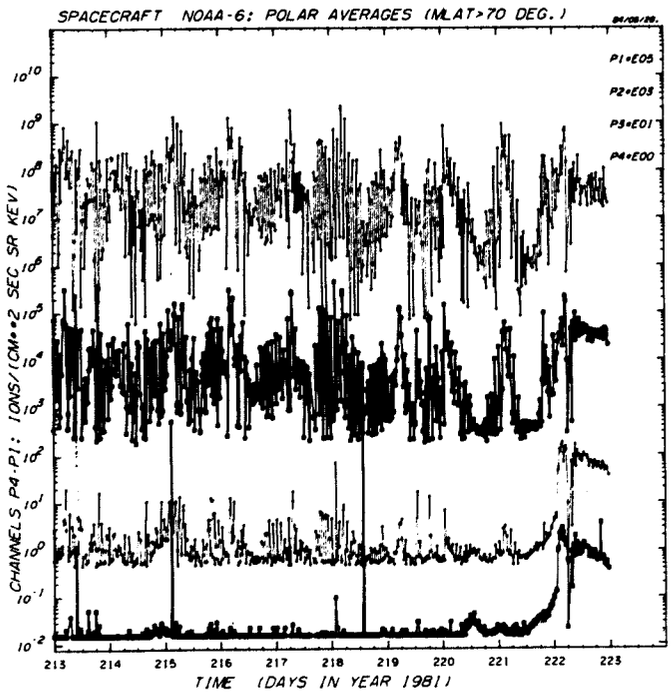
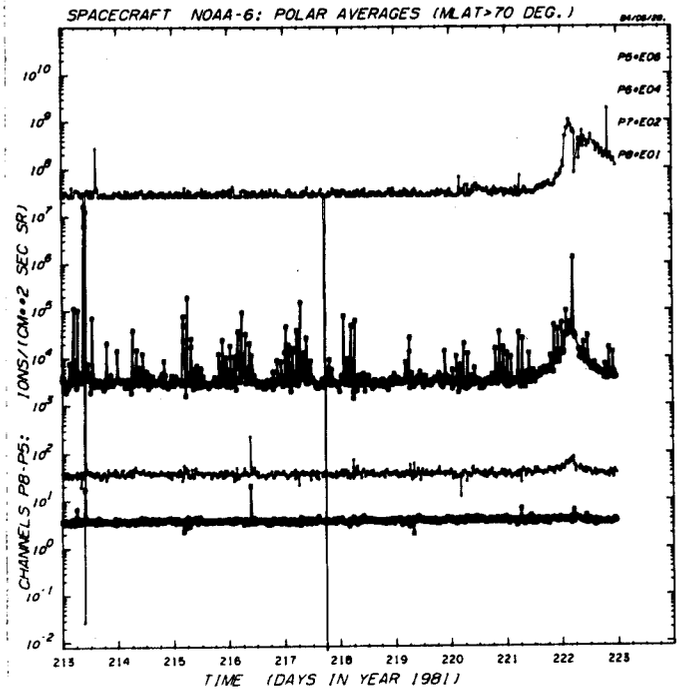


July 21, 1981





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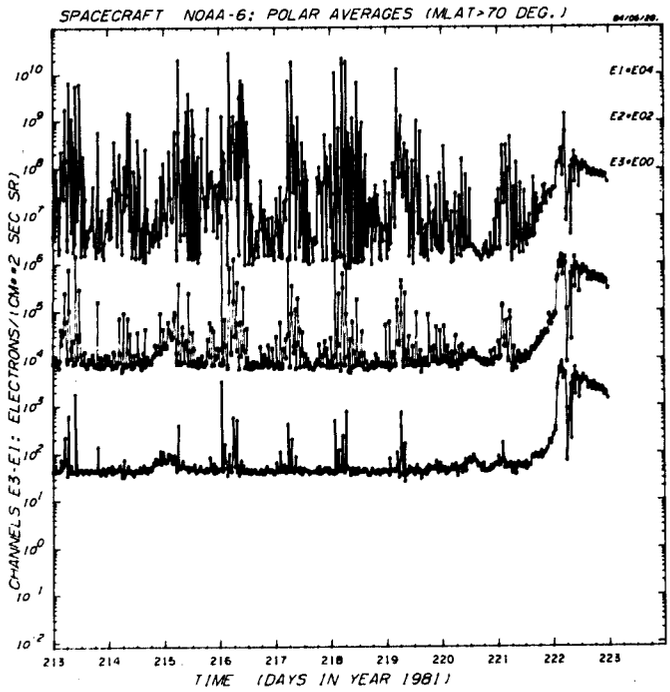
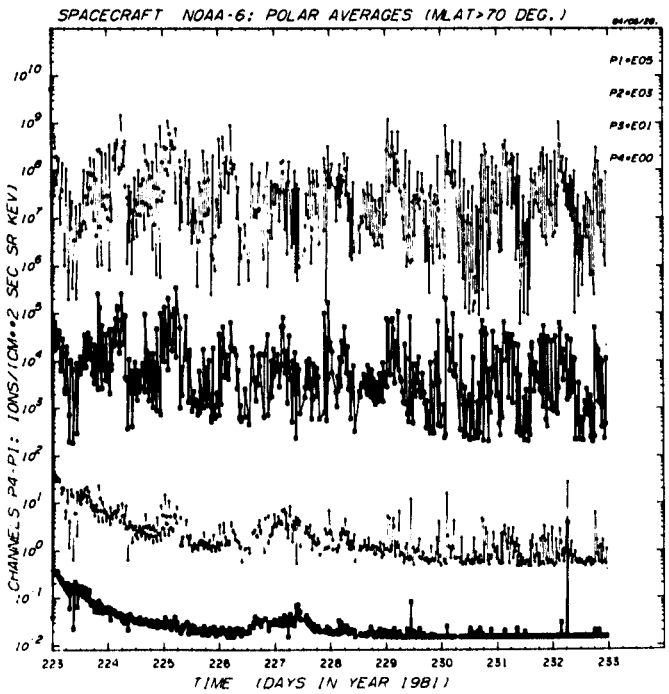
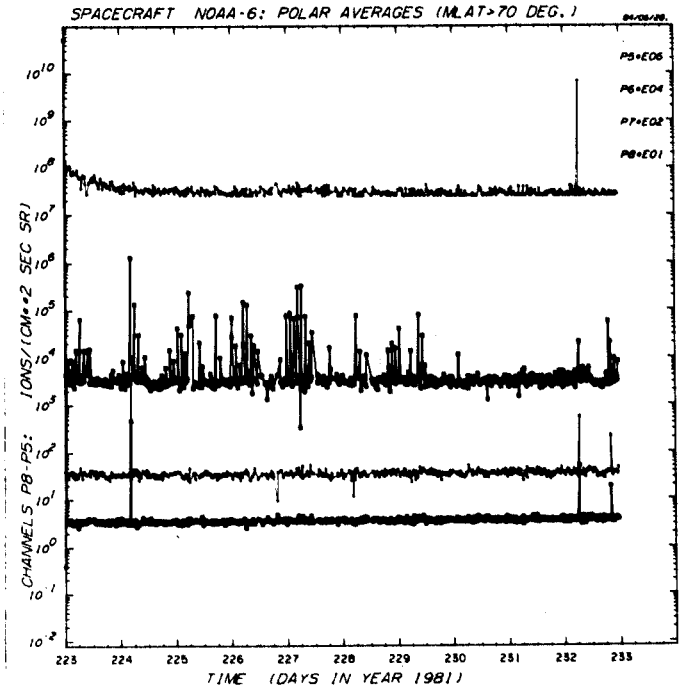


August 1, 1981





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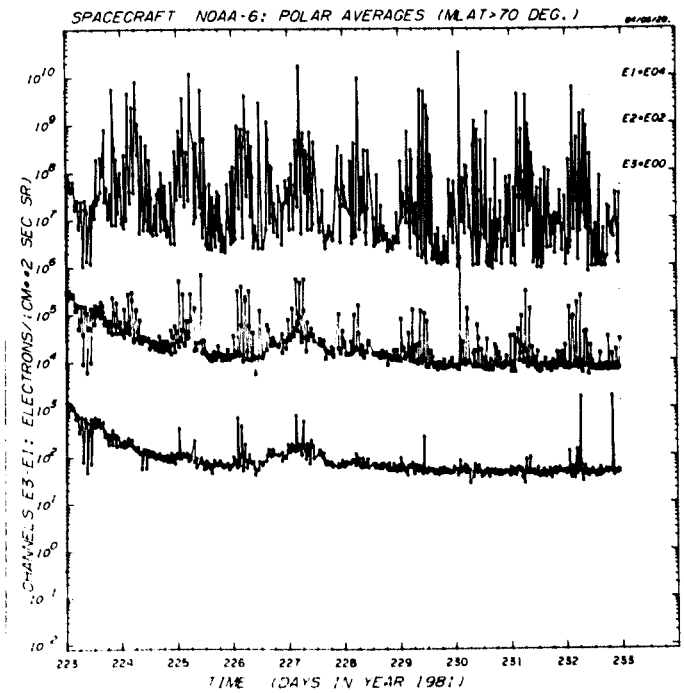
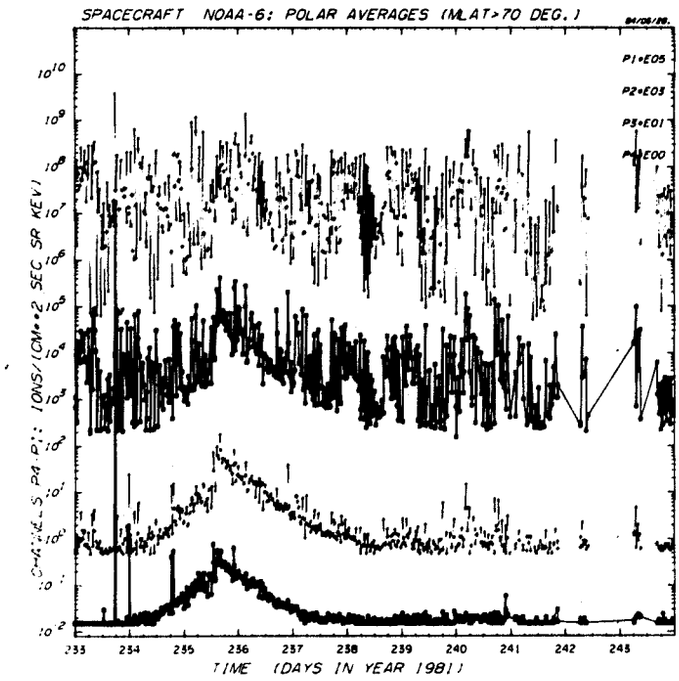
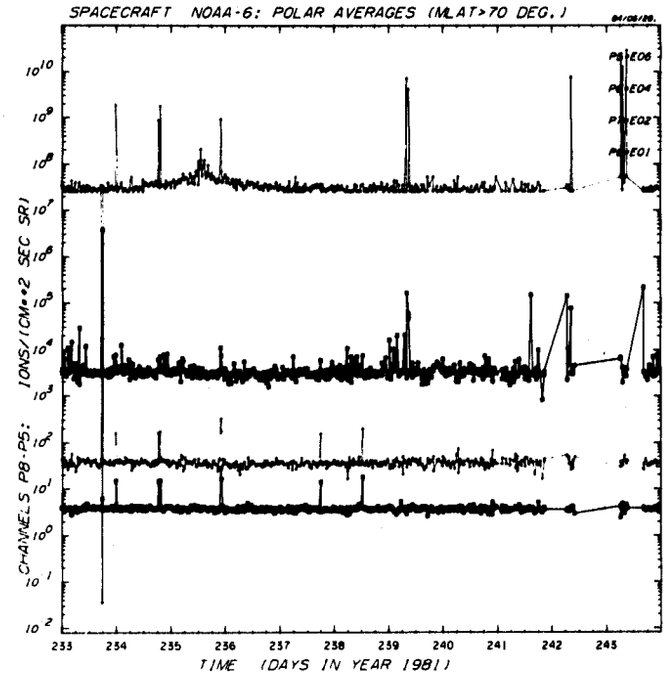


August 11, 1981





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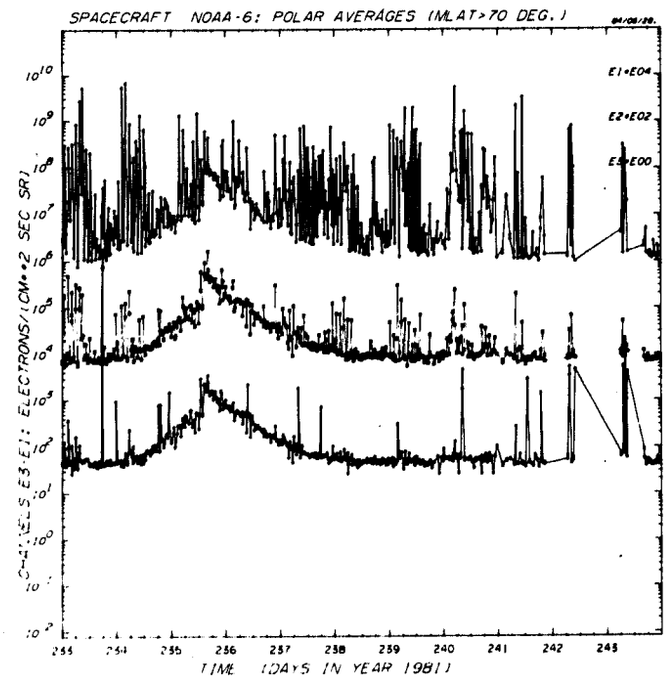
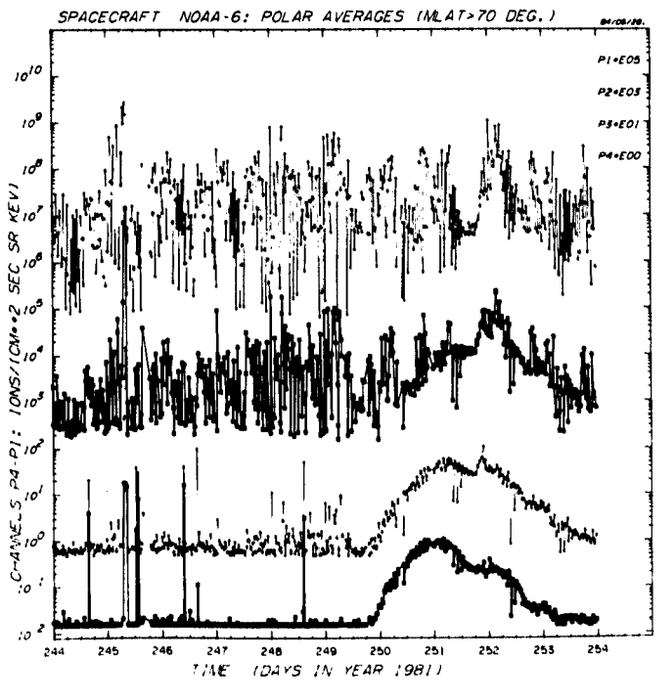
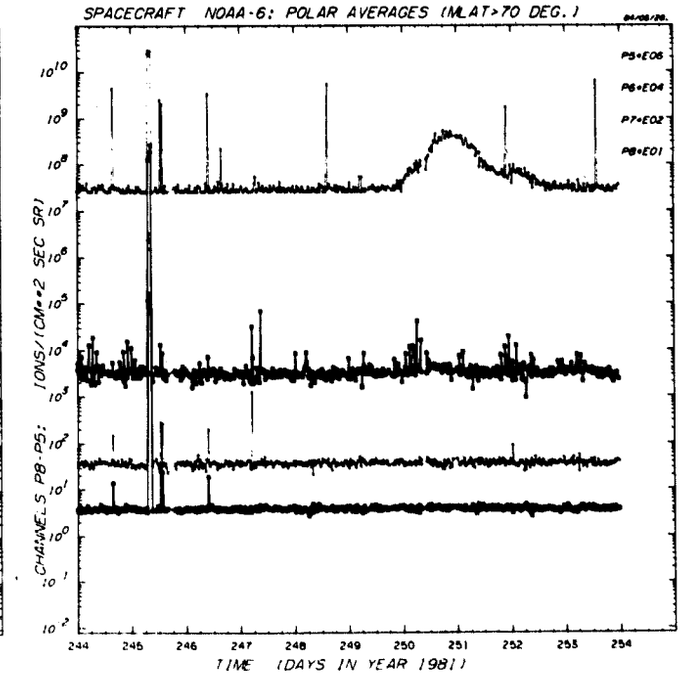


August 21, 1981





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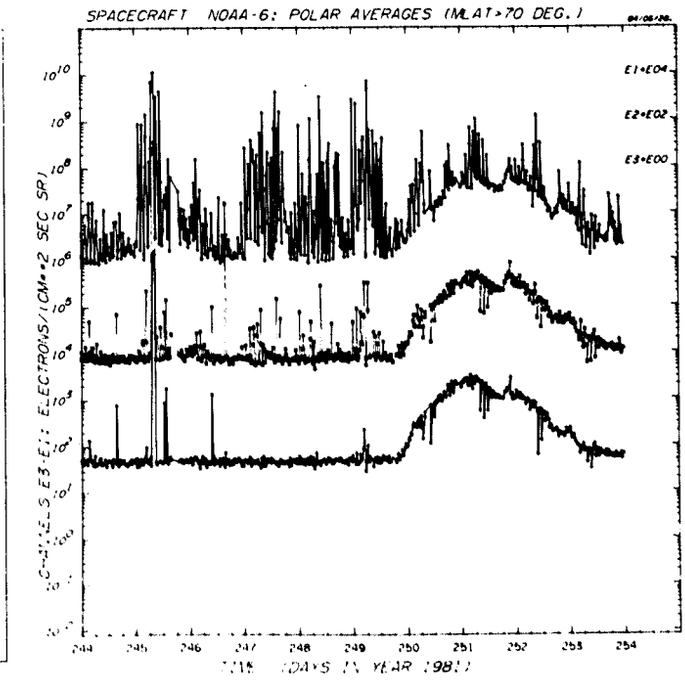
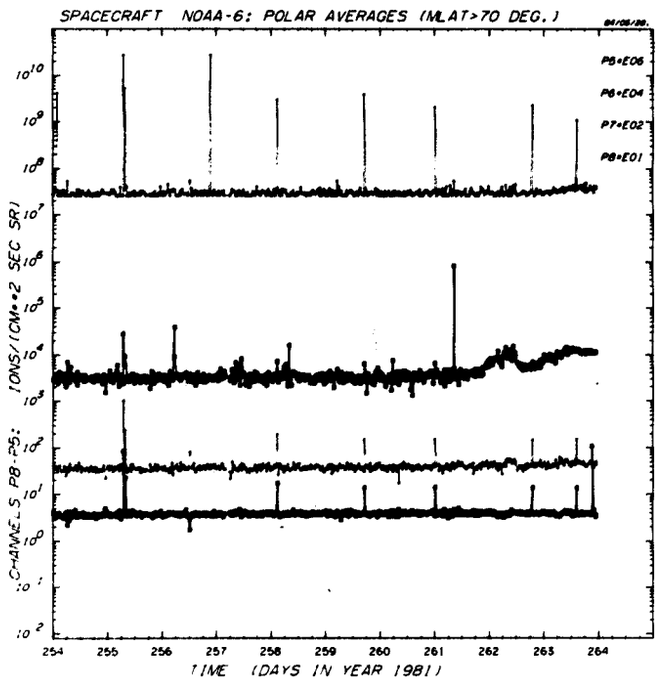
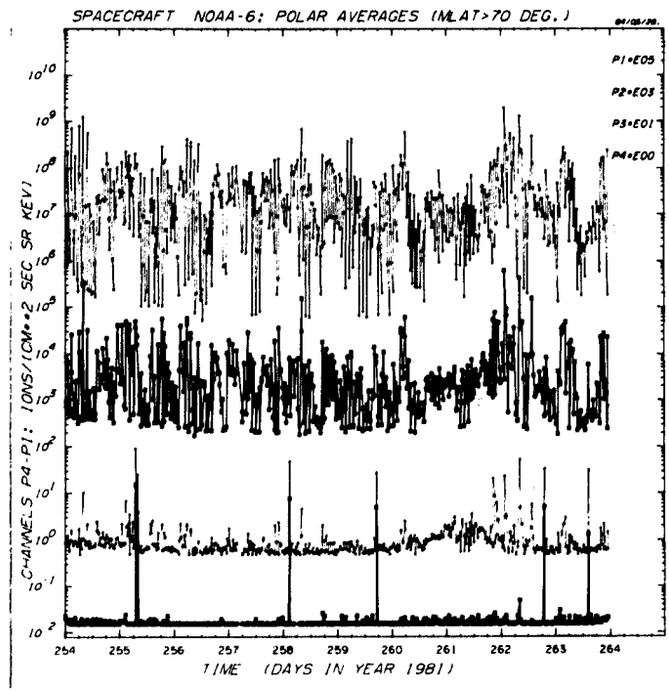


September 1, 1981





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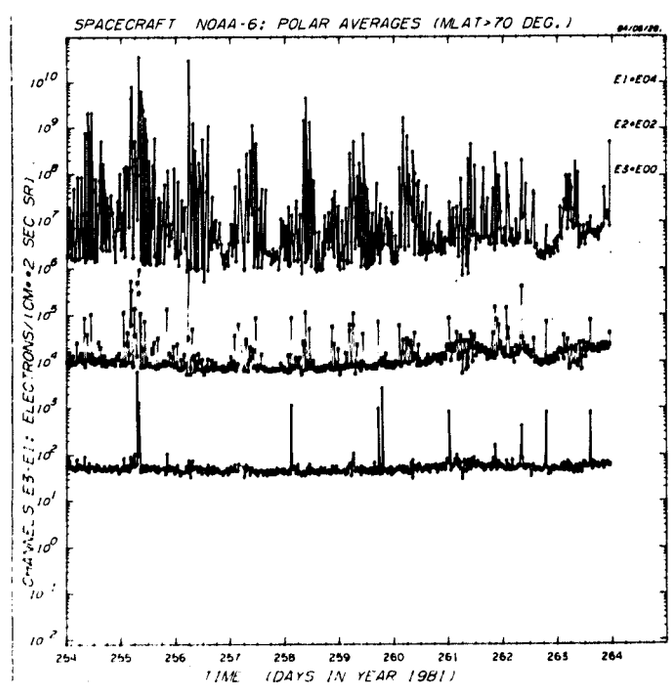
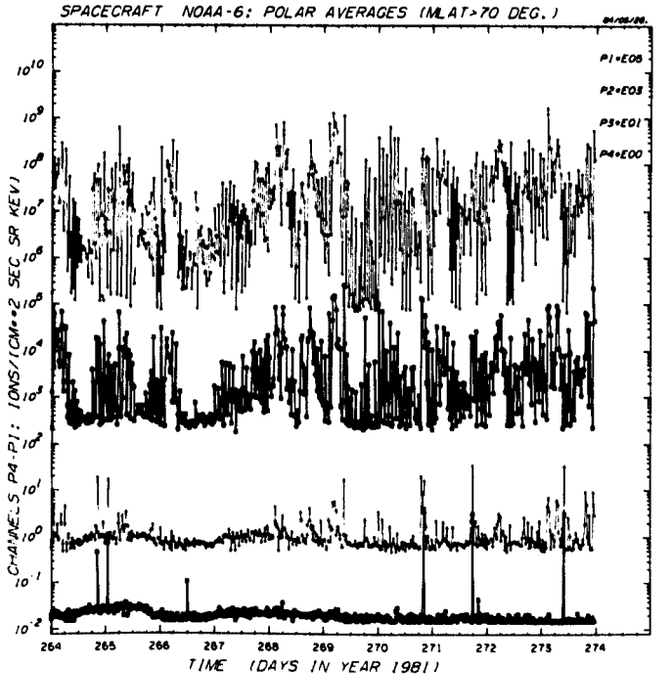
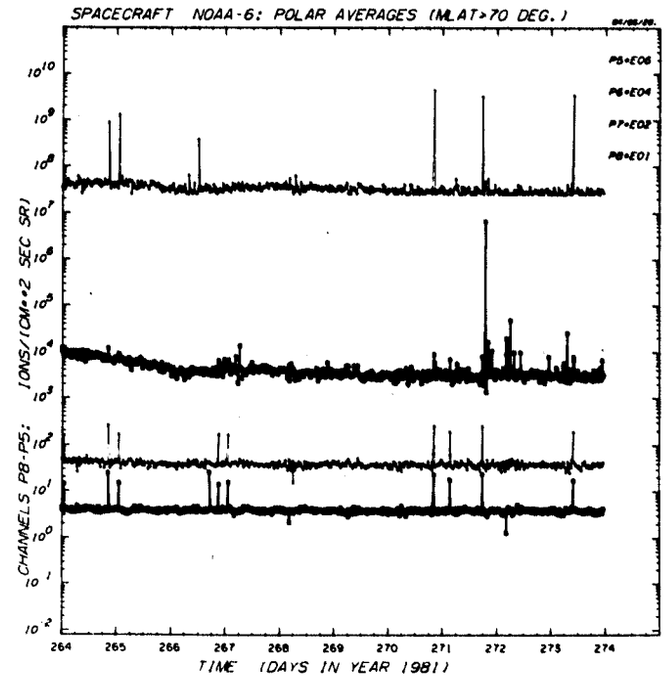


September 11, 1981





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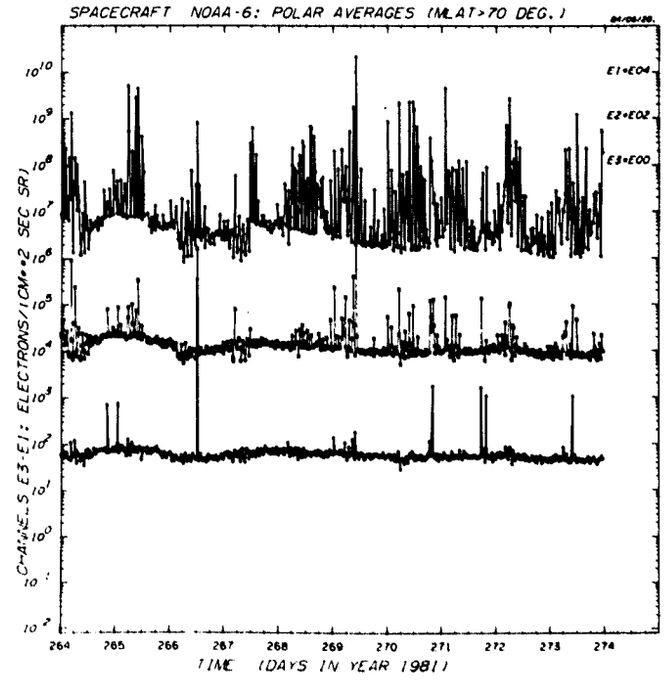
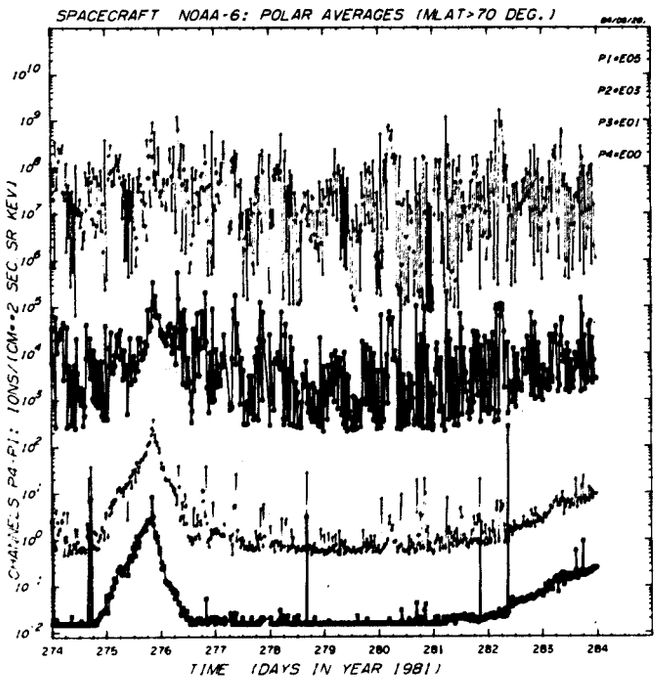
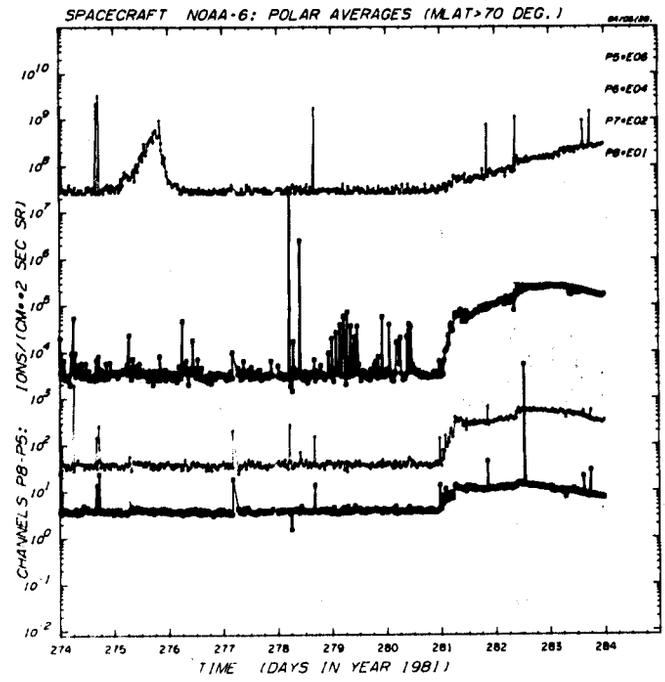


September 21, 1981





ENERGY CHANNELS:

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P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
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P7: E > 36000 KEV
P8: E > 80000 KEV
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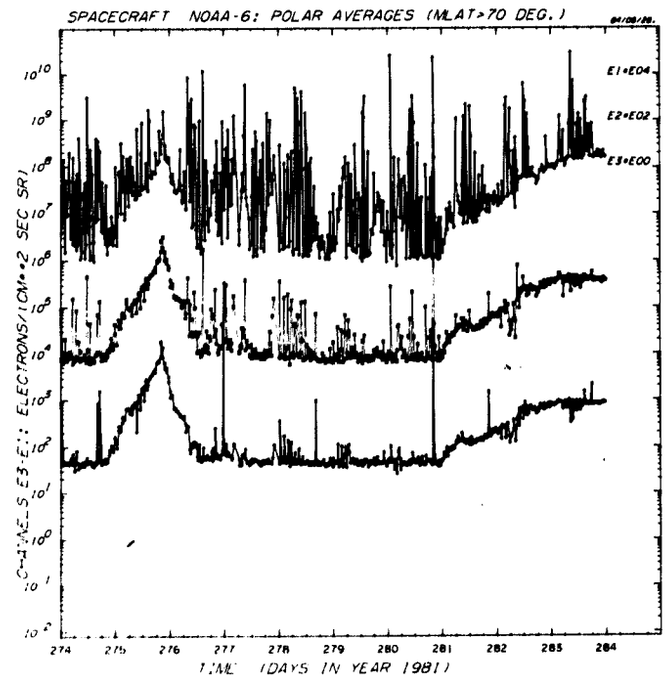
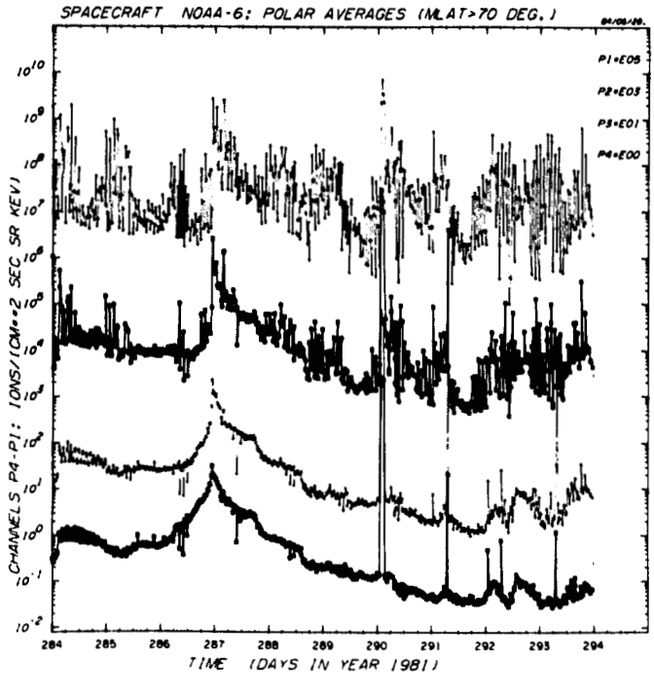
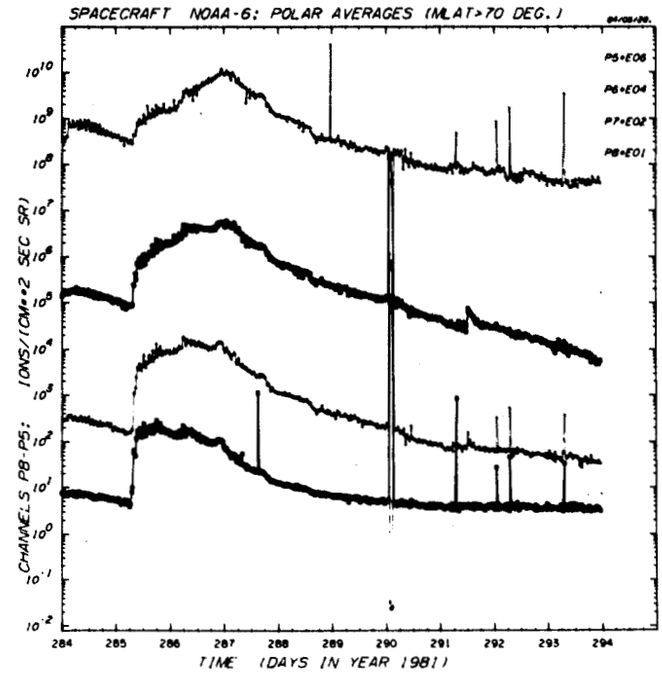


October 1, 1981





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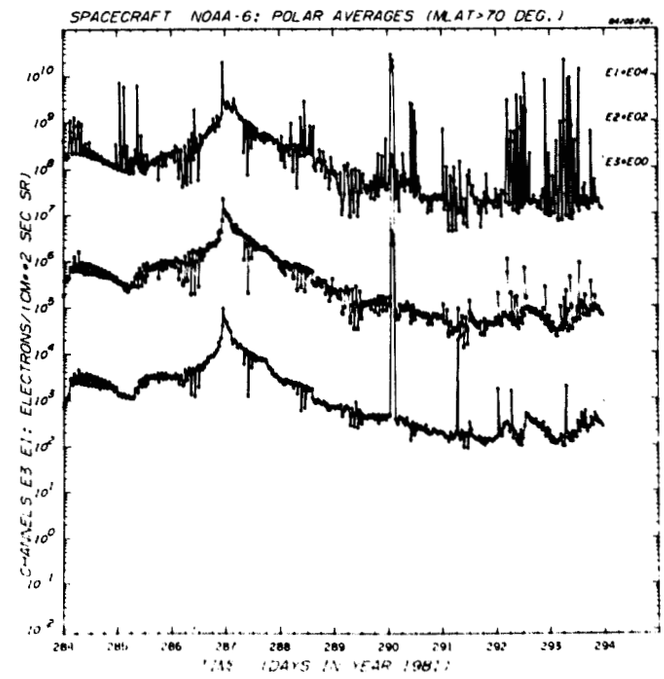
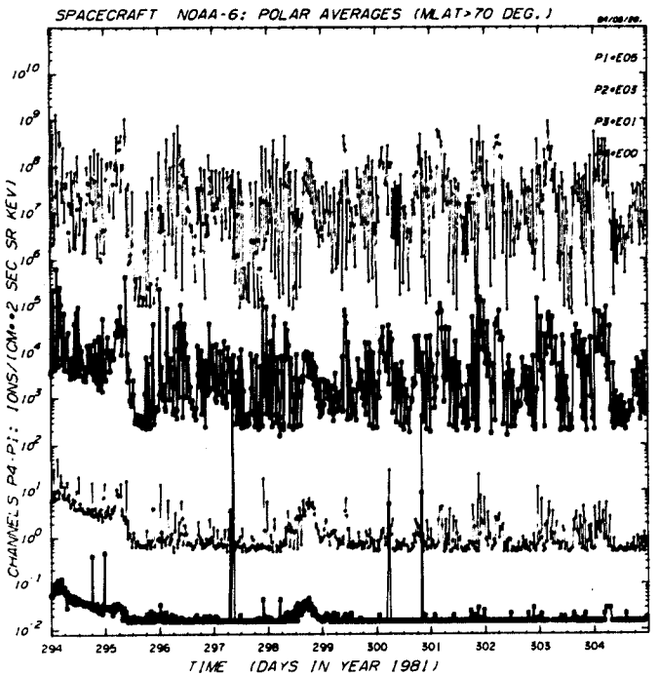
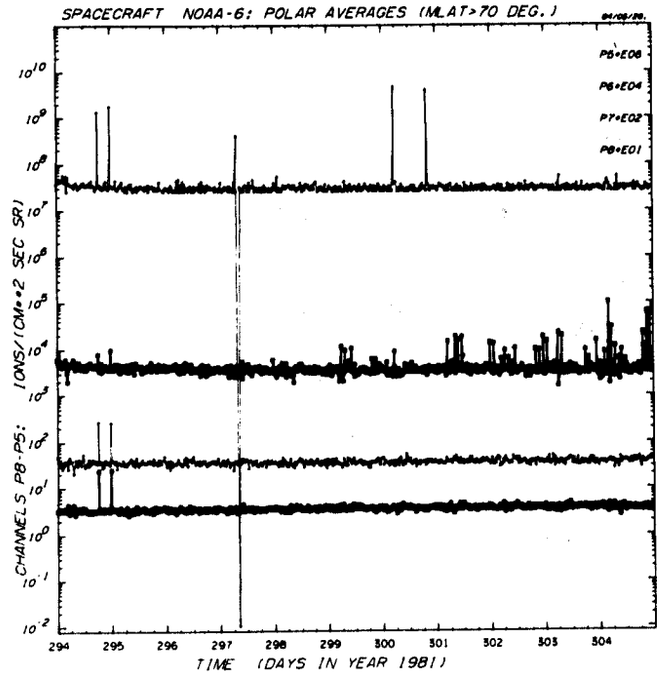


October 11, 1981





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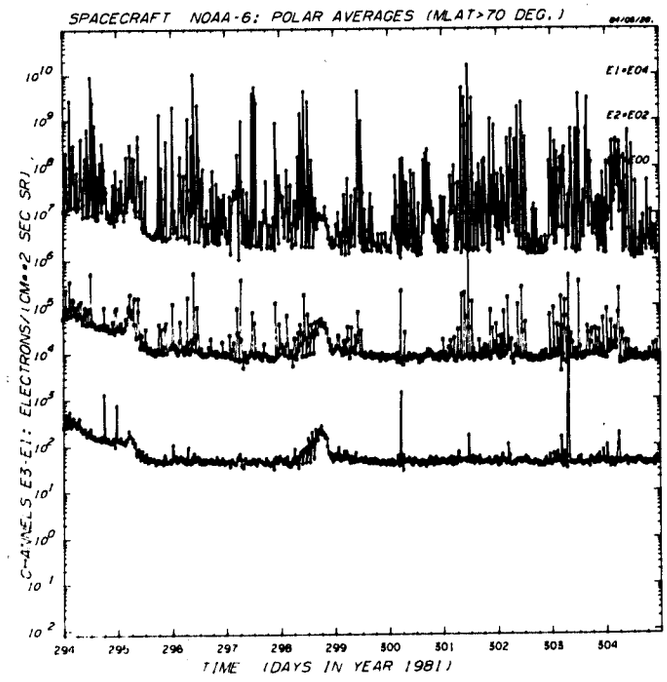
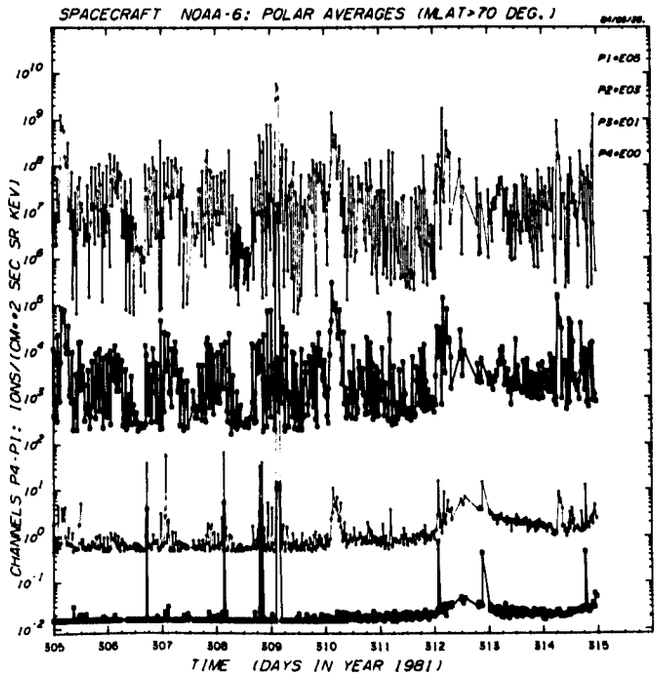
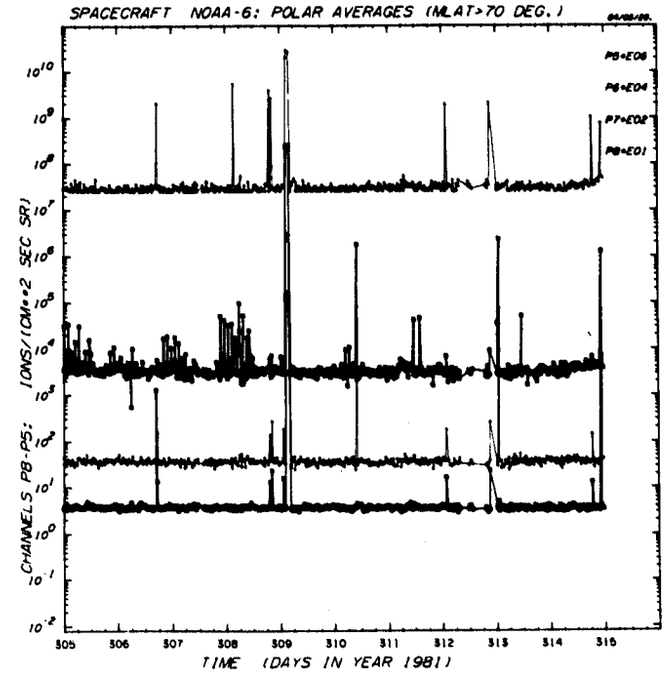


October 21, 1981





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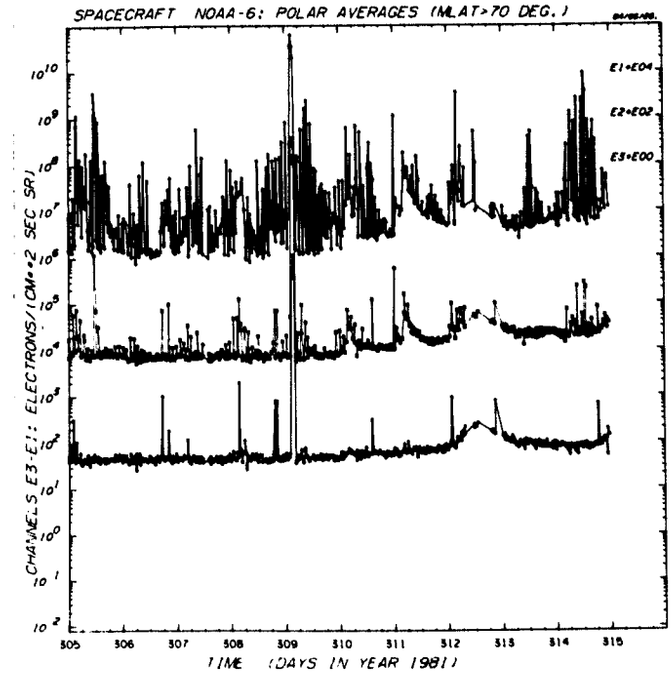
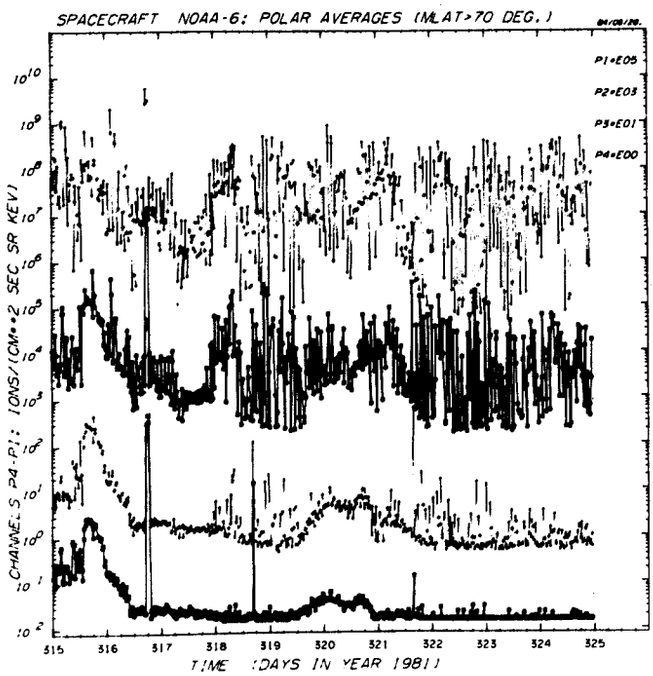
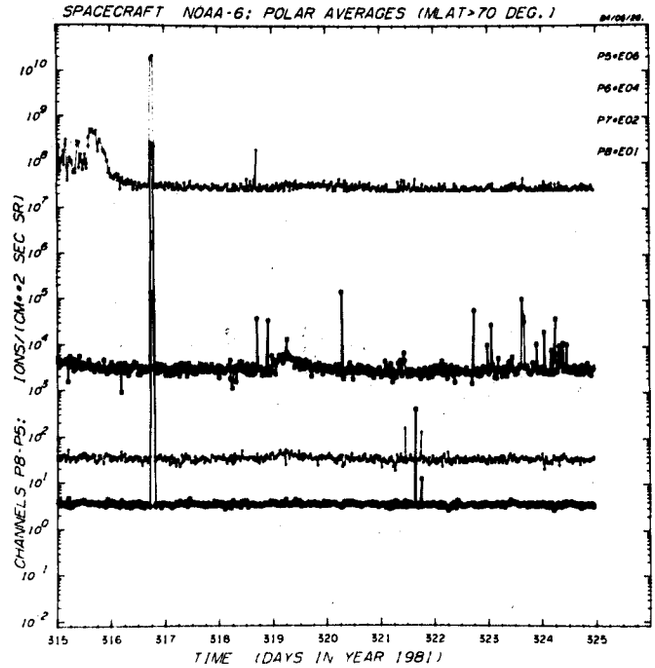


November 1, 1981





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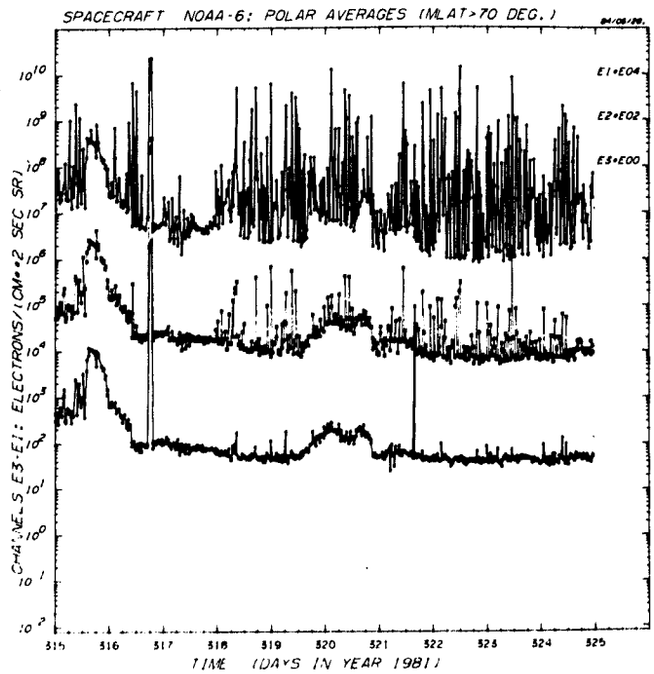
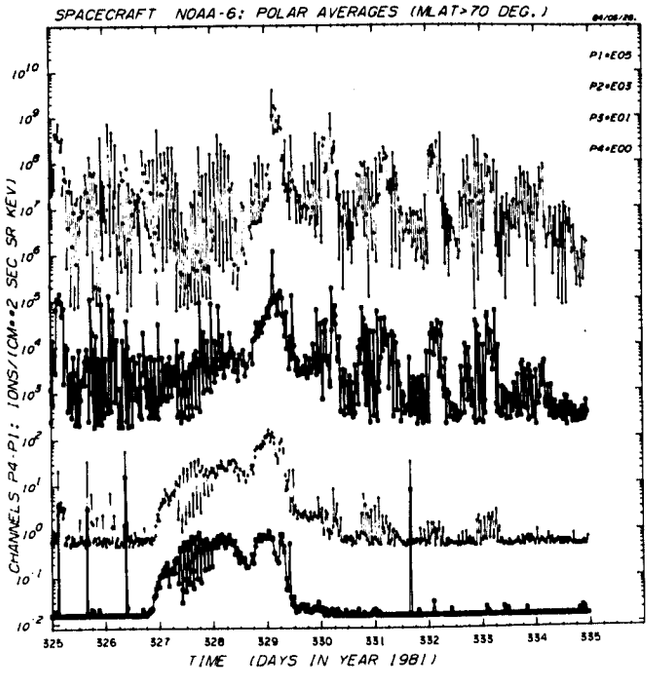
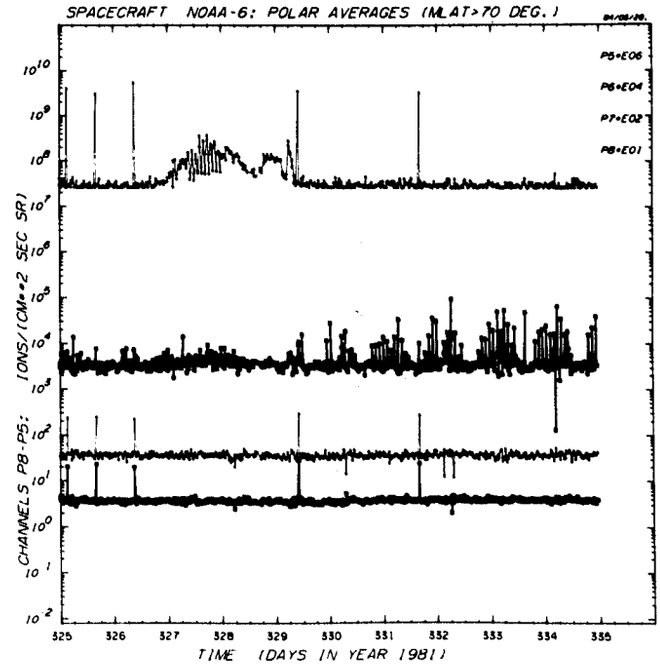


November 11, 1981





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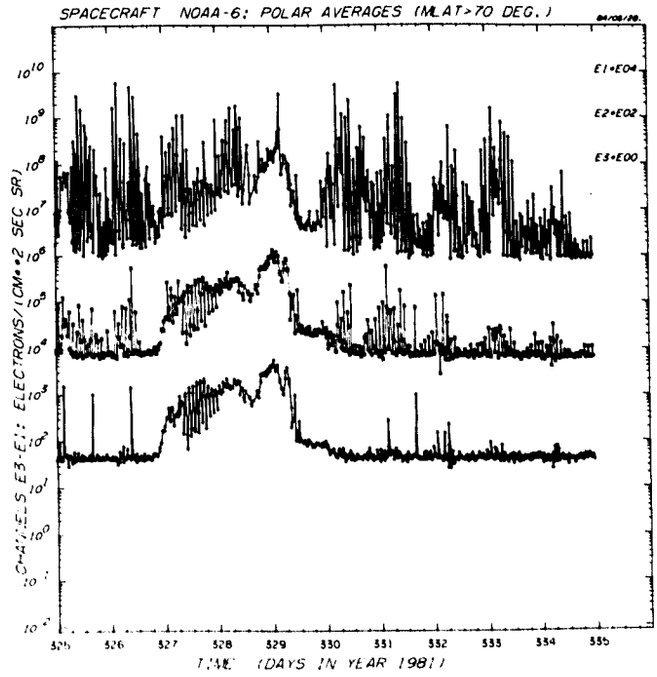
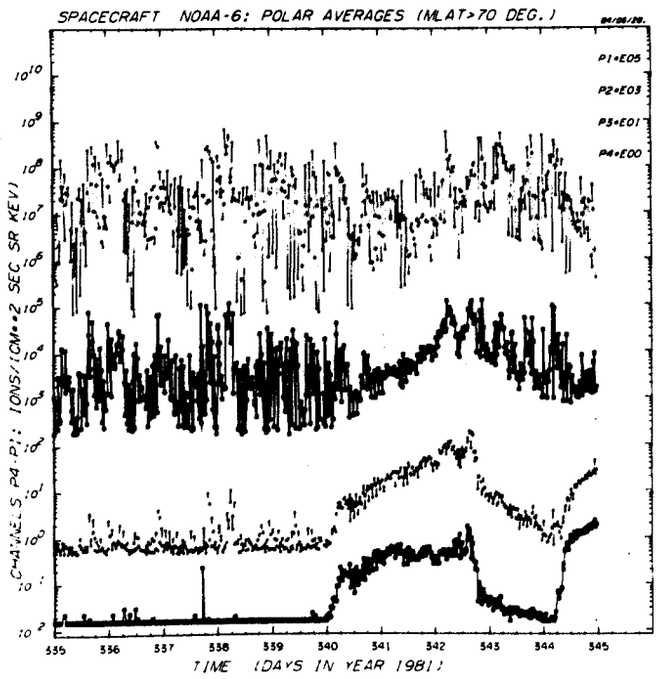
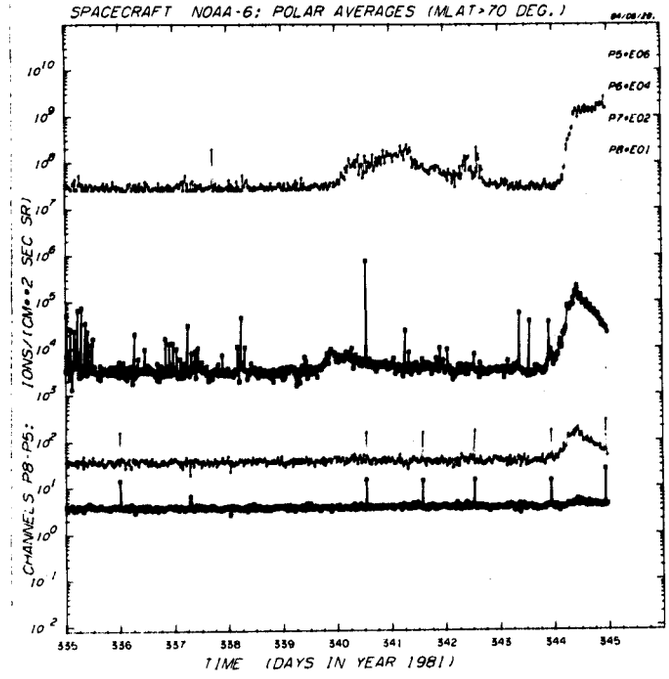


November 21, 1981





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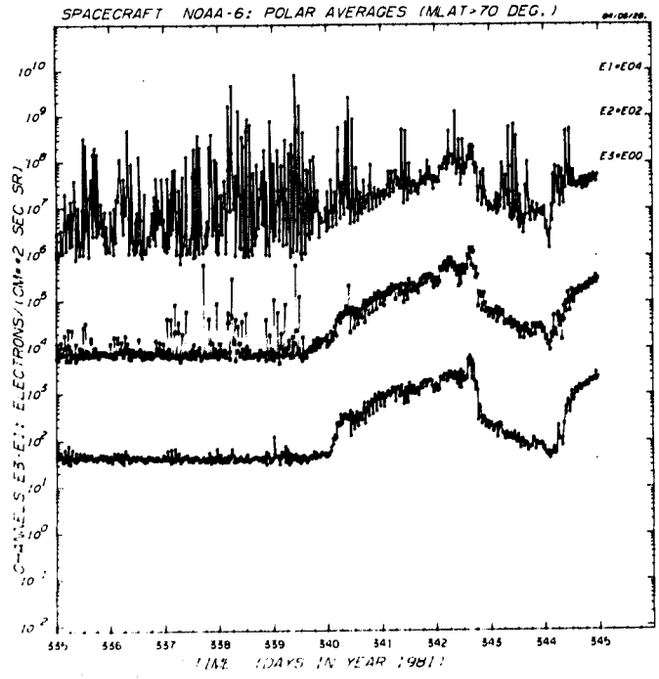
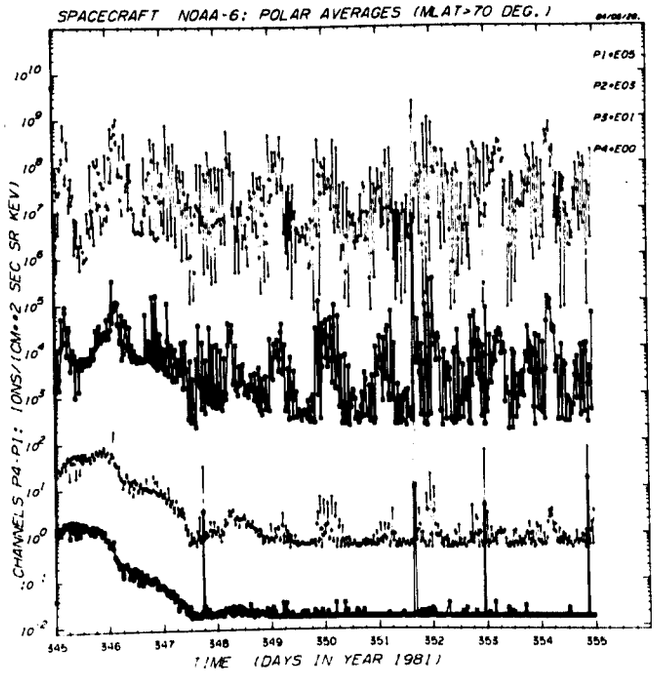
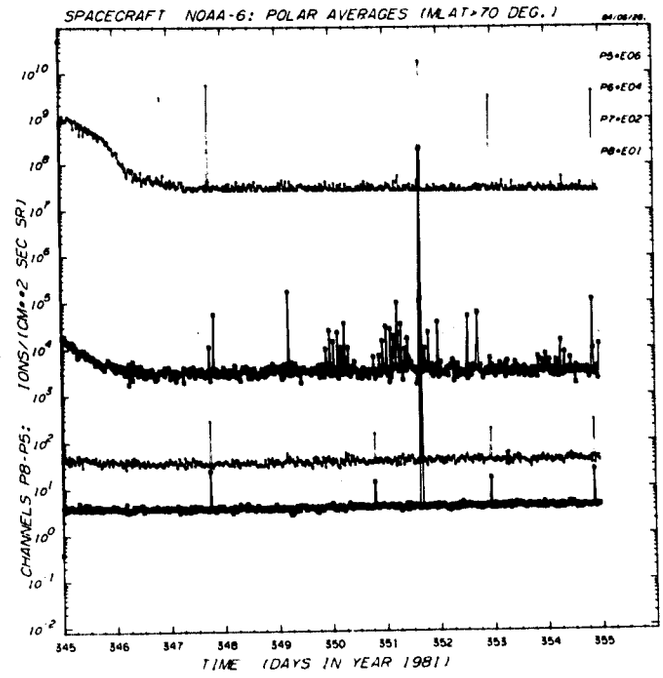


December 1, 1981





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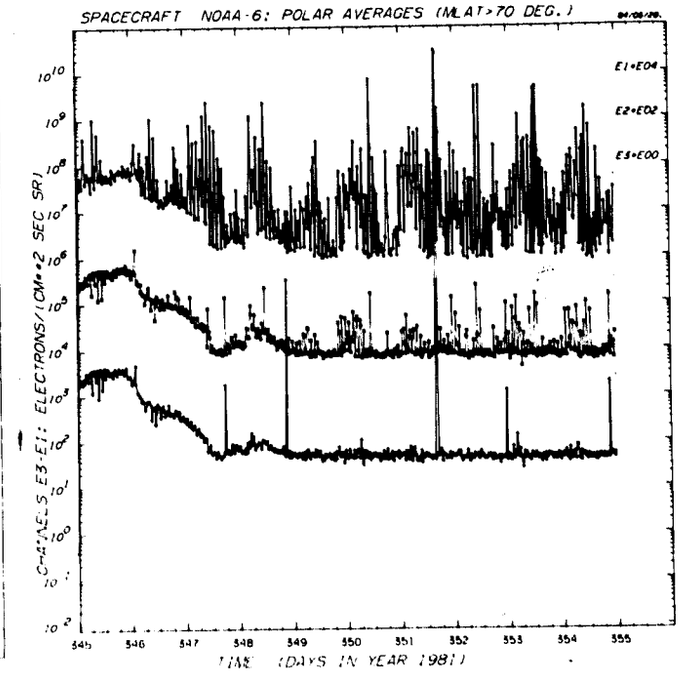
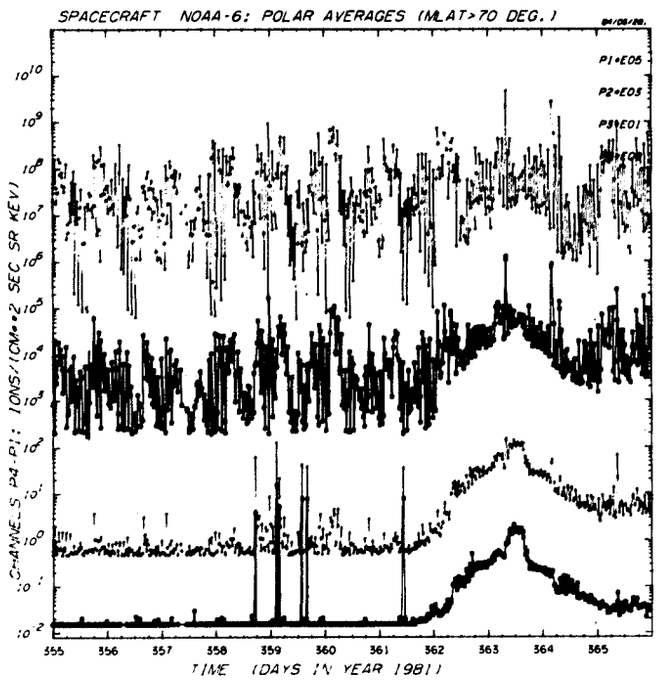
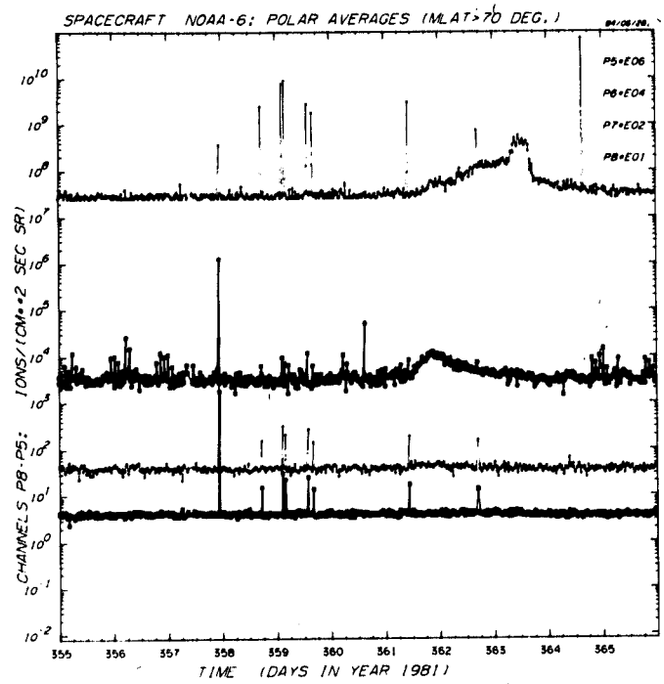


December 11, 1981





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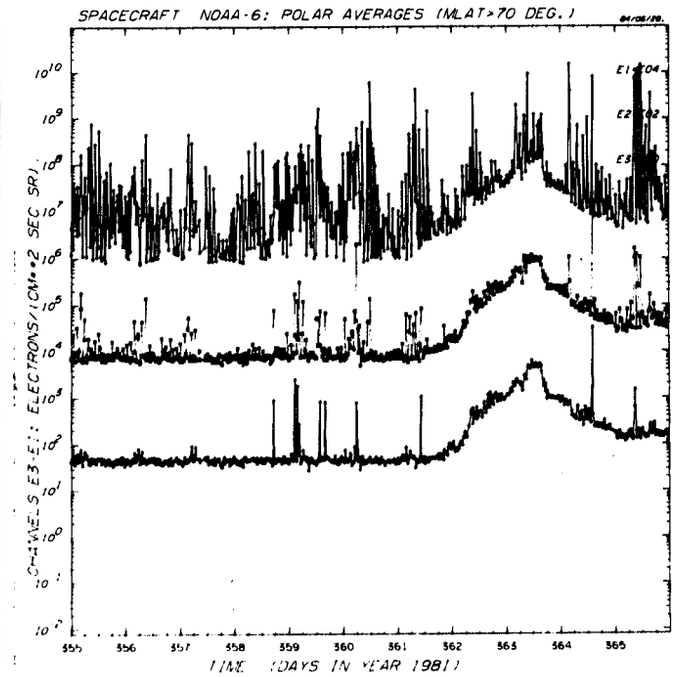

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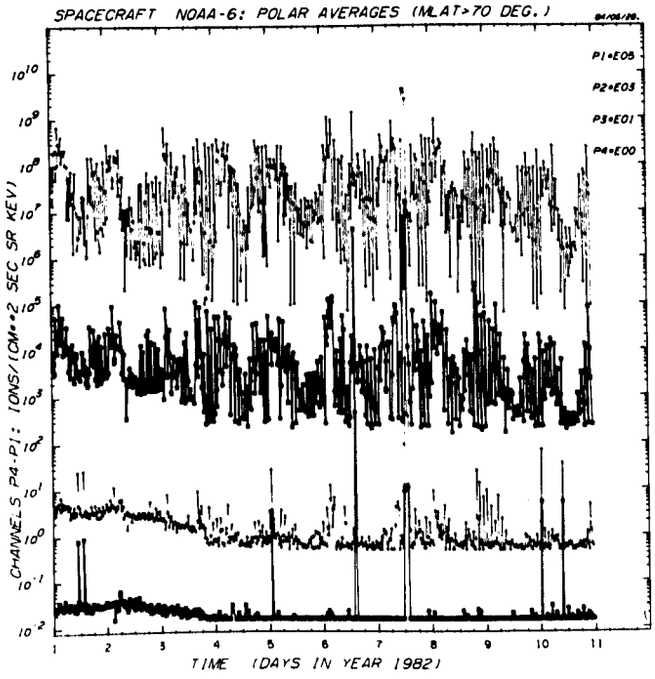

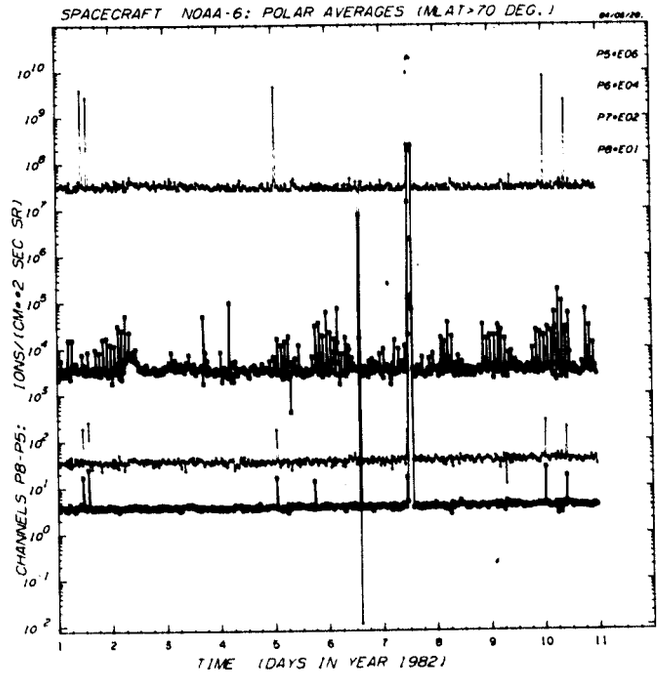

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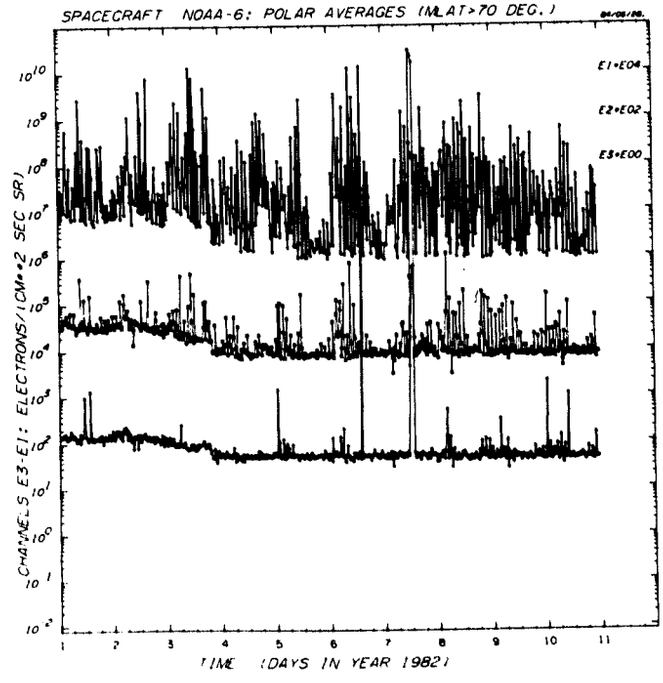
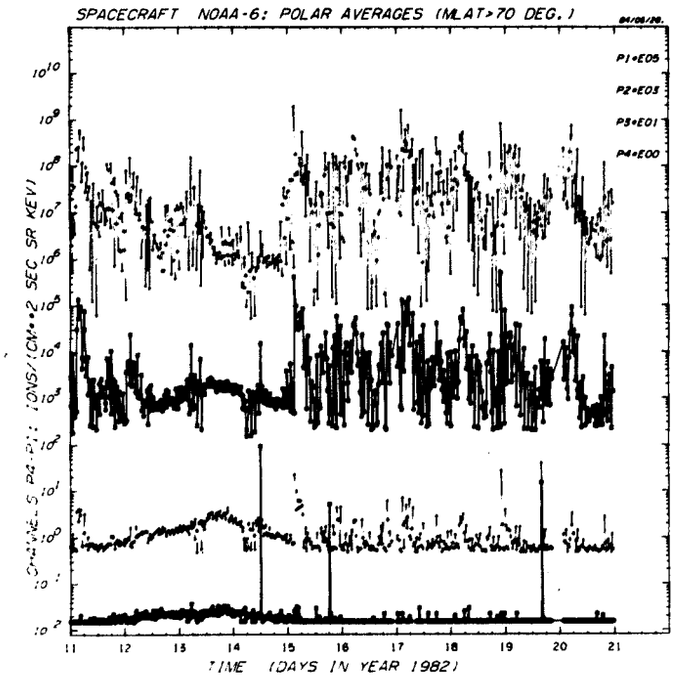
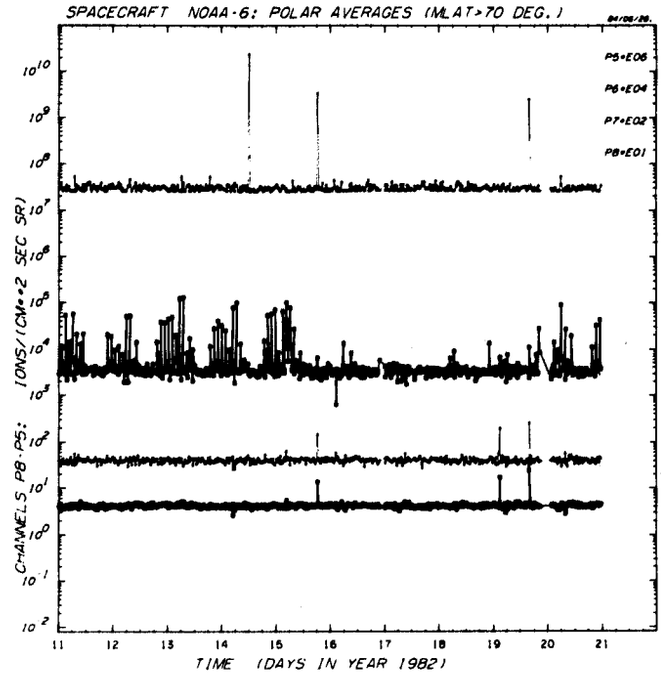


January 1, 1982





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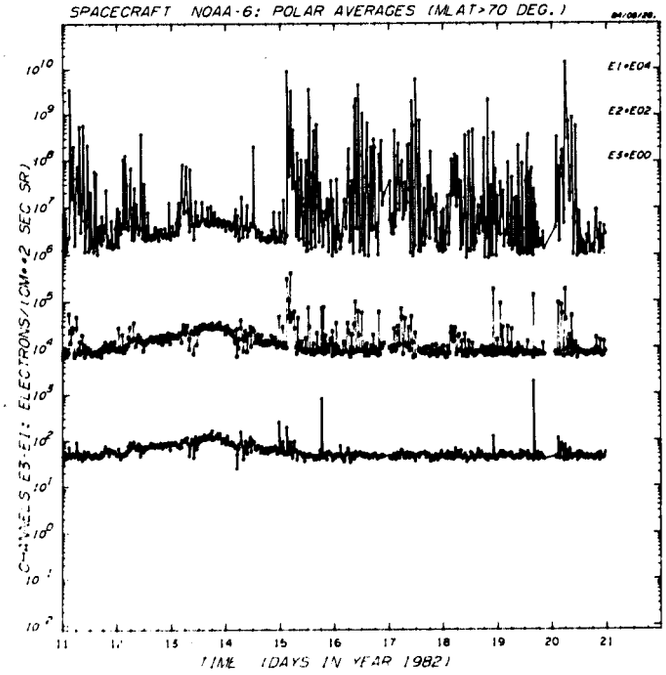

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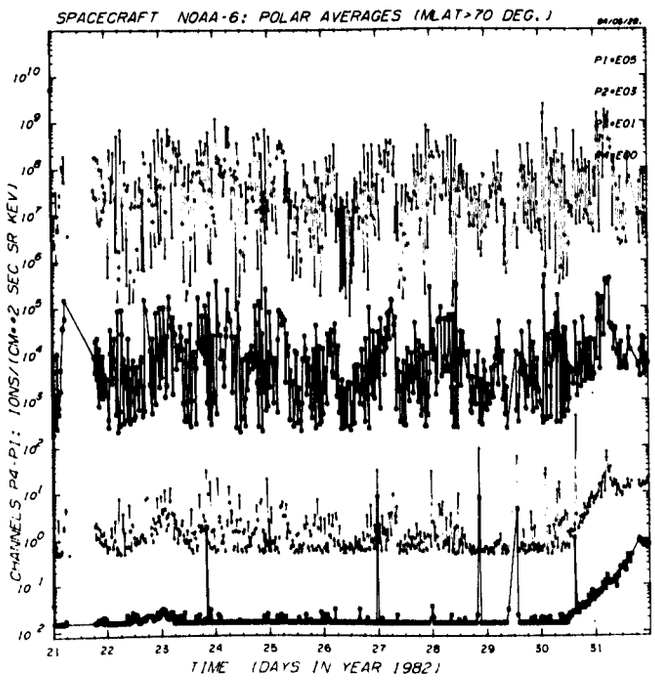

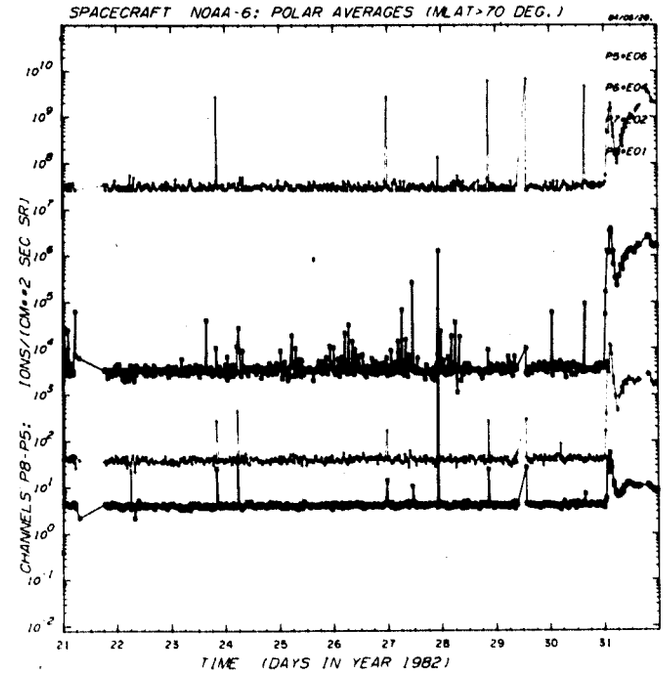

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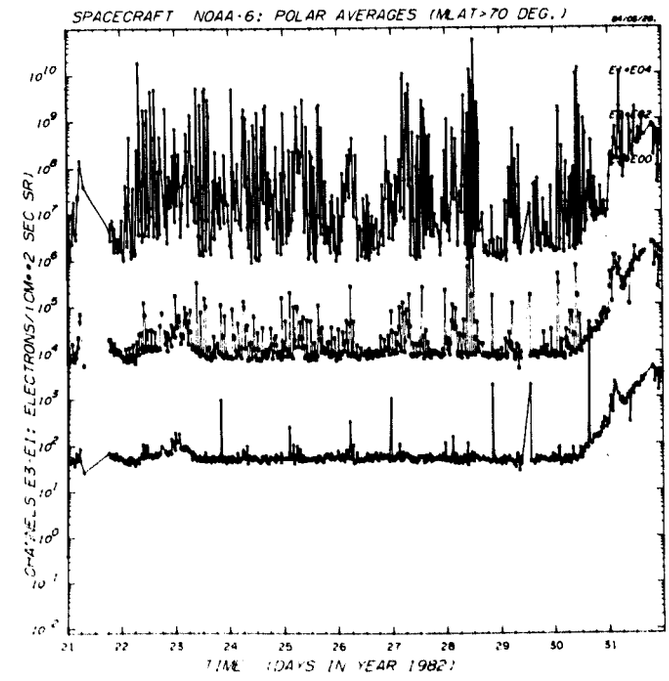

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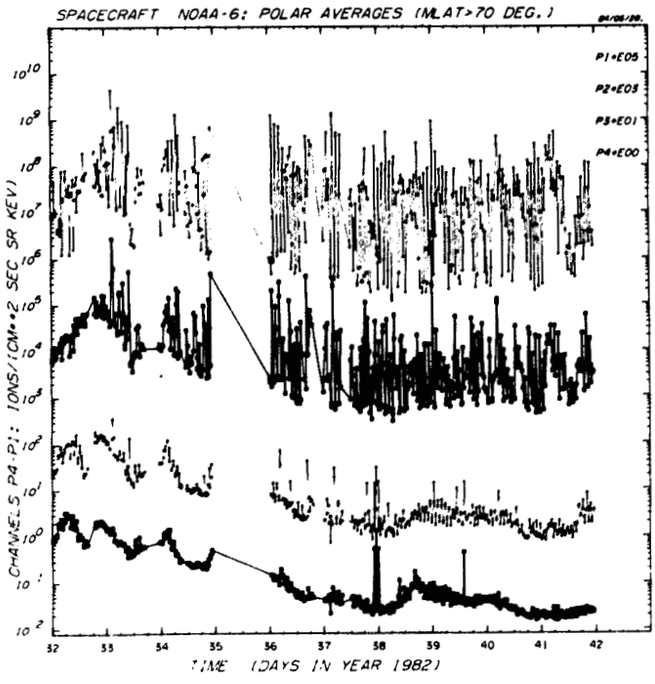

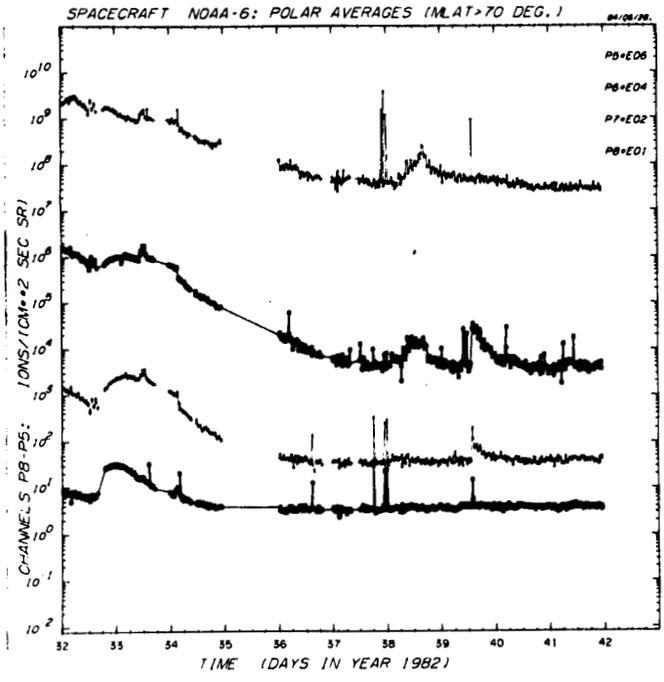

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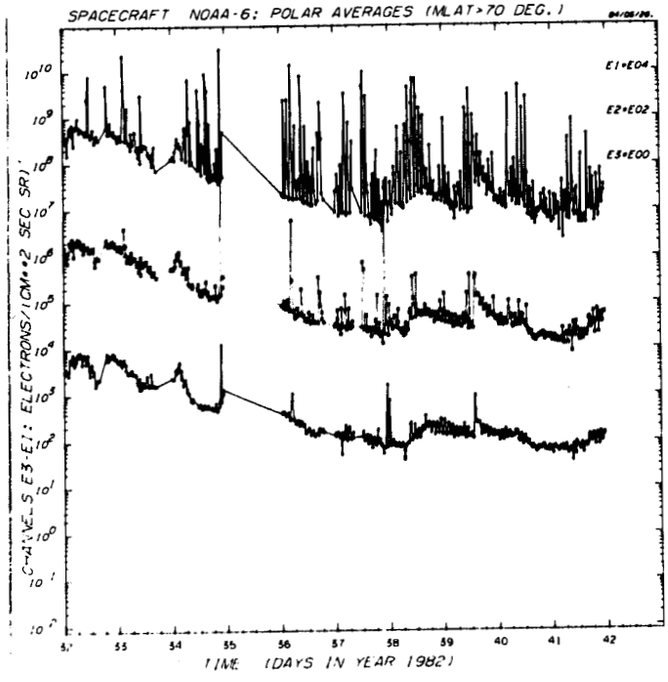
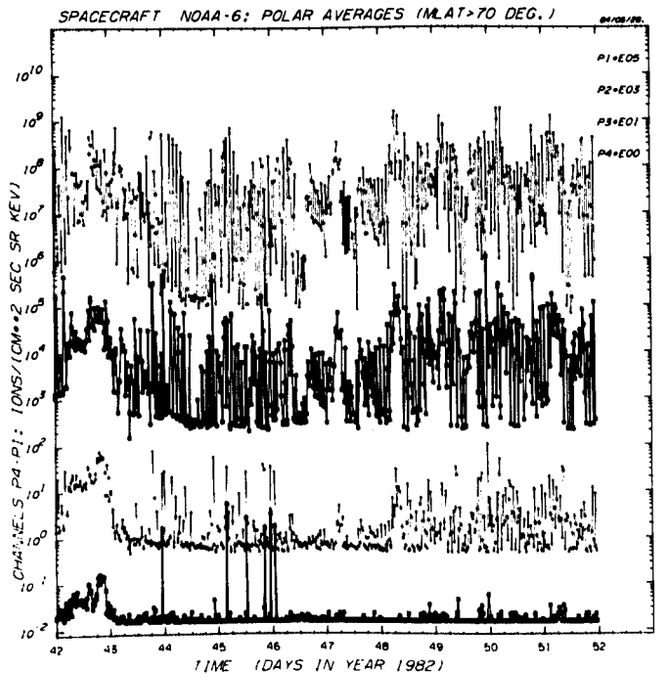
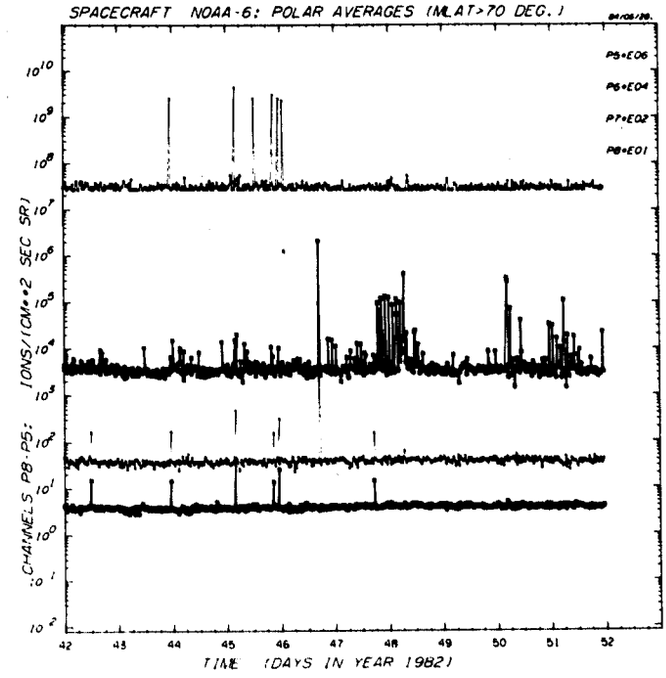


February 1, 1982





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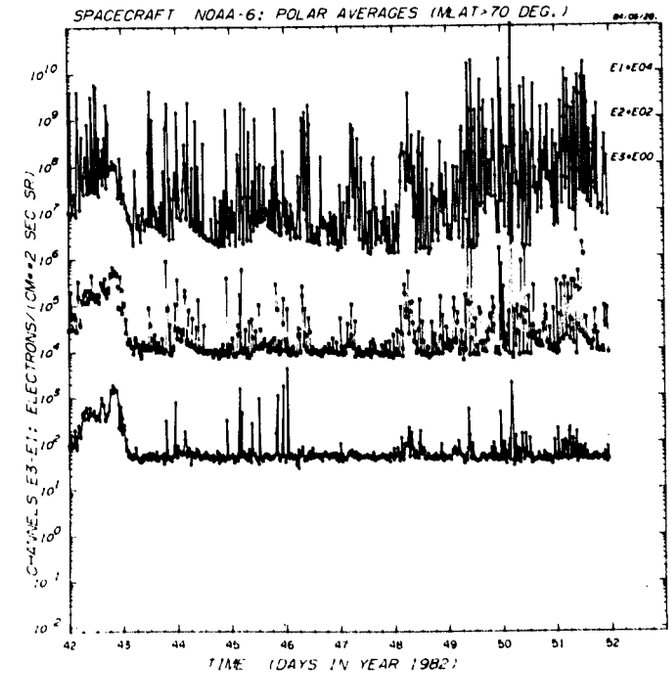

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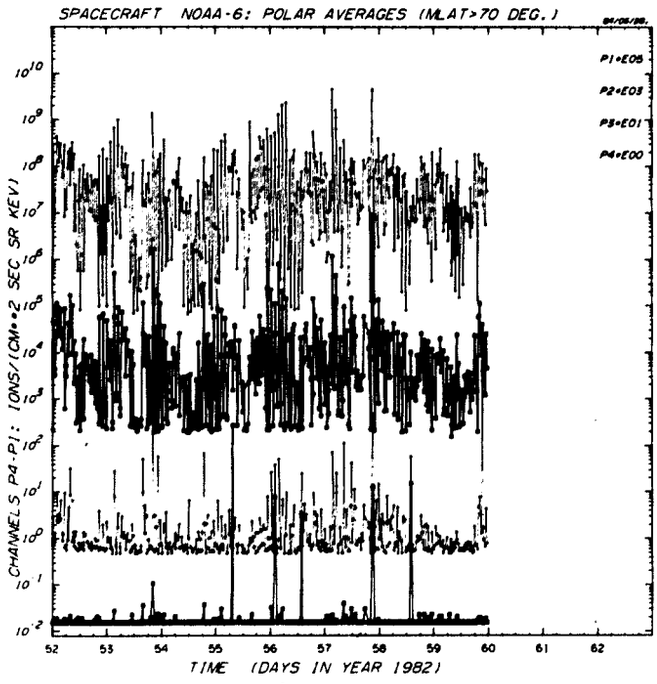

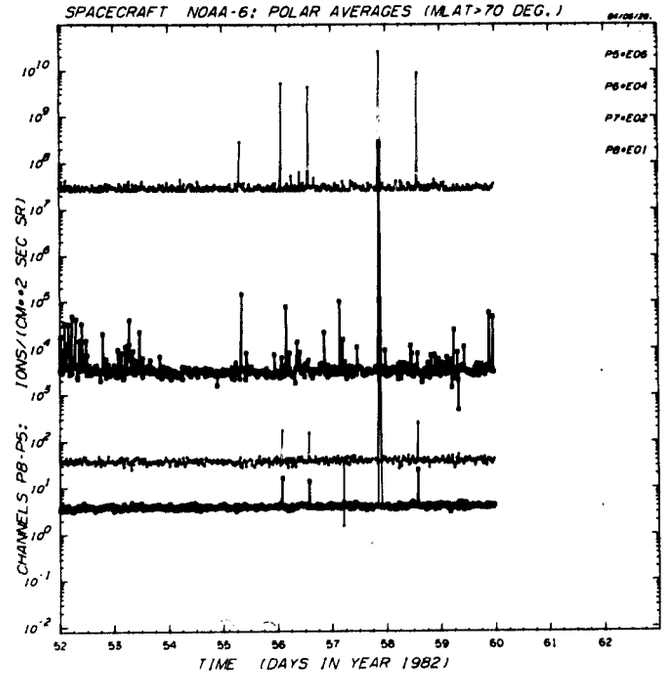

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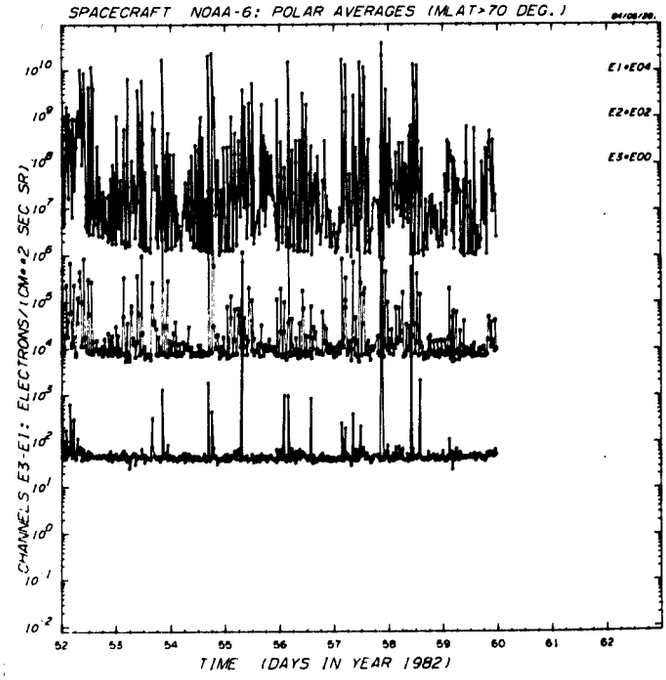
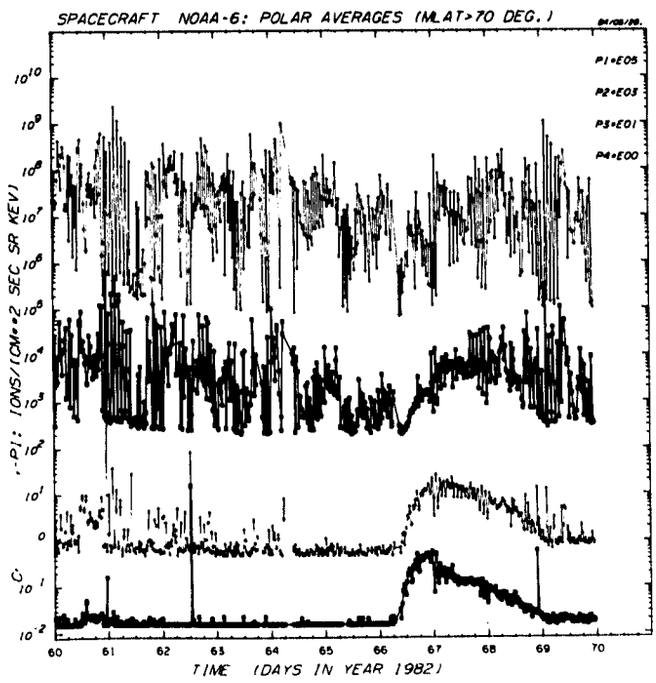
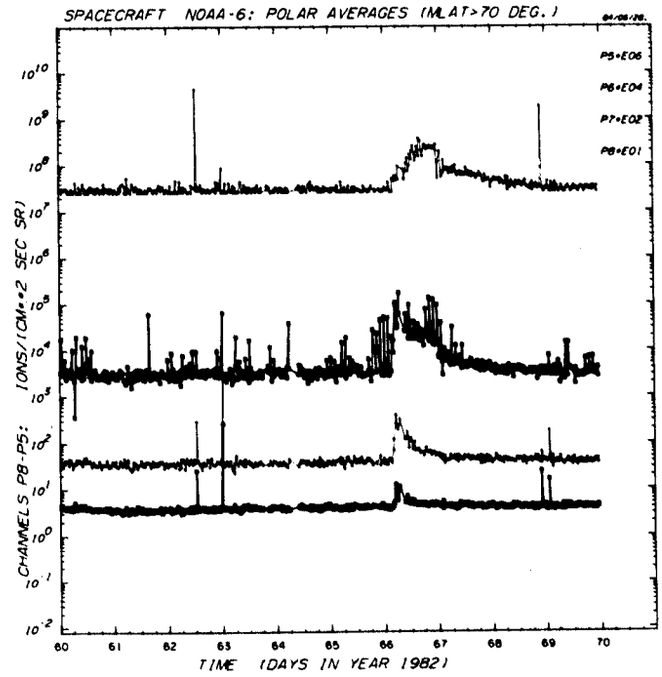


February 21, 1982





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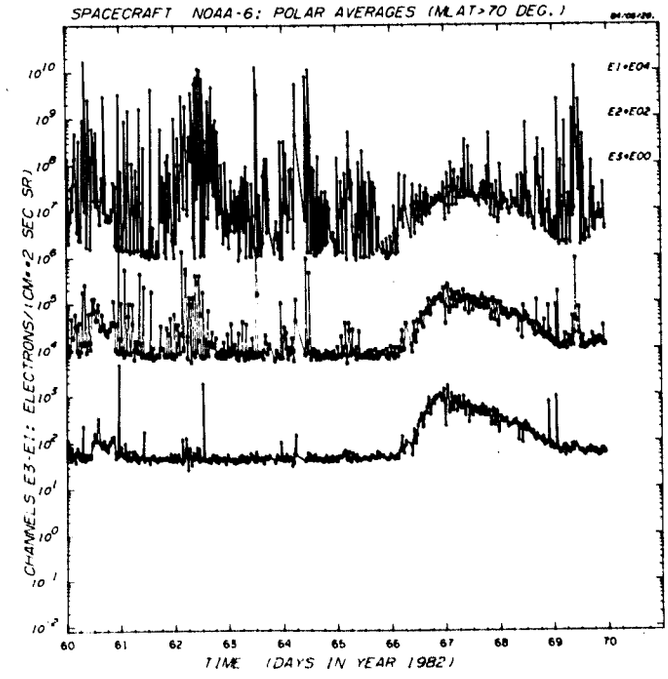
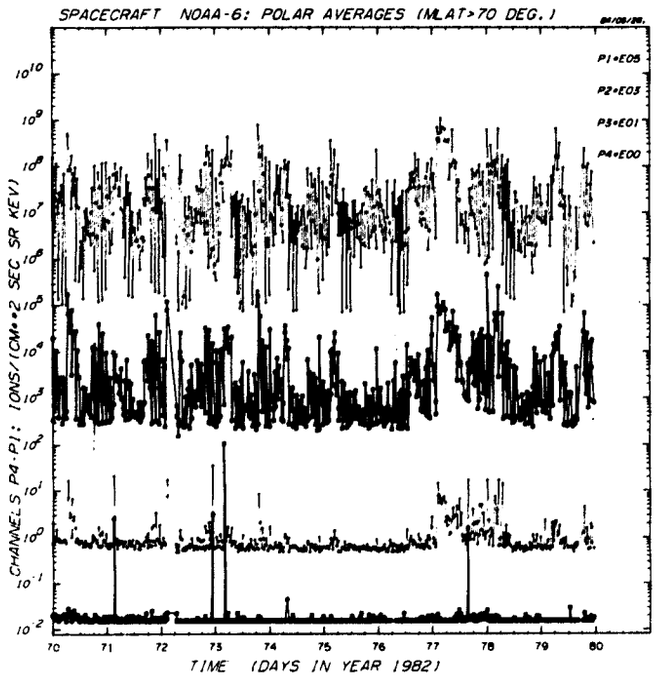
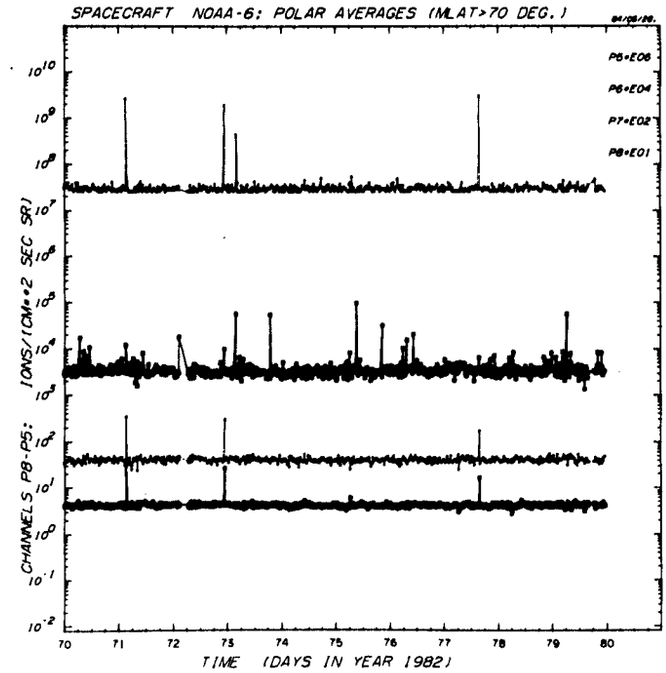
E2: E > 100 KEV
E3: E > 300 KEV



March 1, 1982





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
P2: E= 80 - 250 KEV
P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
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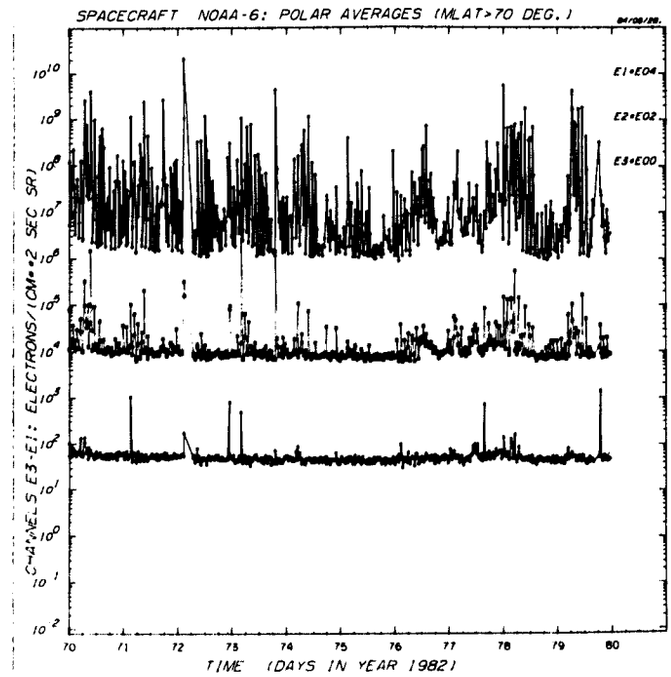
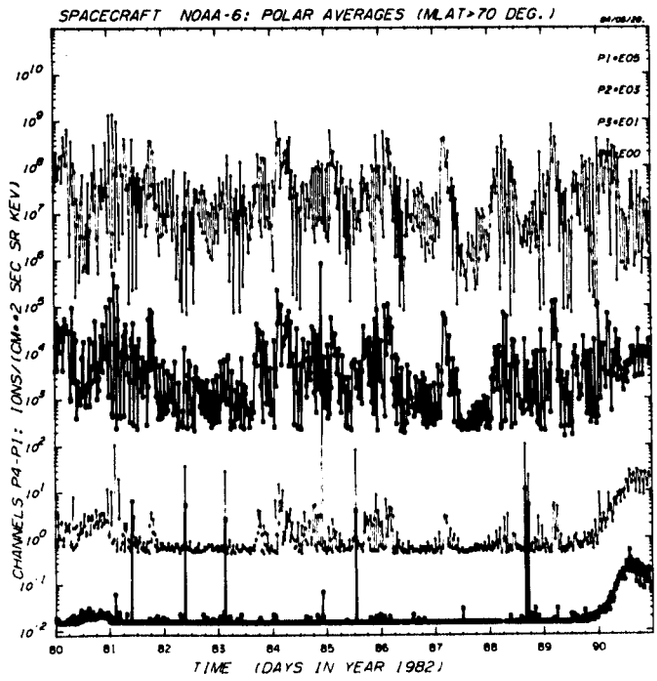
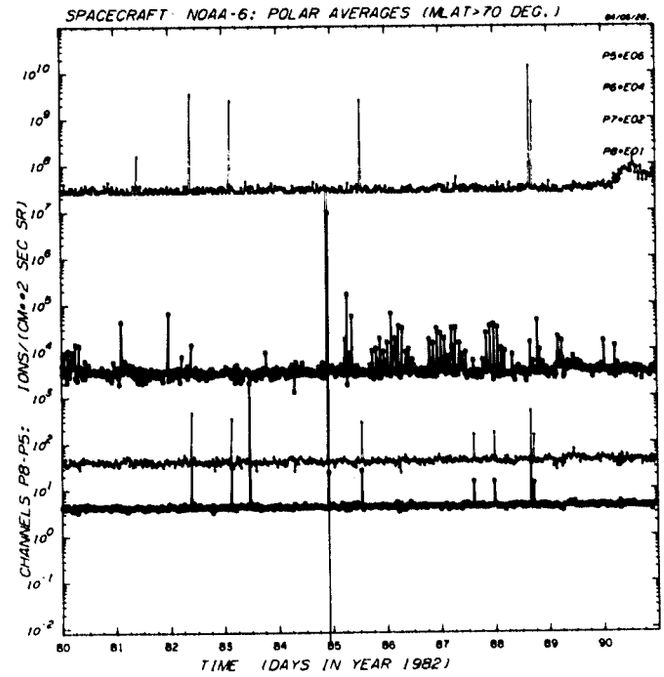


March 11, 1982





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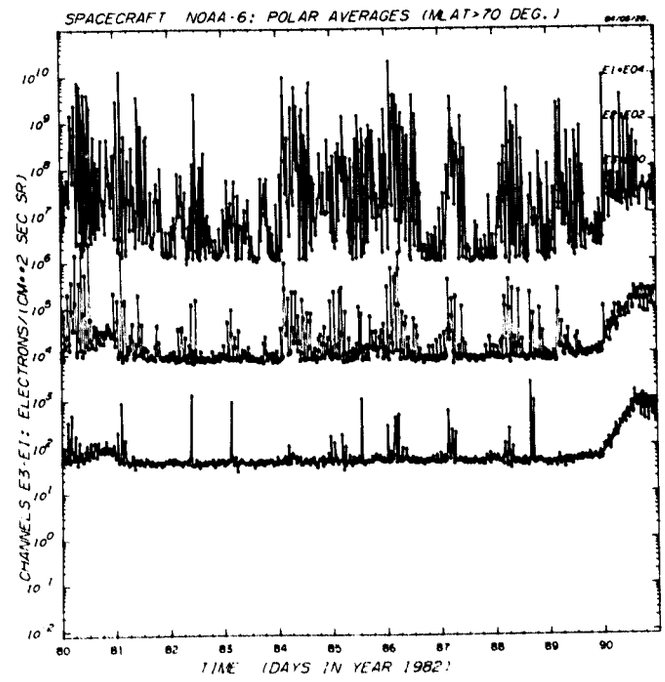
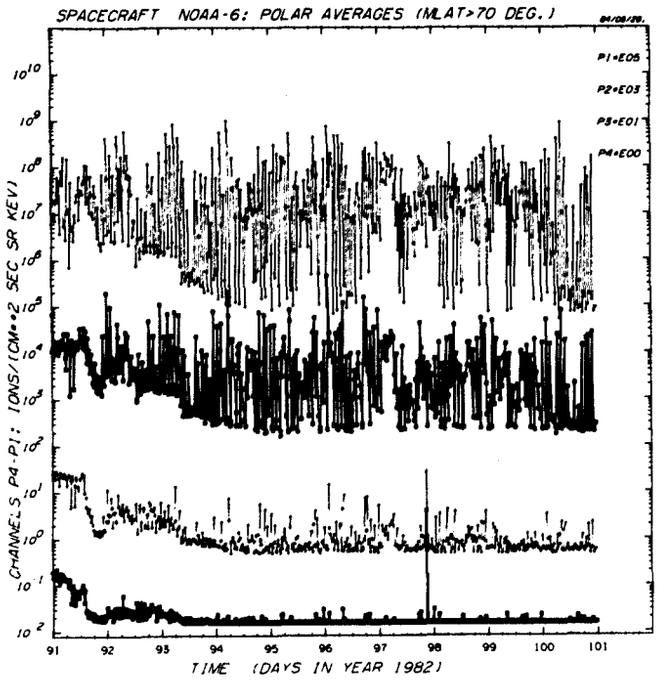
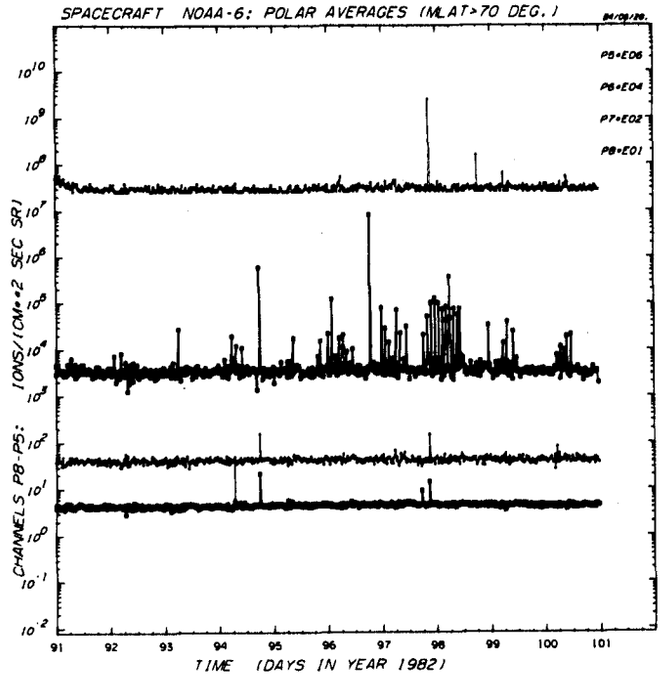


March 21, 1982





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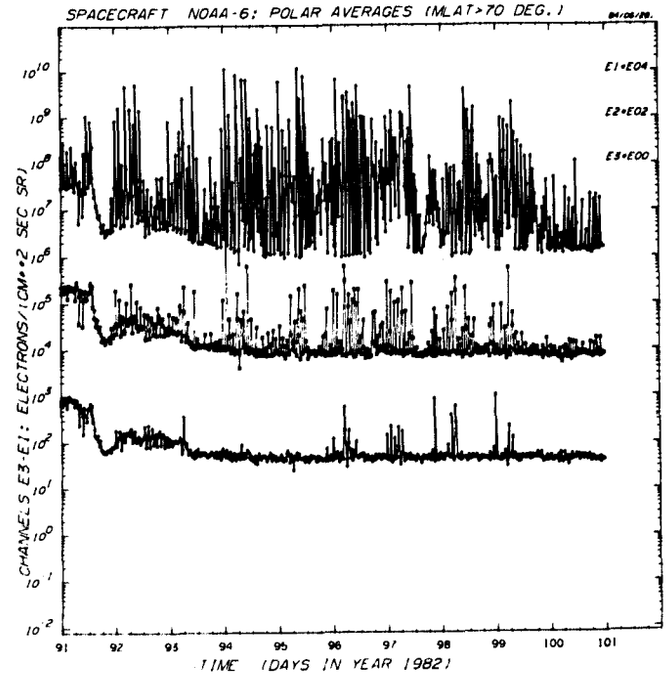
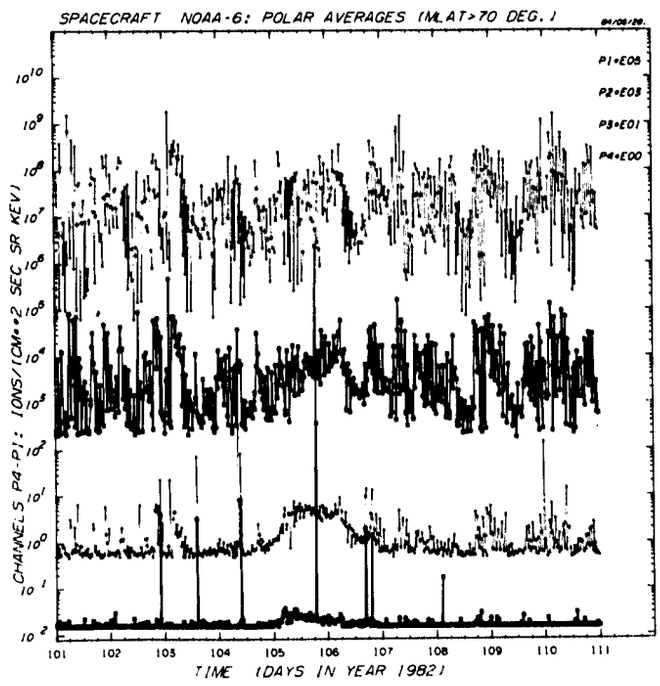
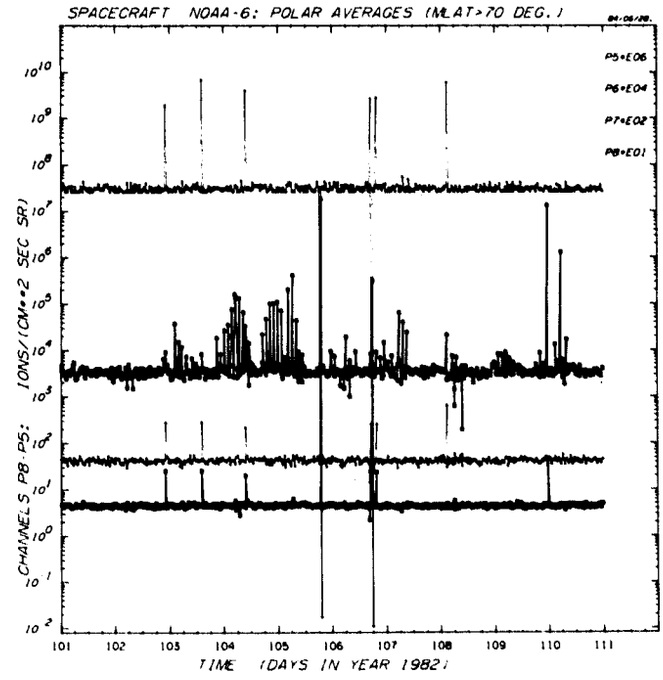


April 1, 1982





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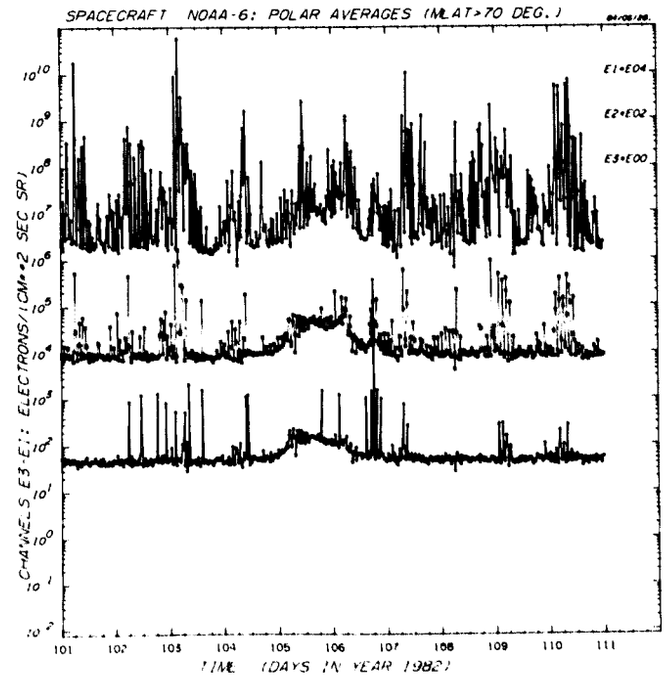
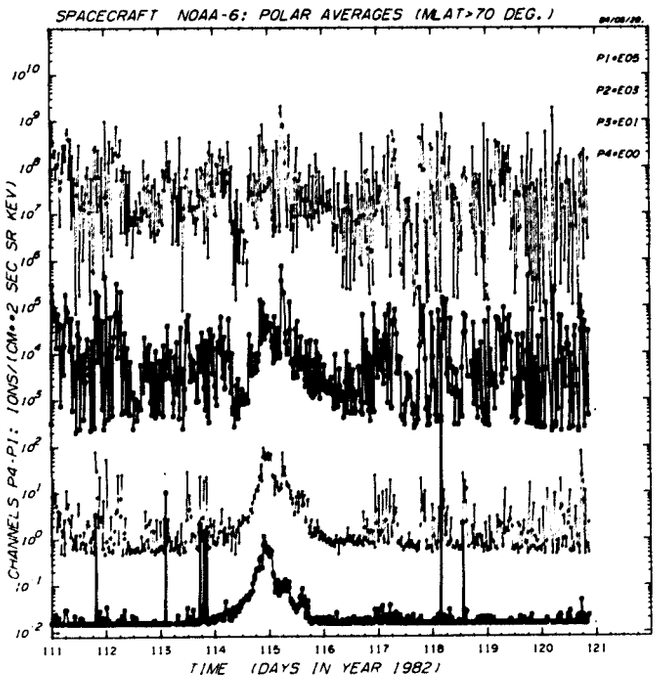
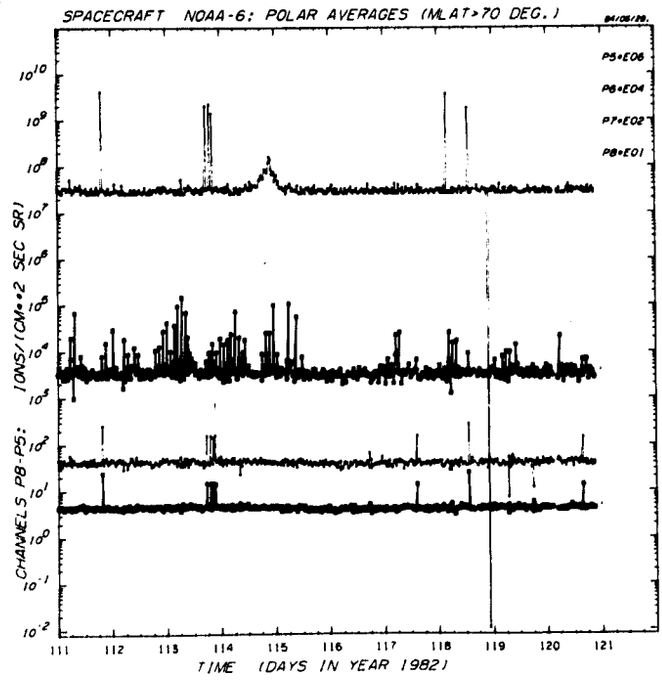


April 11, 1982





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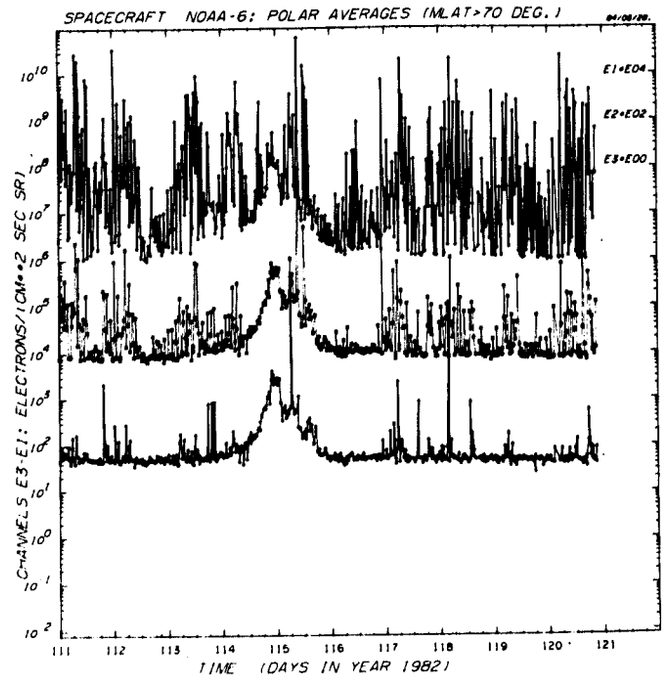
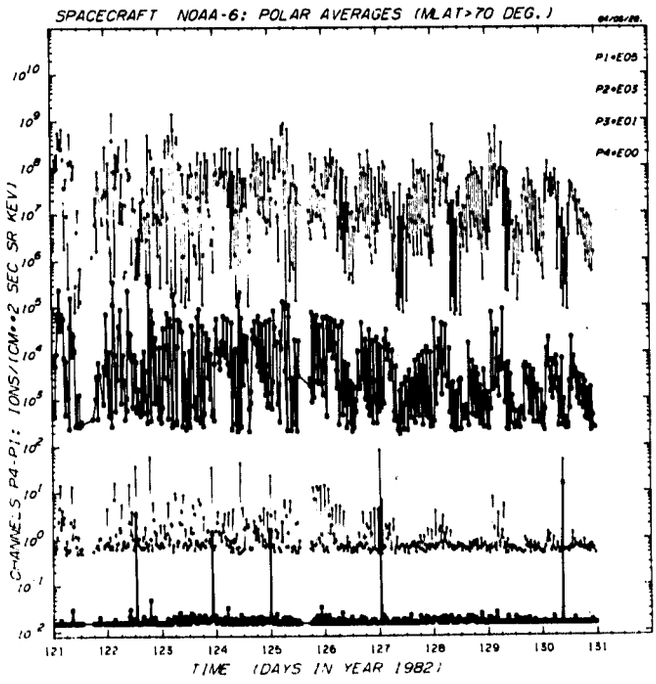
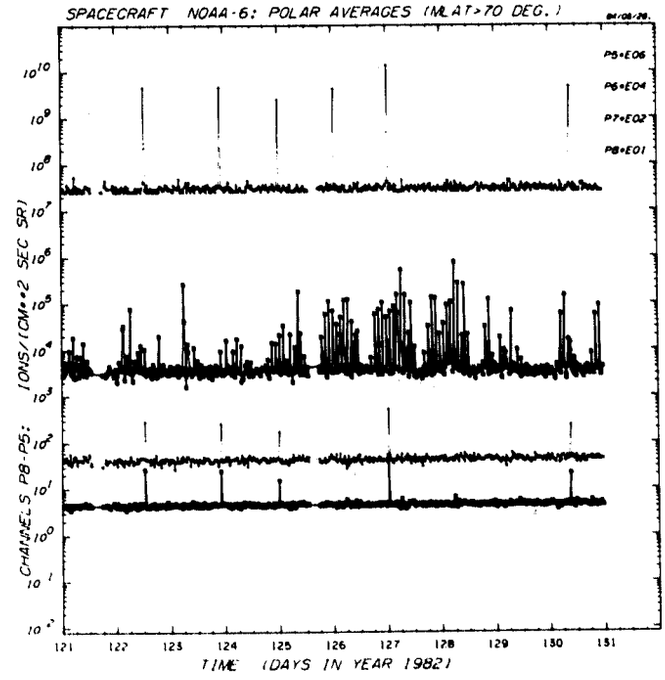


April 21, 1982





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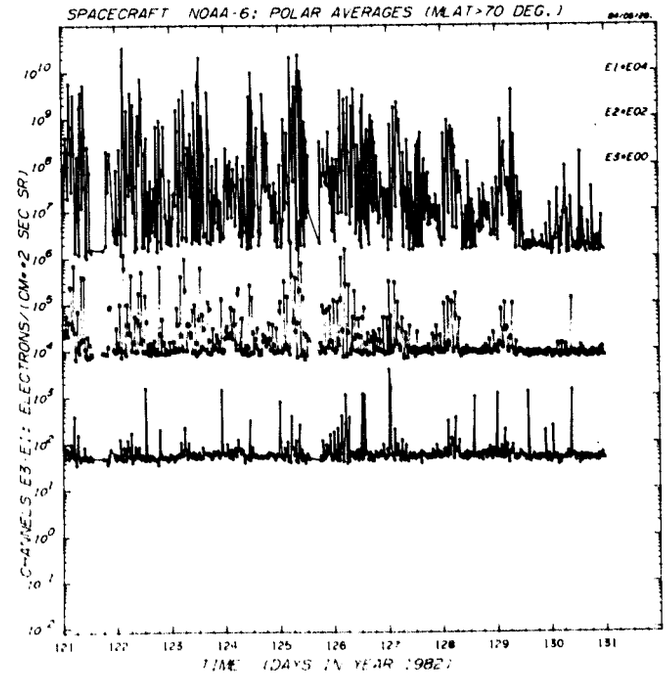
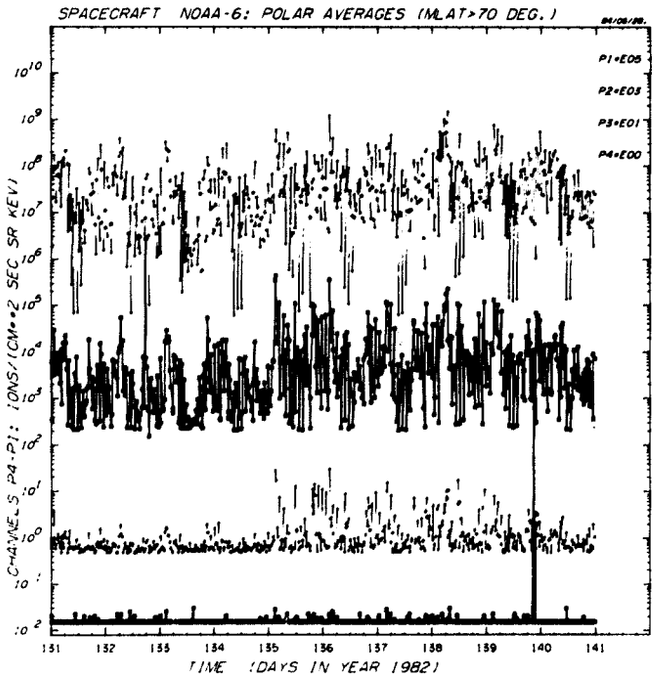
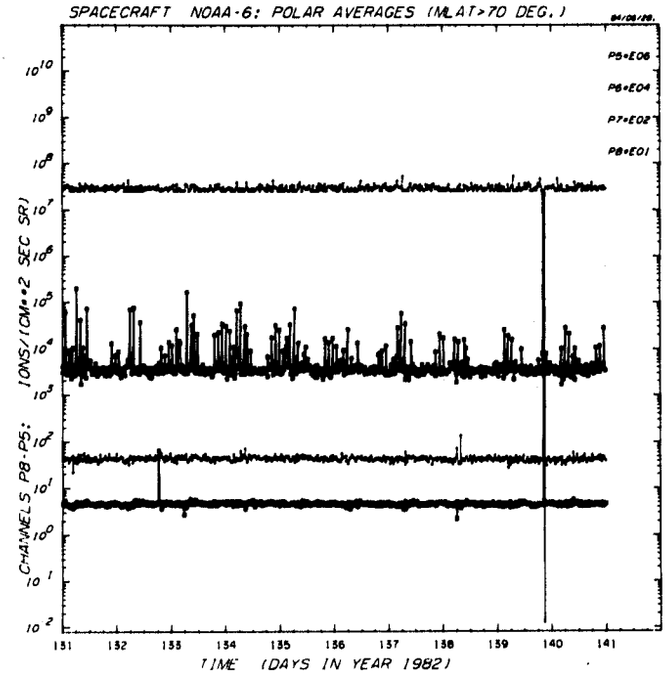


May 1, 1982





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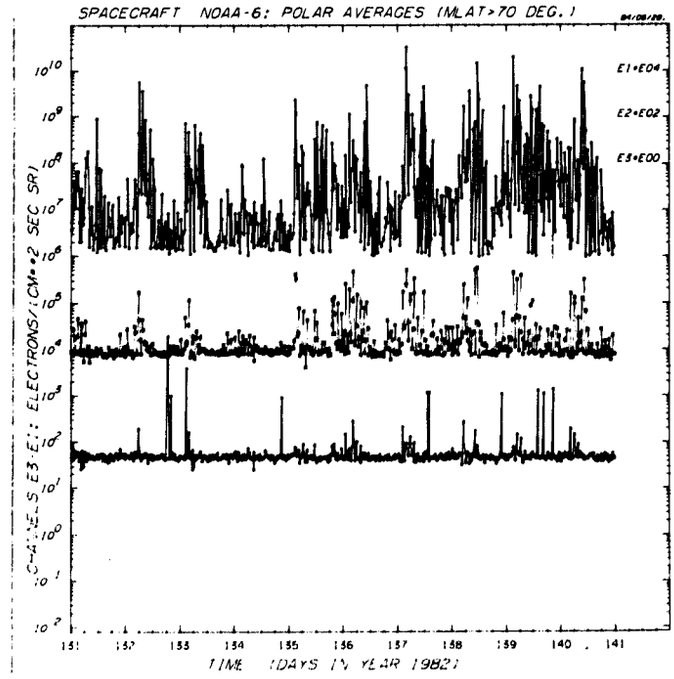
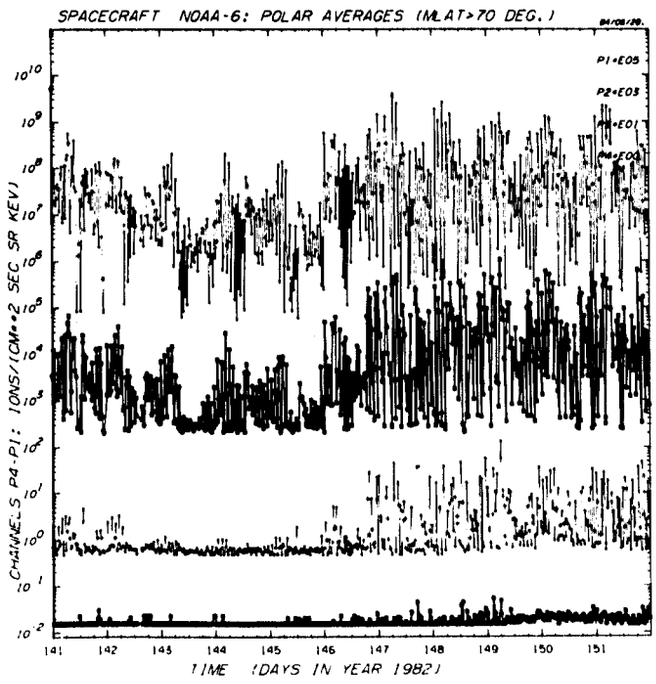
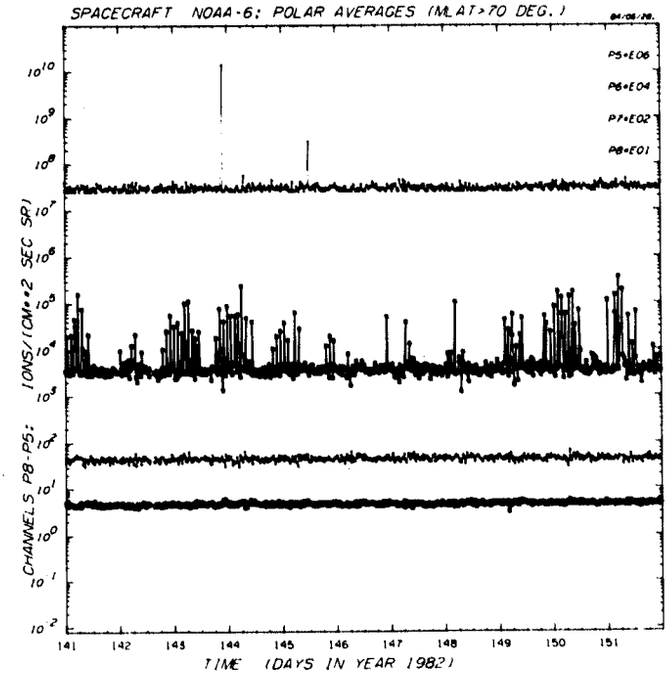


May 11, 1982





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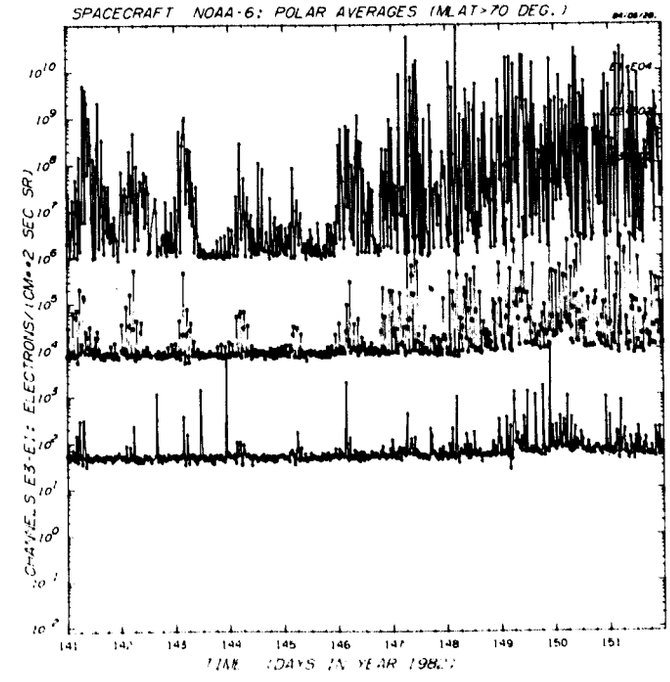
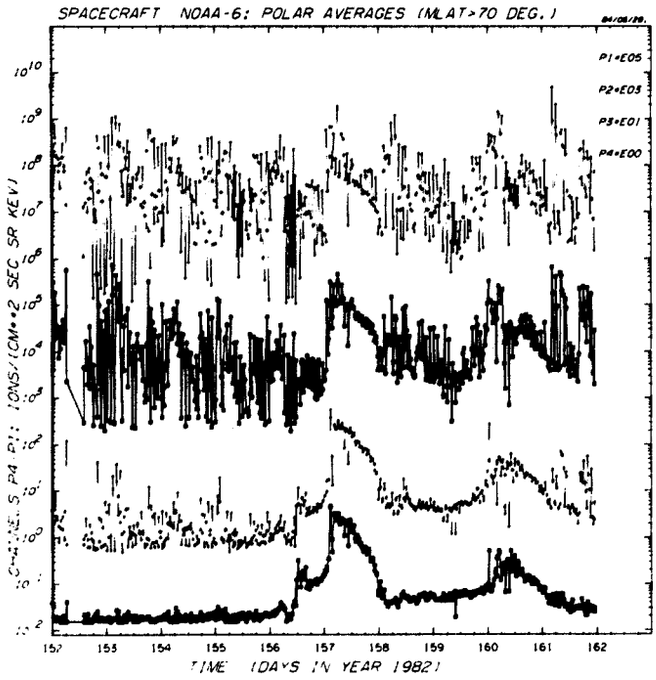
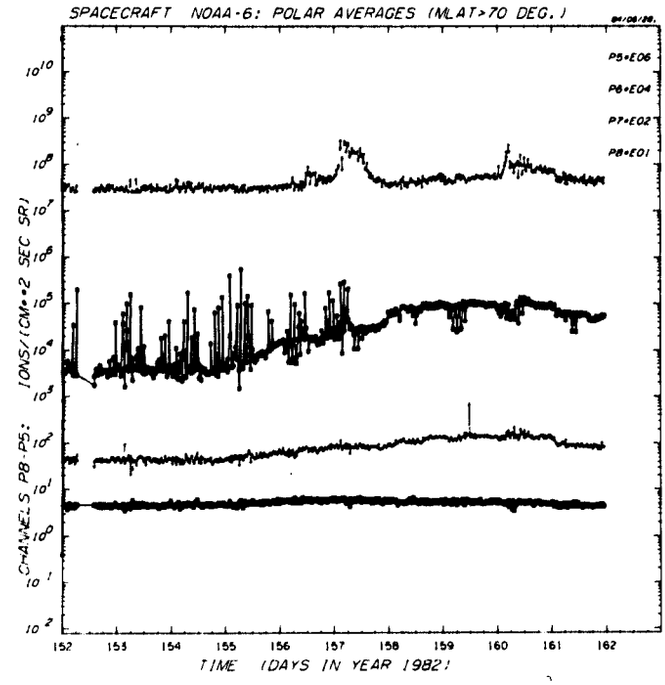


May 21, 1982





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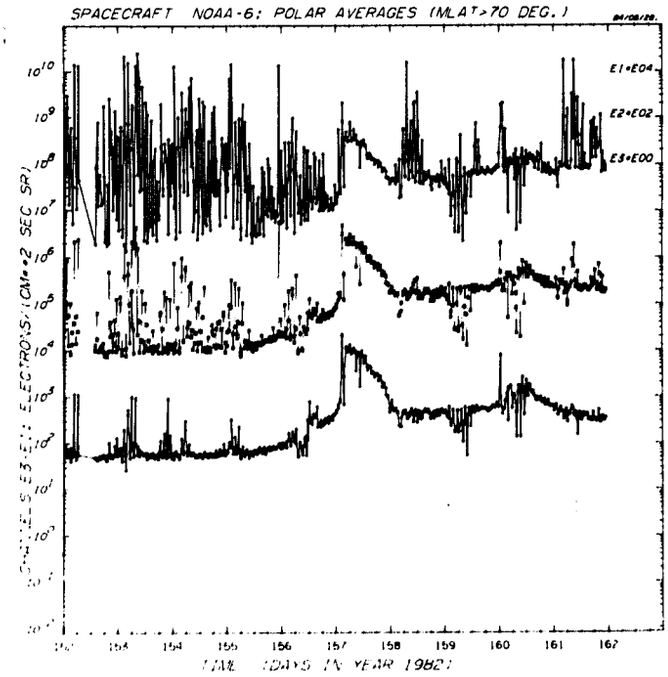
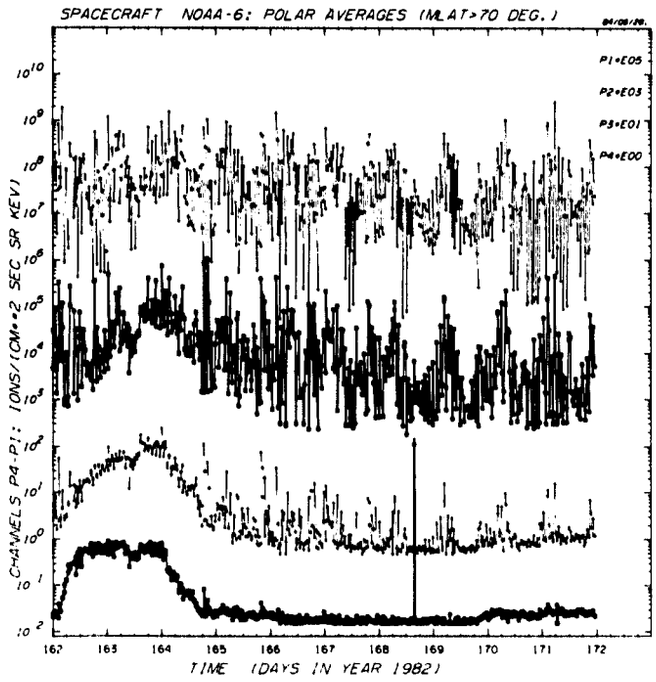
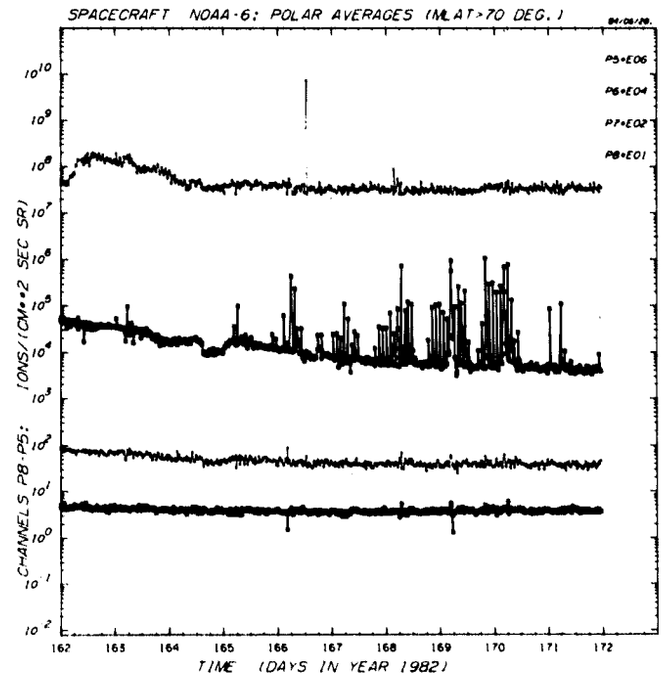


June 1, 1982





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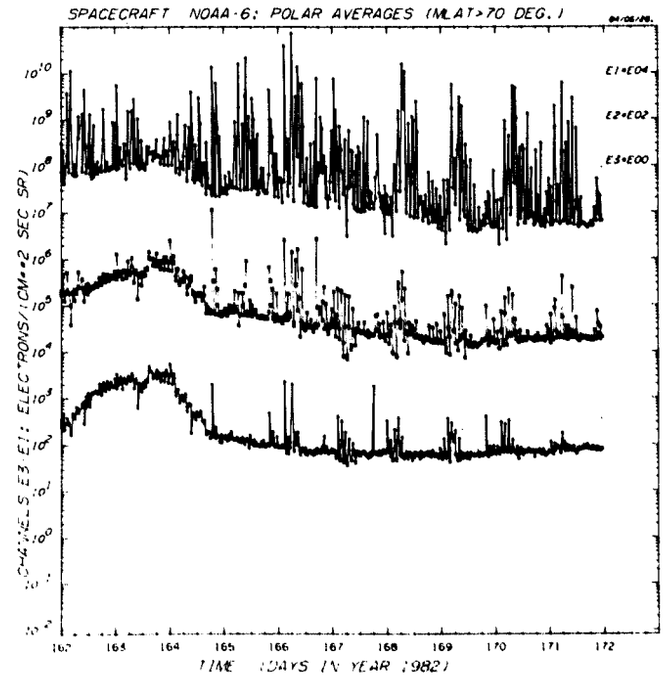
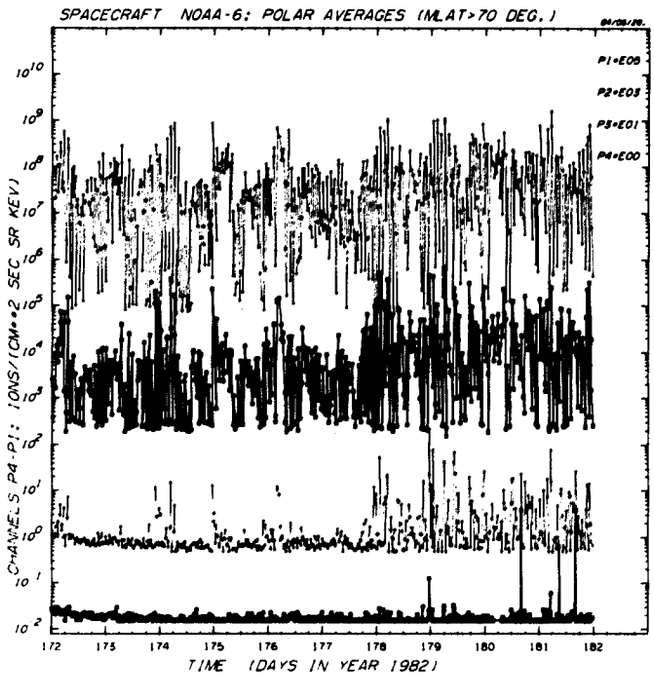
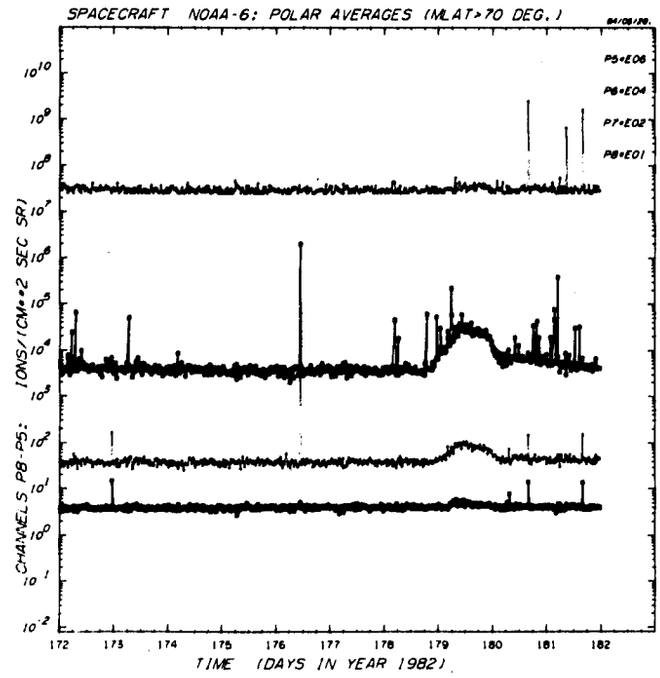


June 11, 1982





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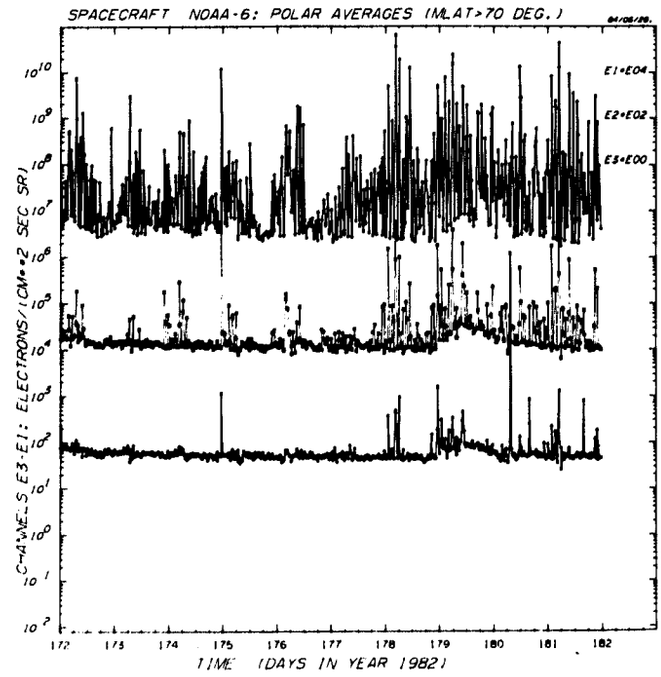
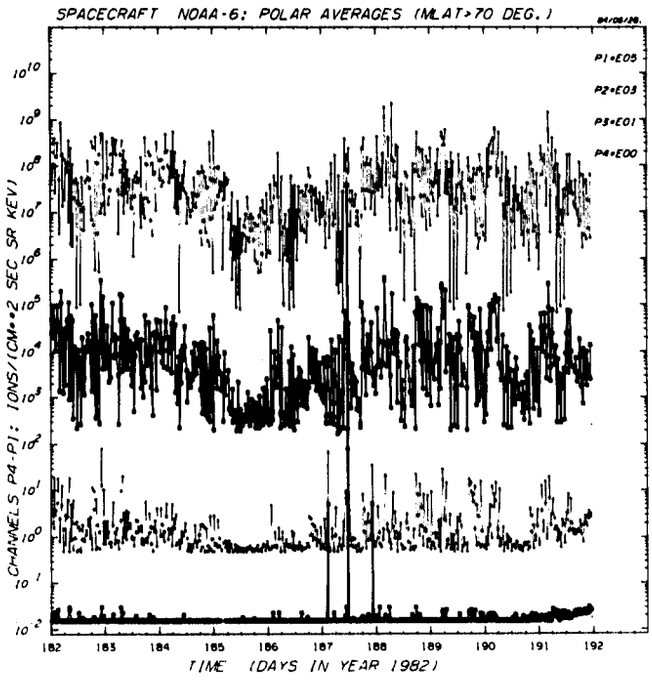
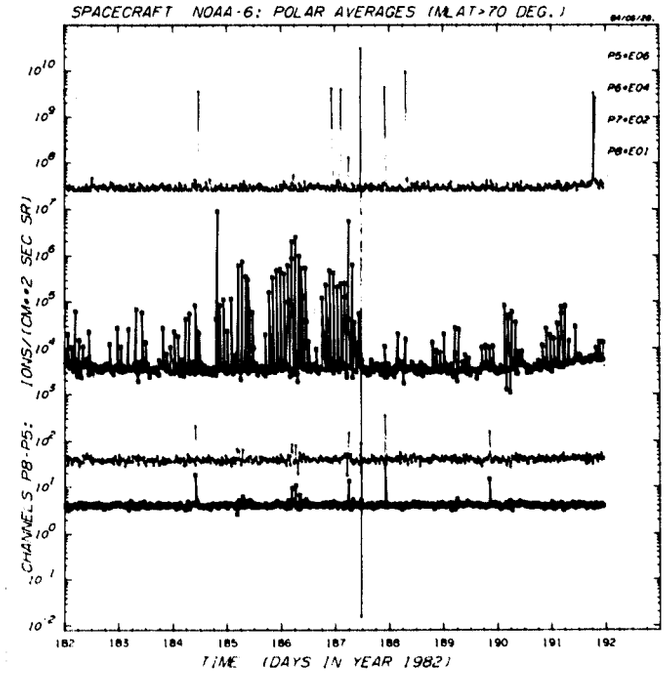


June 21, 1982





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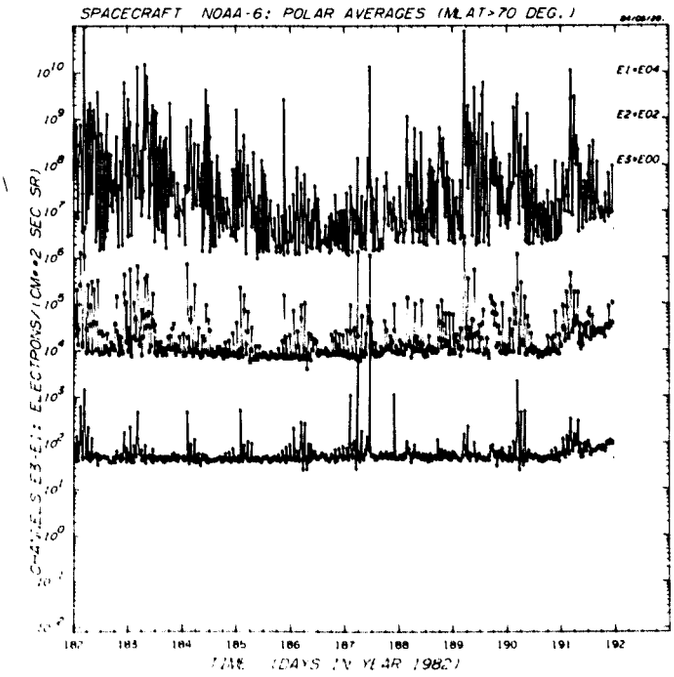
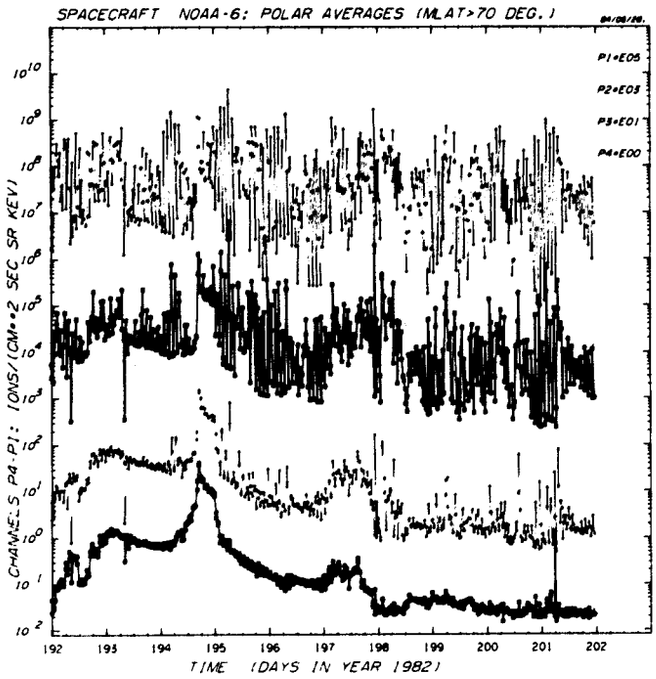
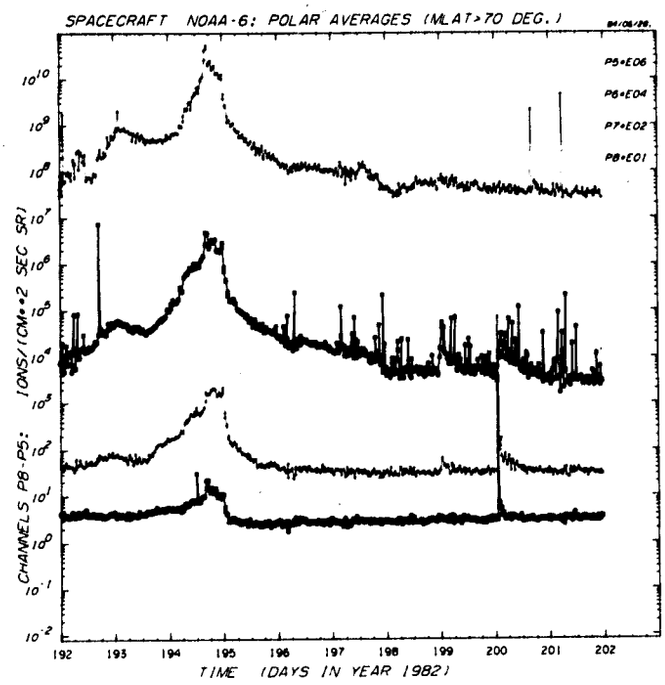


July 1, 1982





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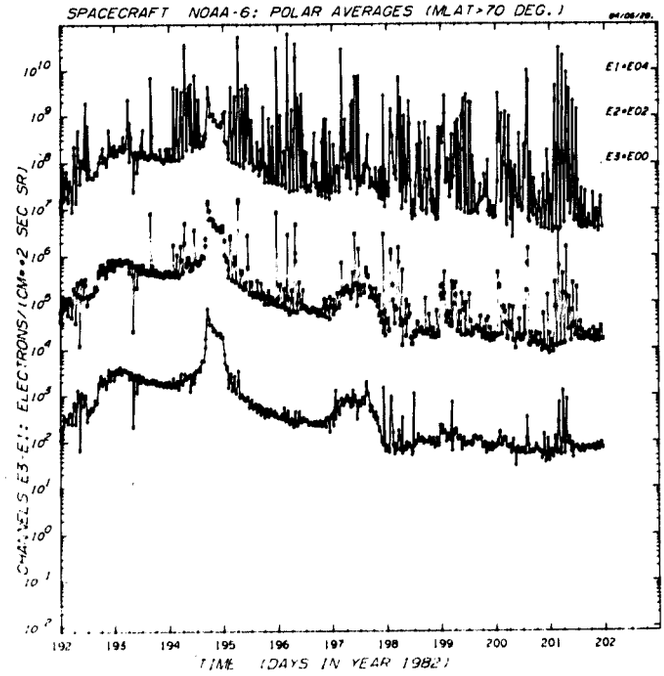
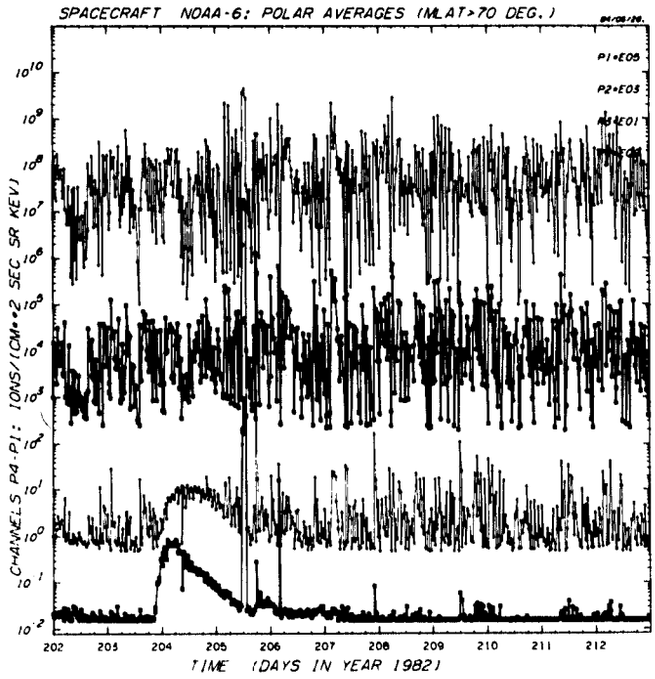
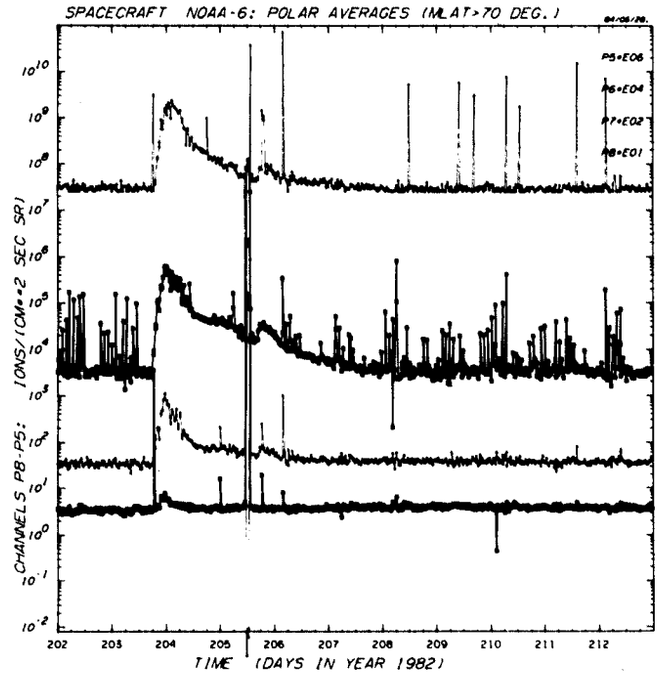


July 11, 1982





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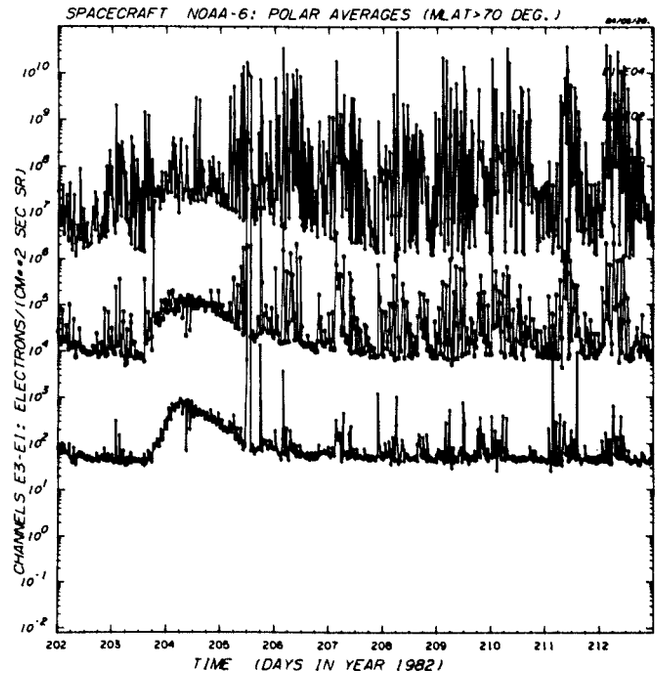
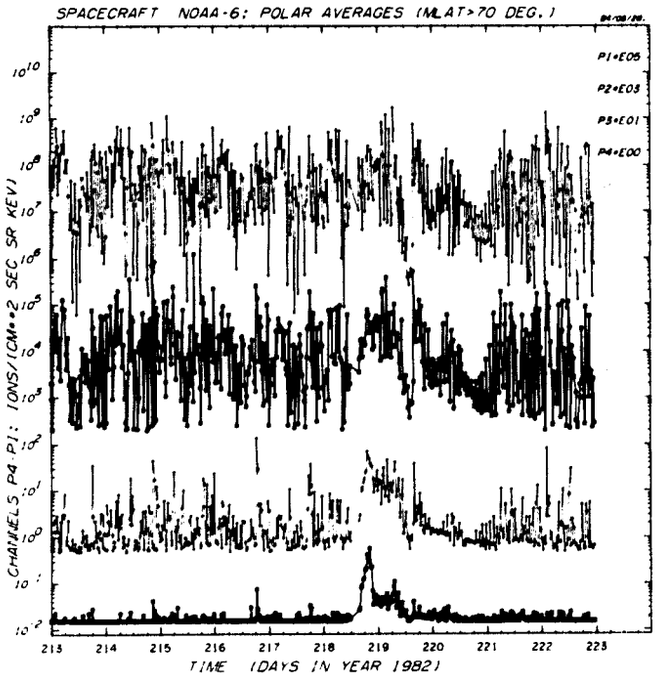
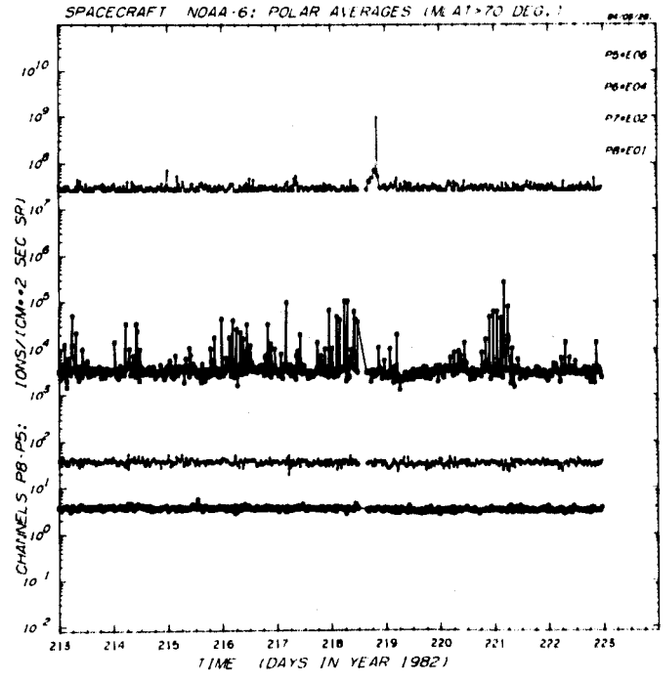


July 21, 1982





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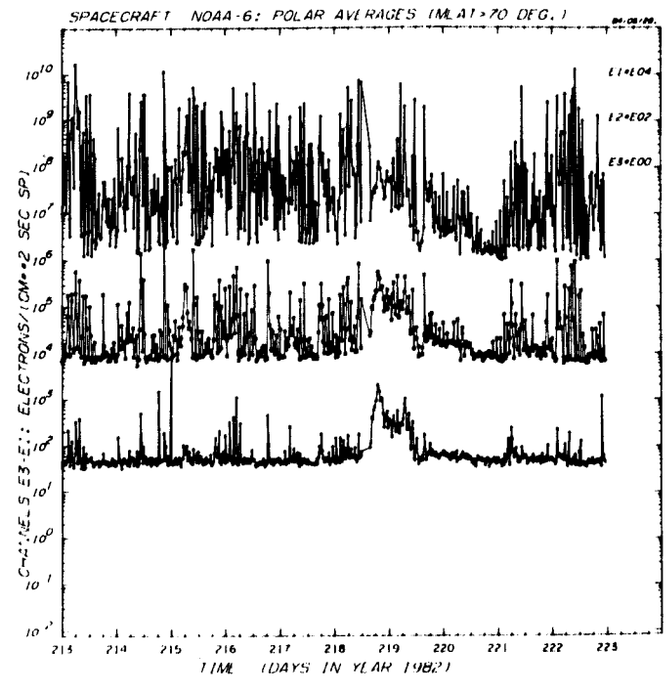
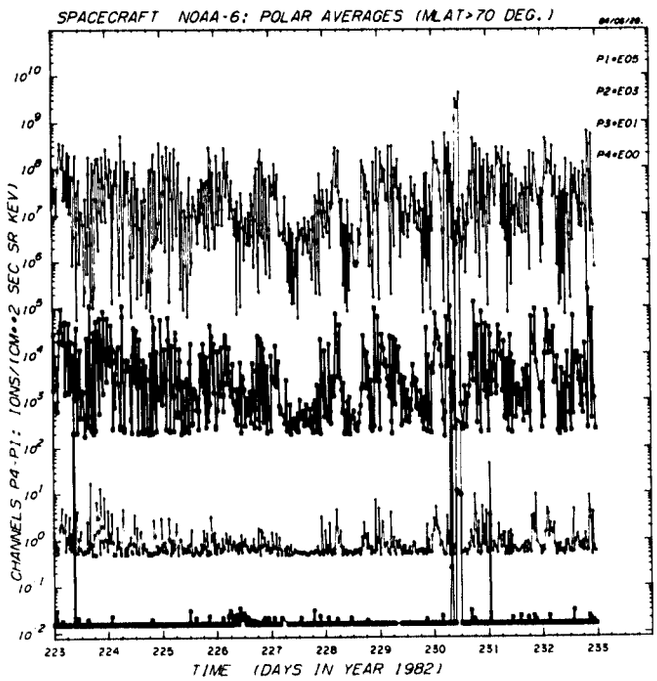
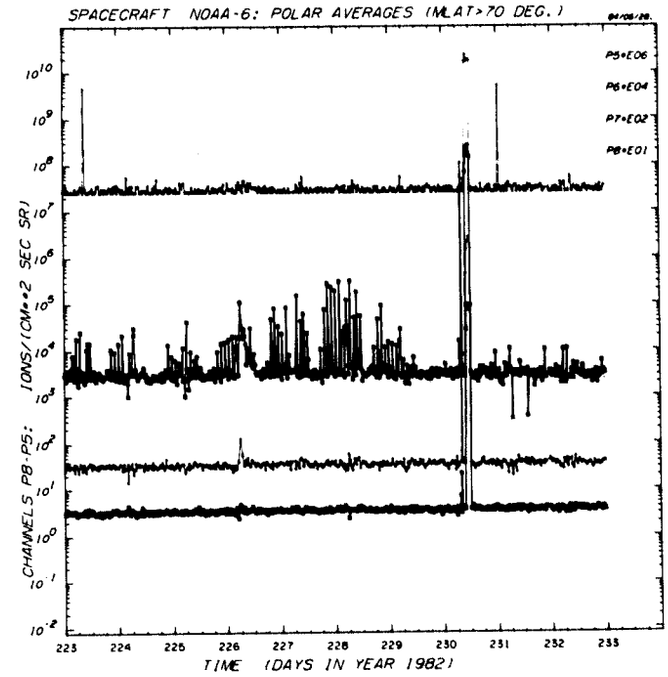


August 1, 1982





ENERGY CHANNELS:

P1: E= 30 - 80 KEV
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P3: E= 250 - 800 KEV
P4: E= 800 -2500 KEV
P5: E > 2500 KEV
P6: E > 16000 KEV
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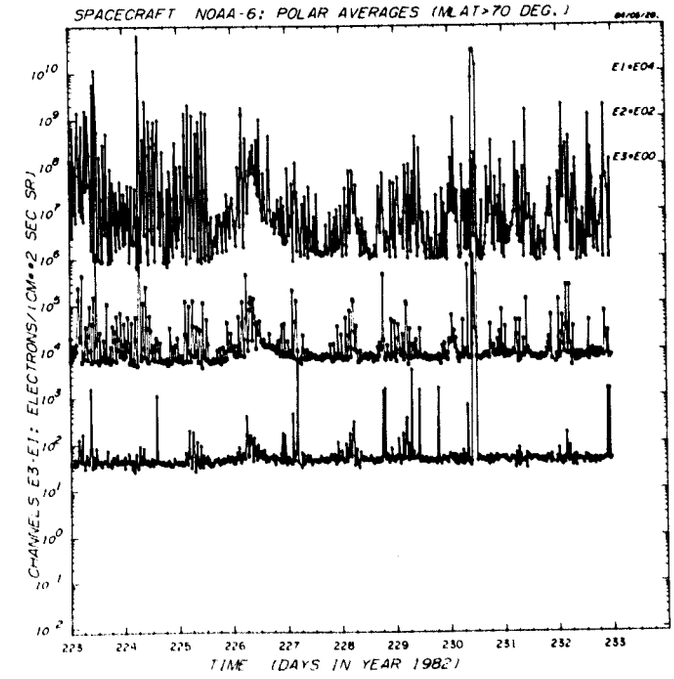
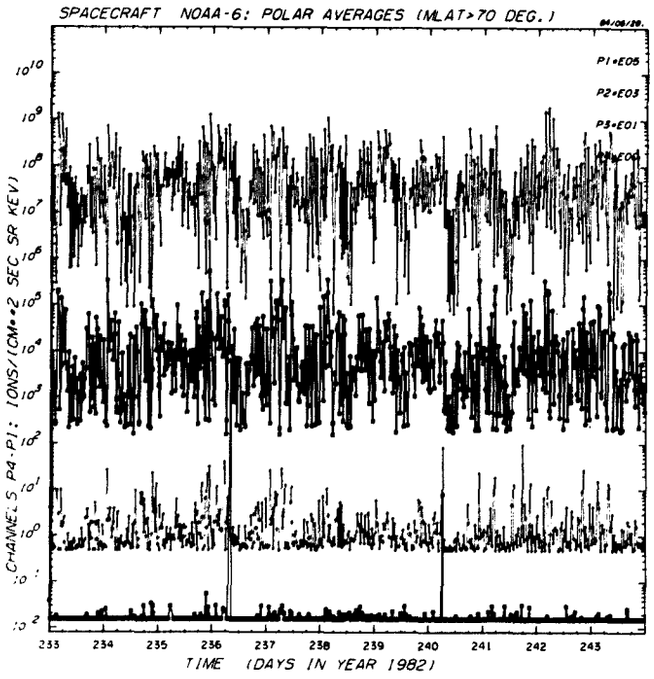
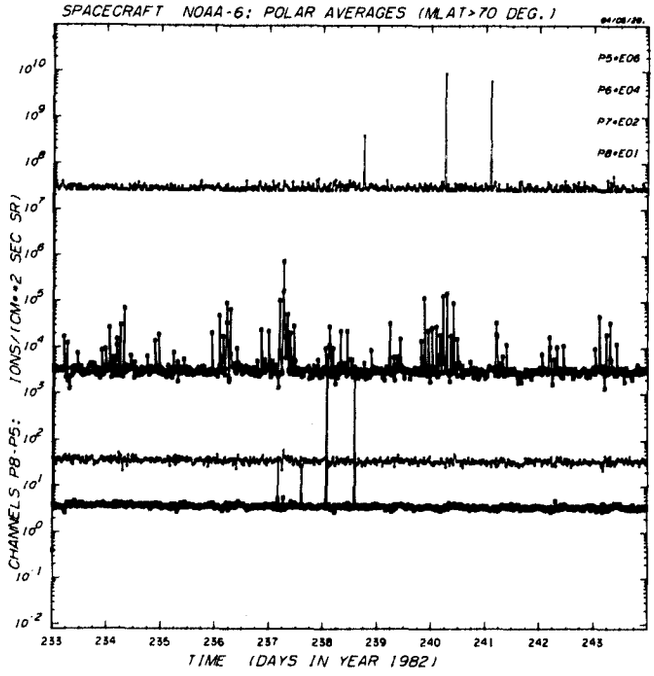


August 11, 1982





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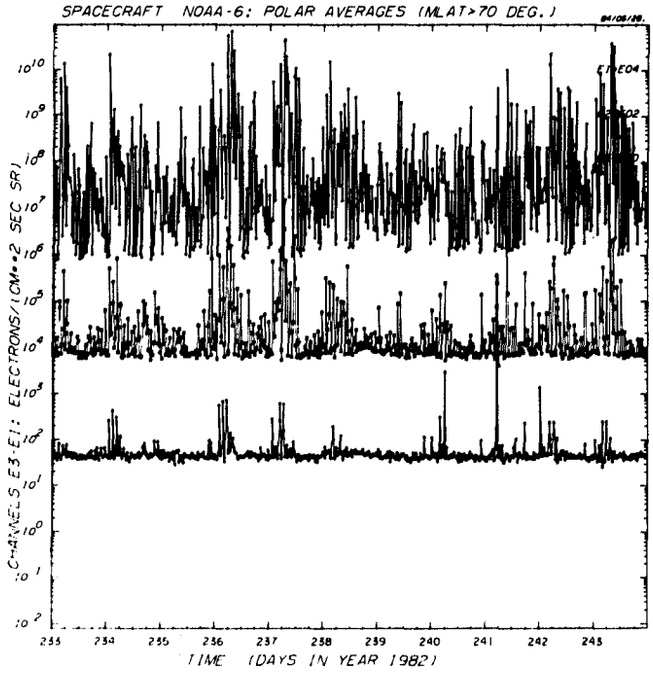
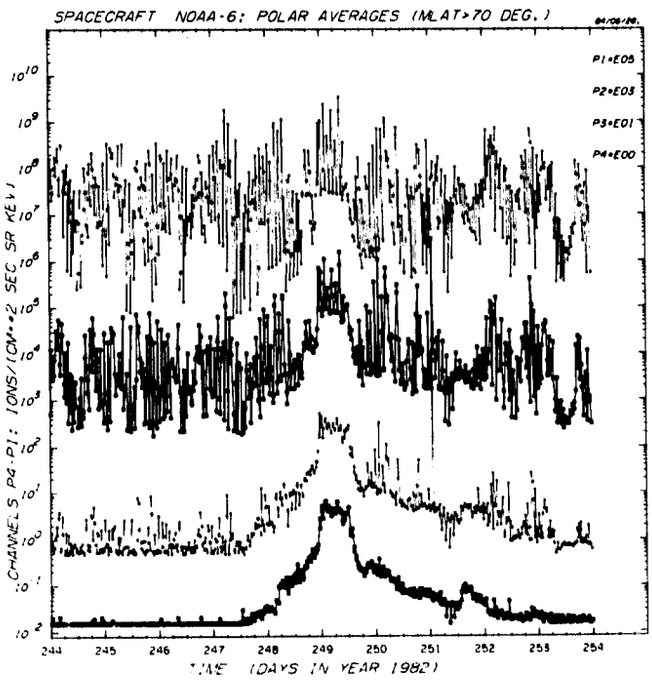
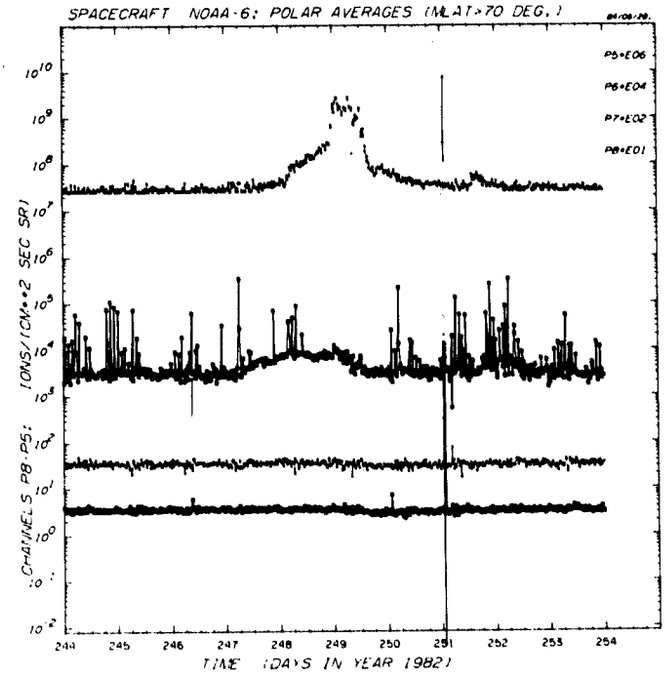


August 21, 1982





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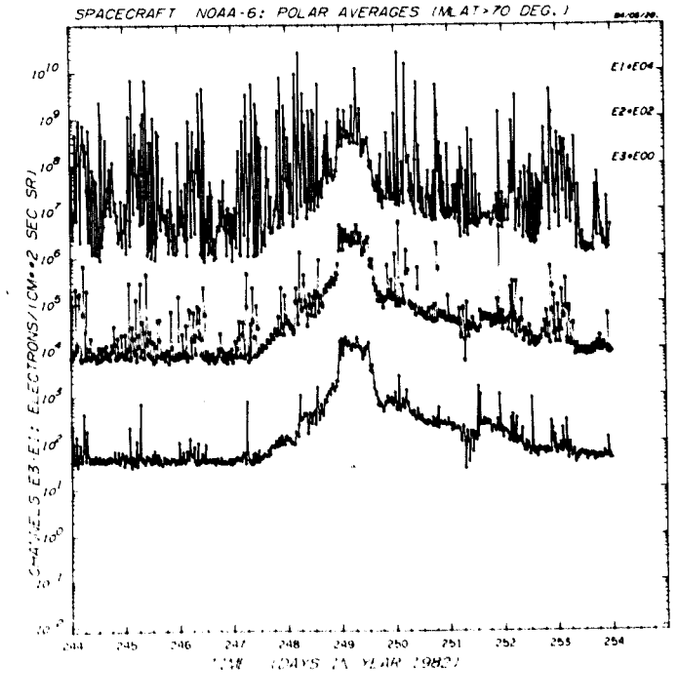
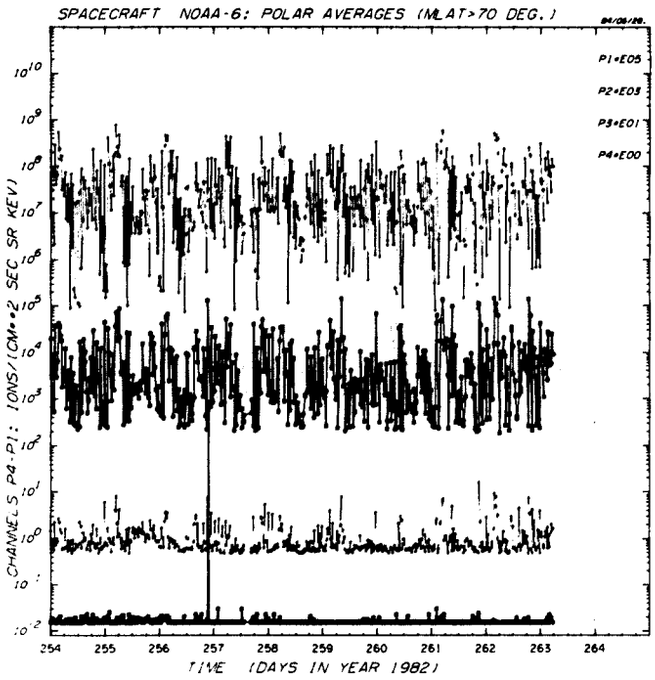
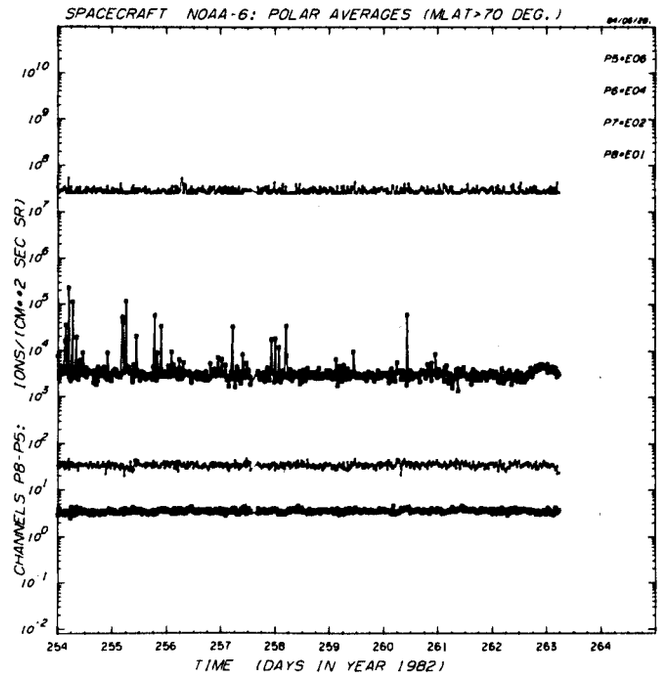


September 1, 1982





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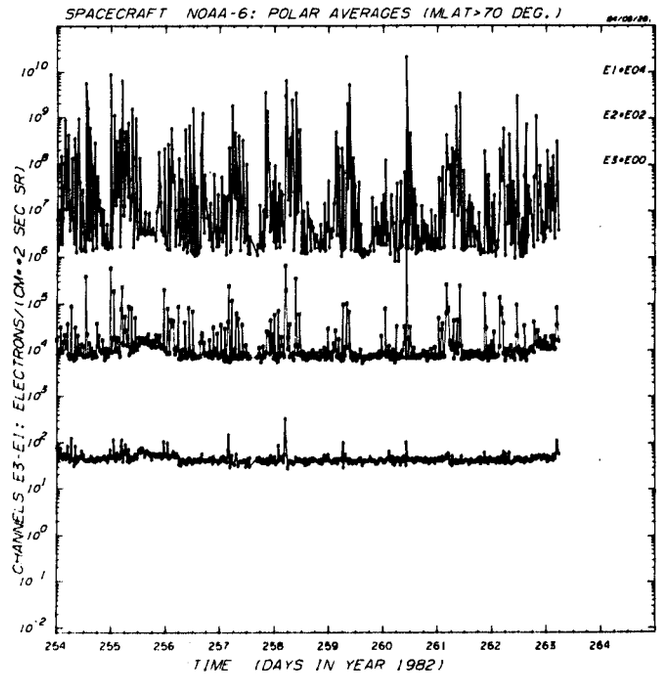
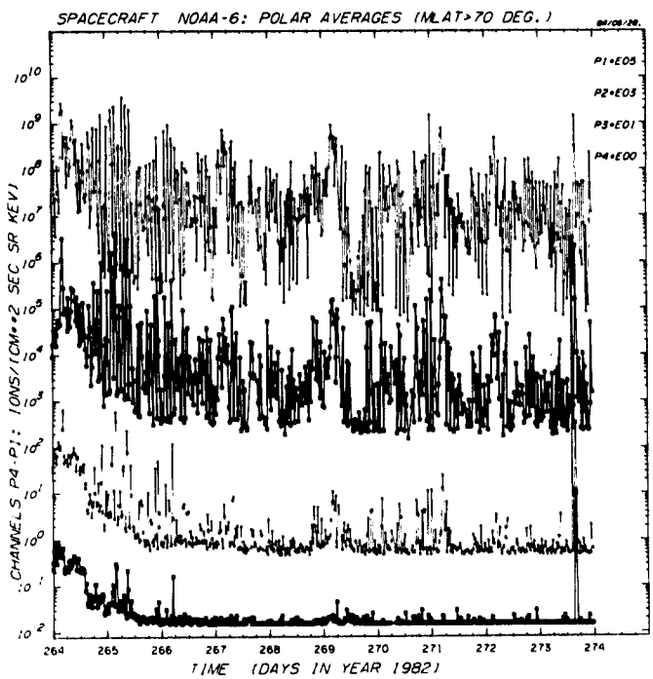
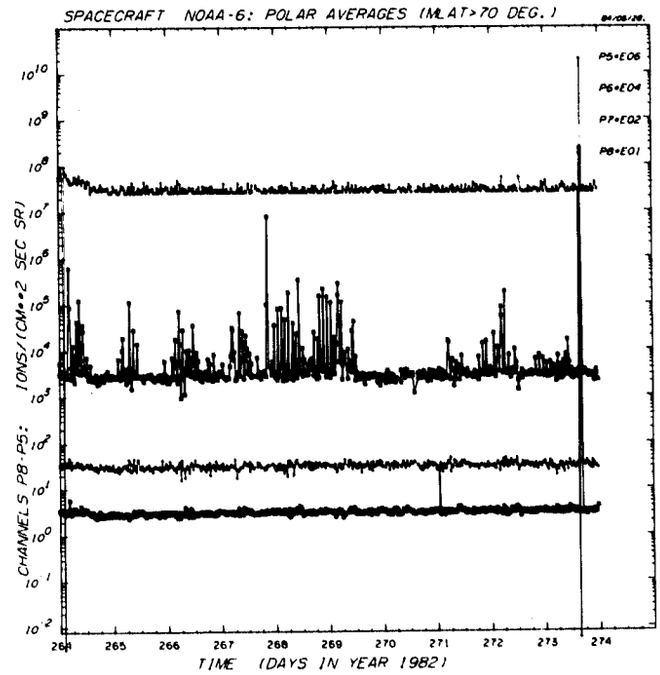


September 11, 1982





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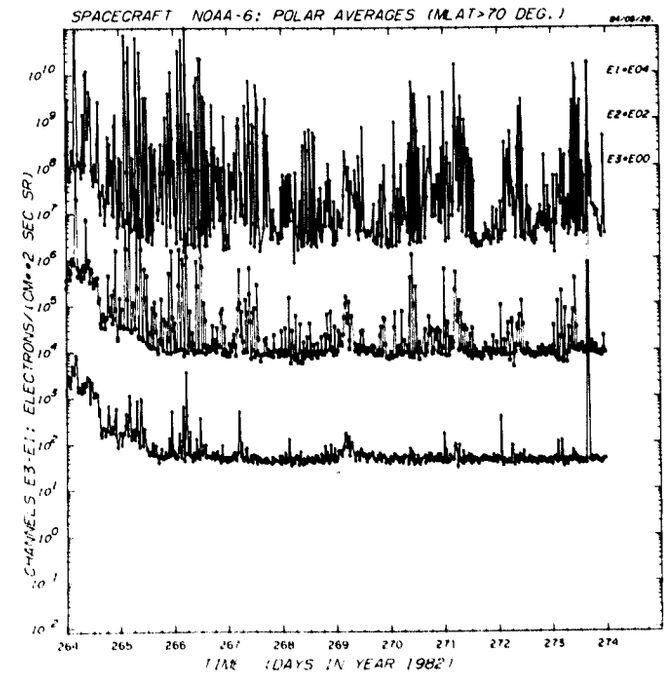
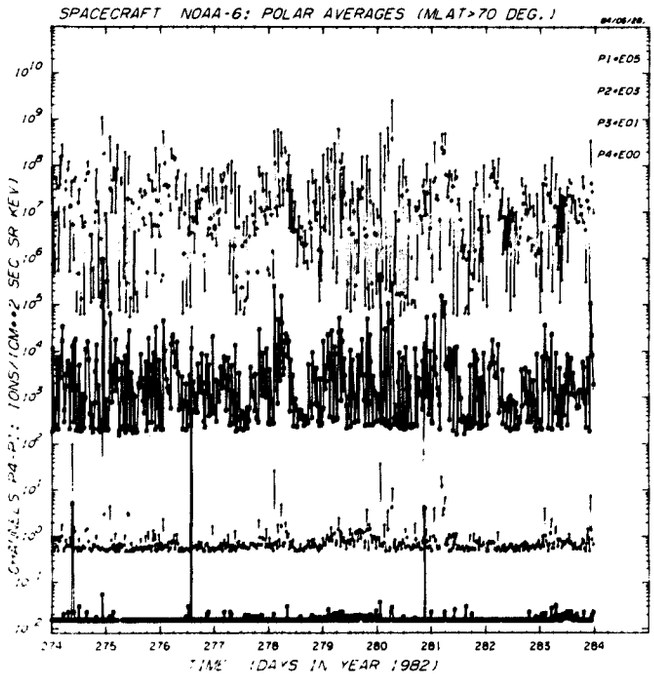
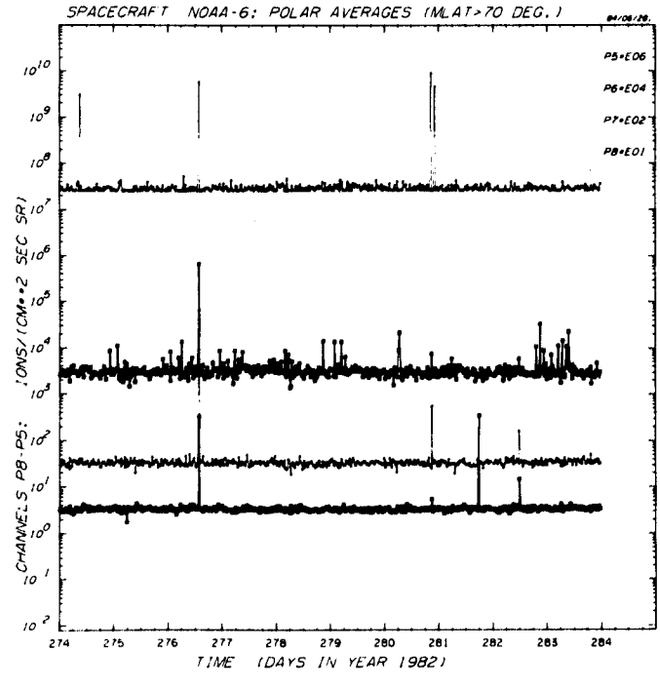


September 21, 1982





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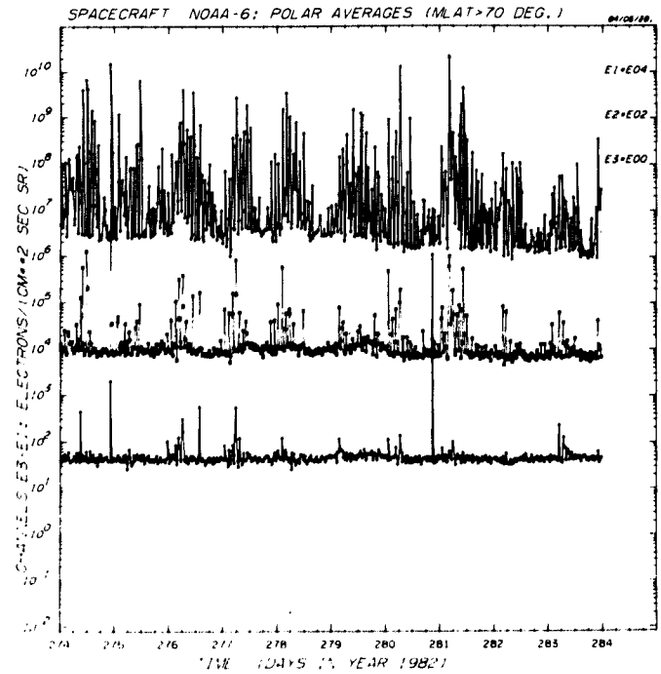
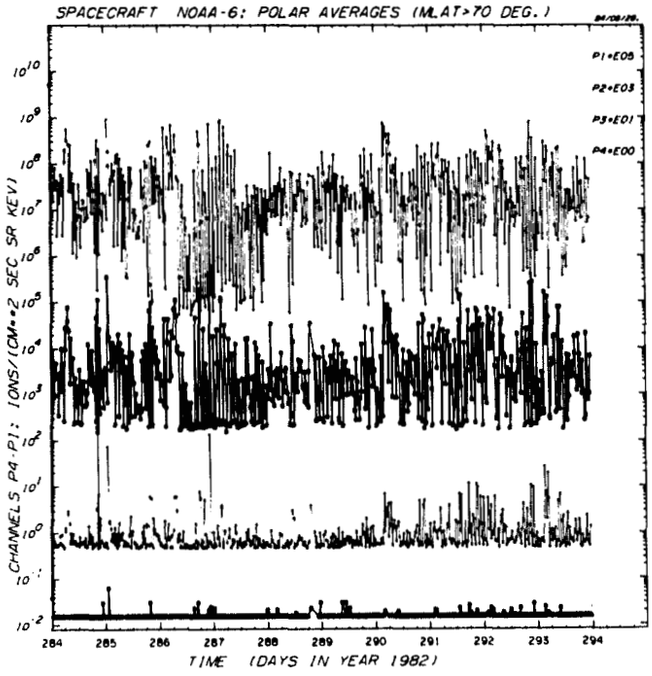
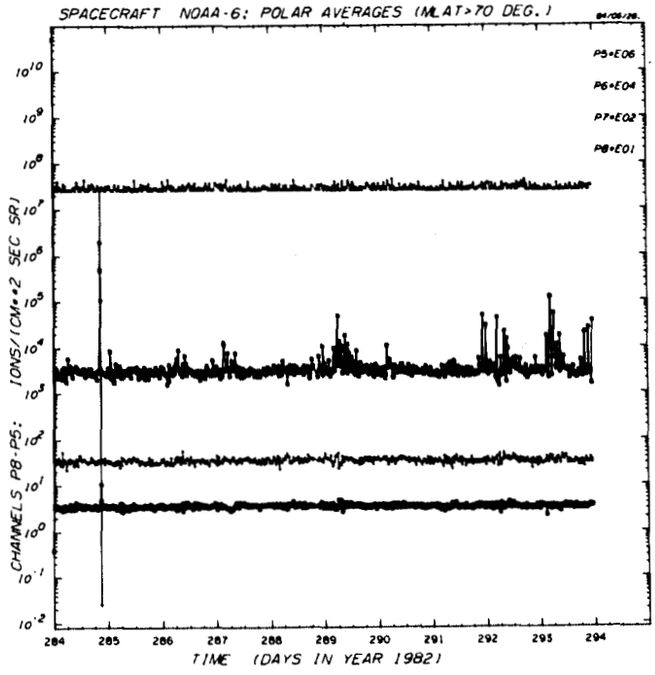


October 1, 1982





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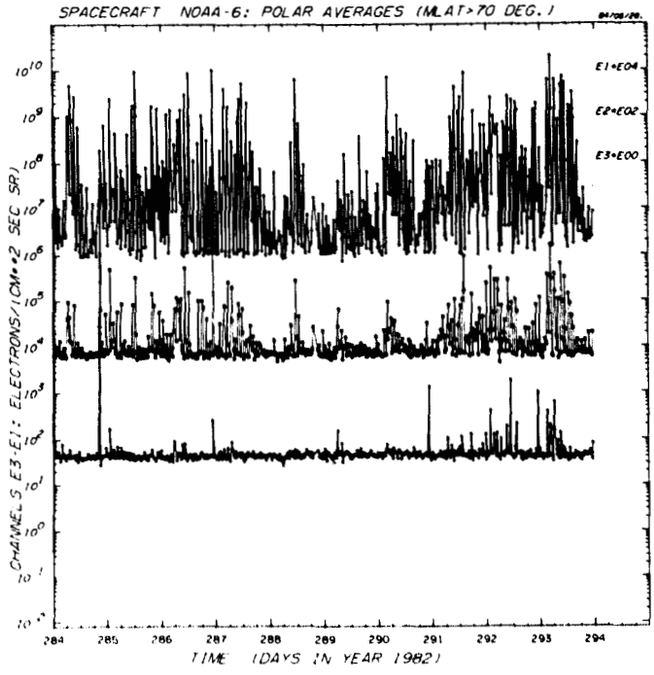
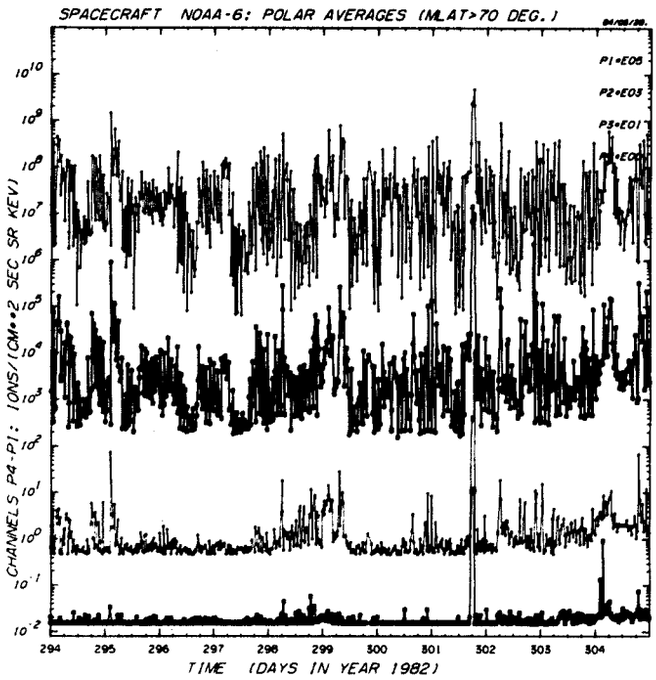
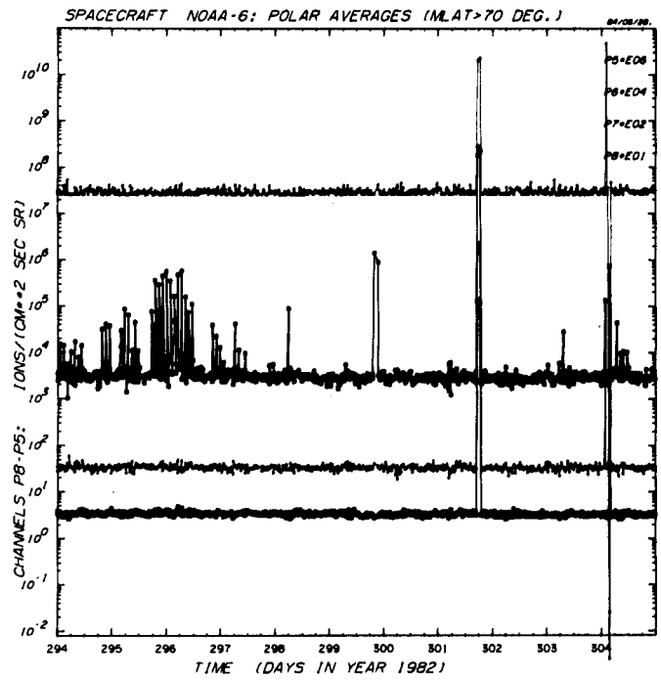


October 11, 1982





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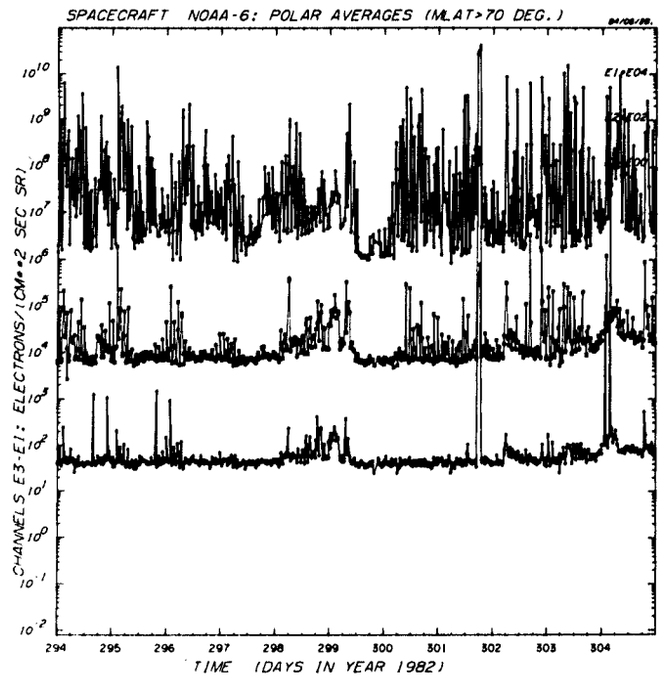
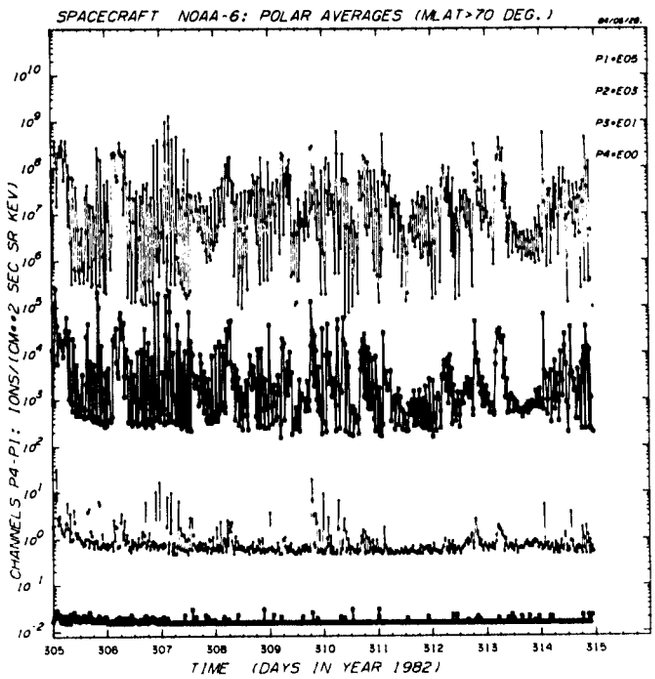
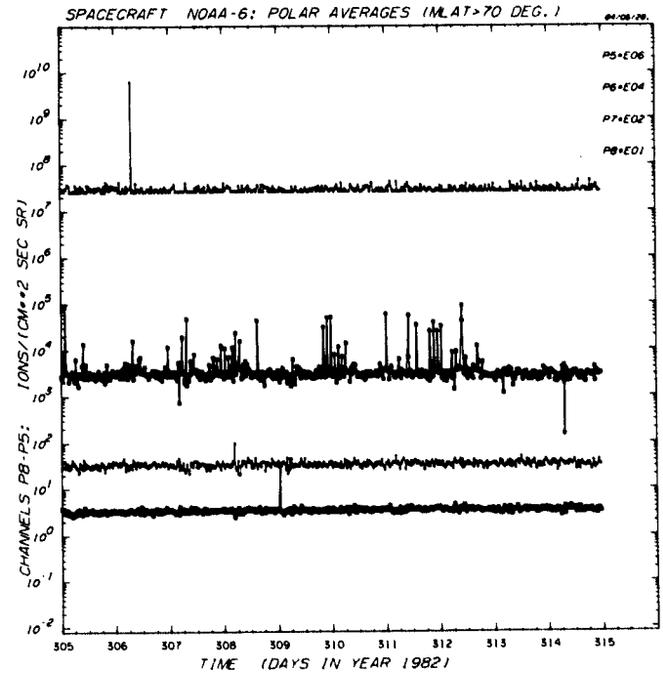


October 21, 1982





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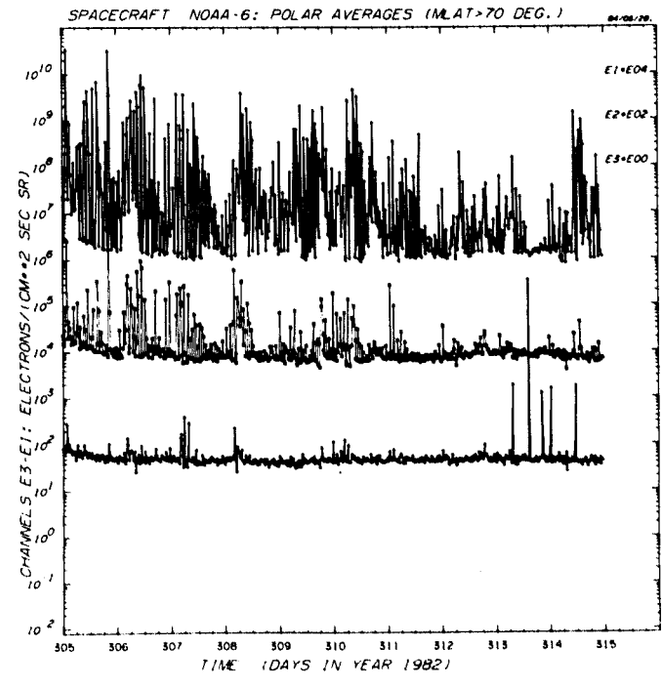
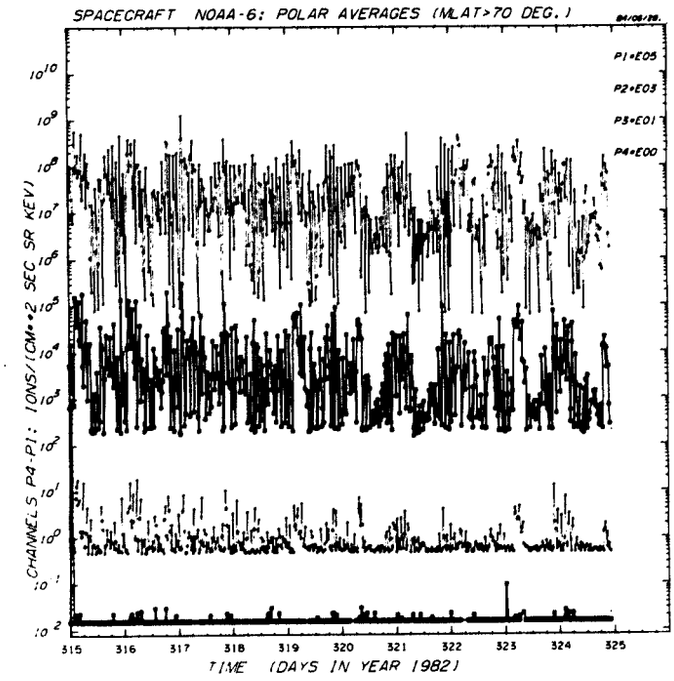
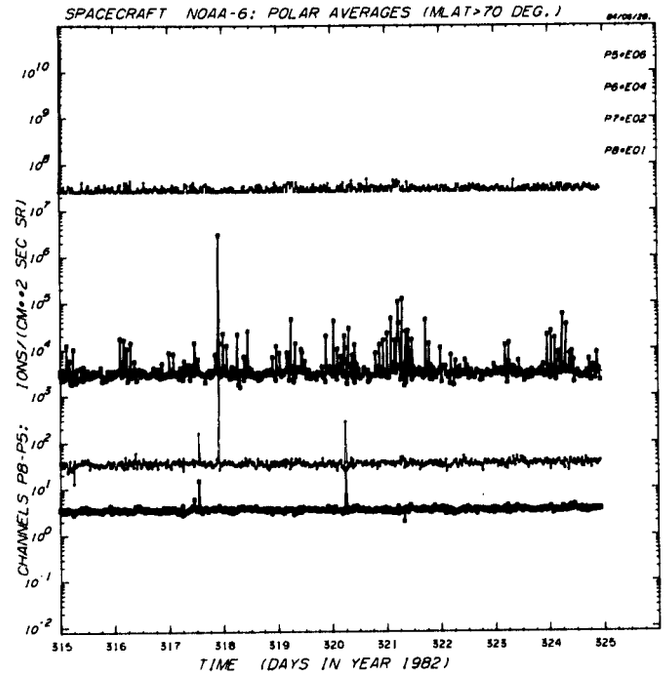


November 1, 1982





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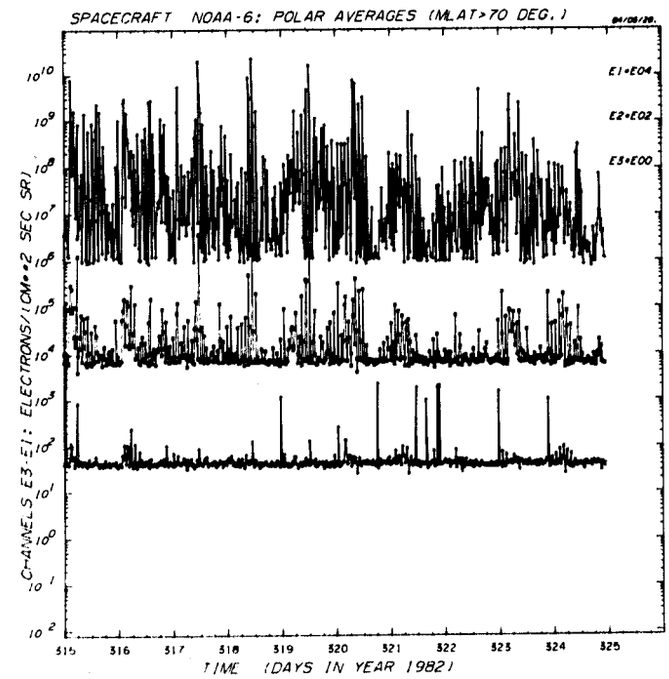
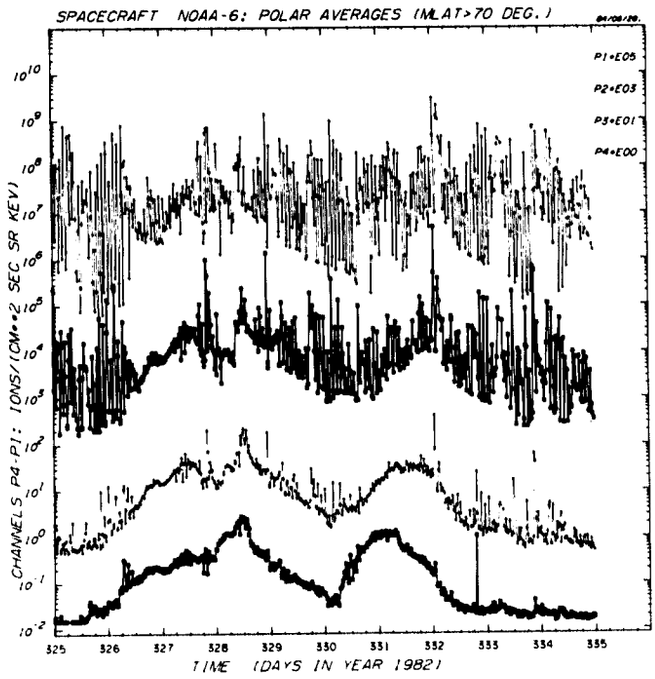
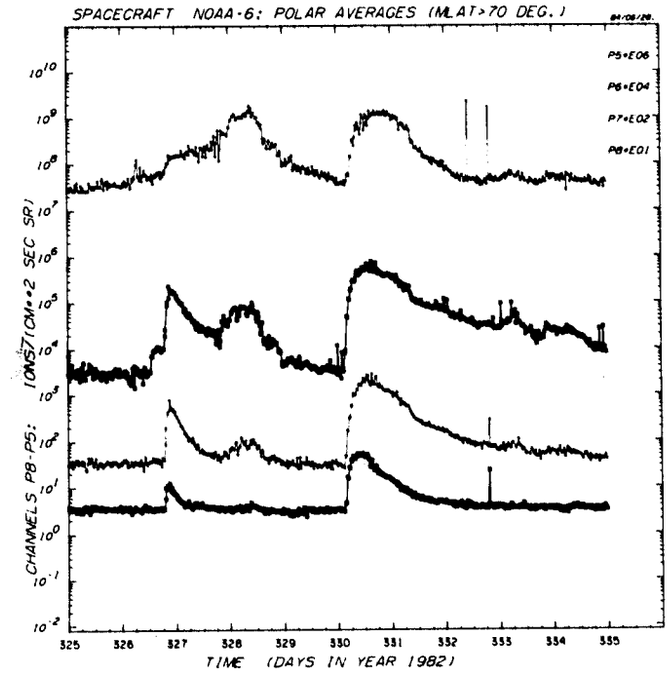


November 11, 1982





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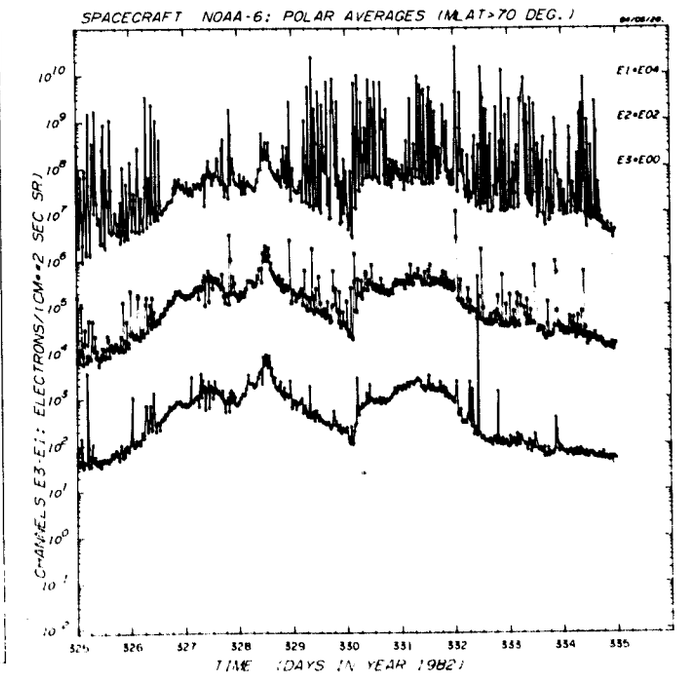
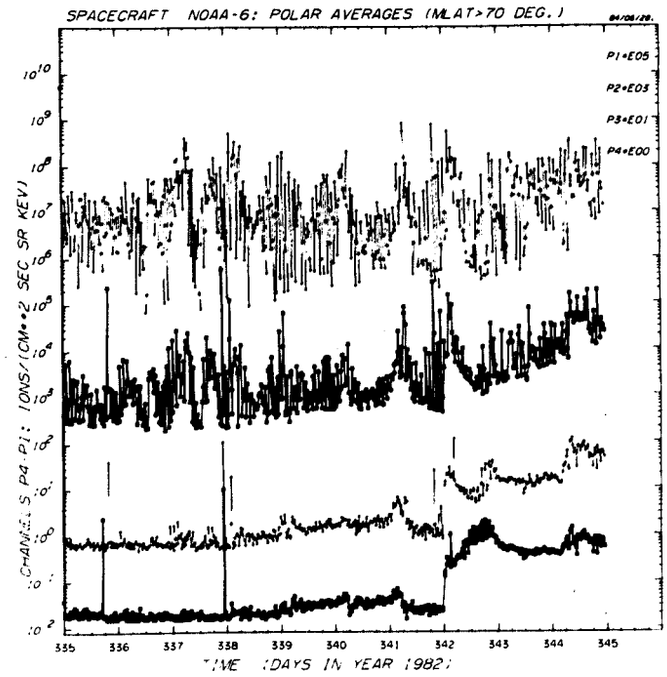
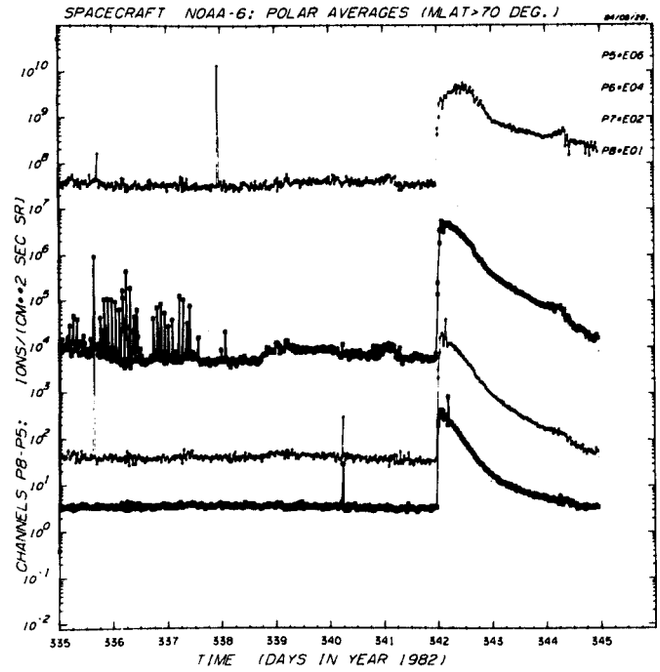


November 21, 1982





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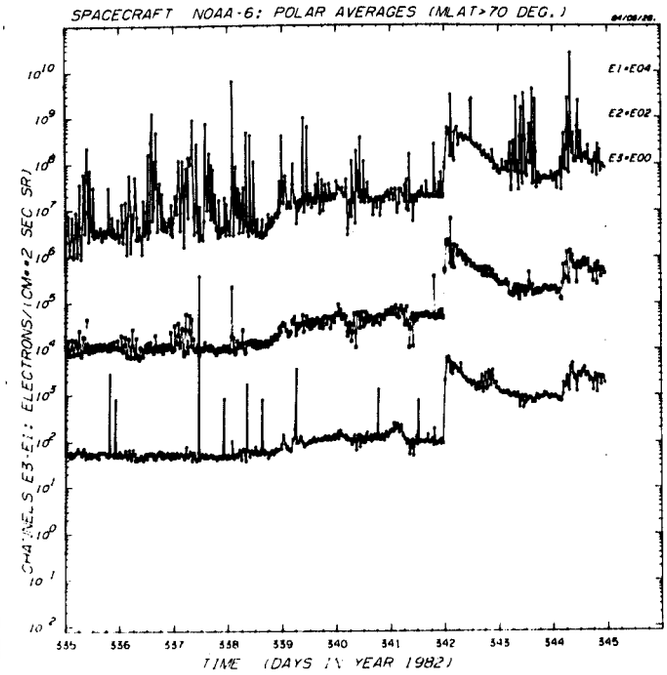
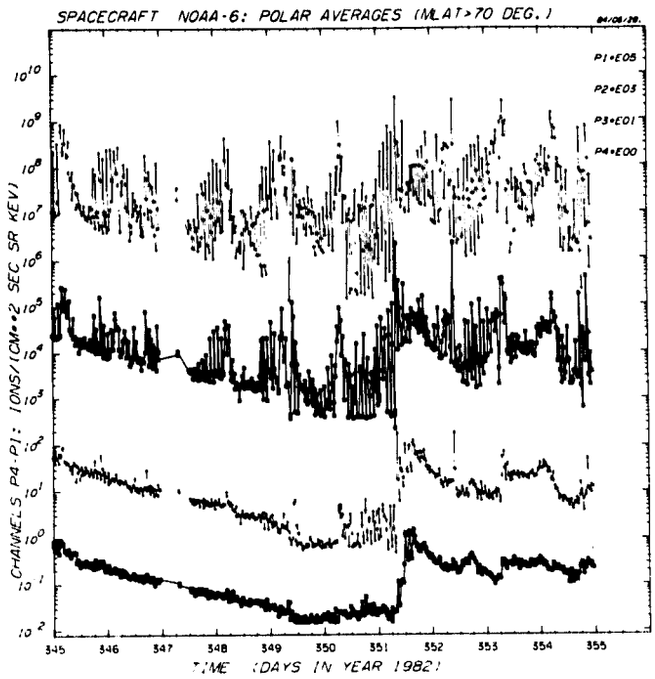
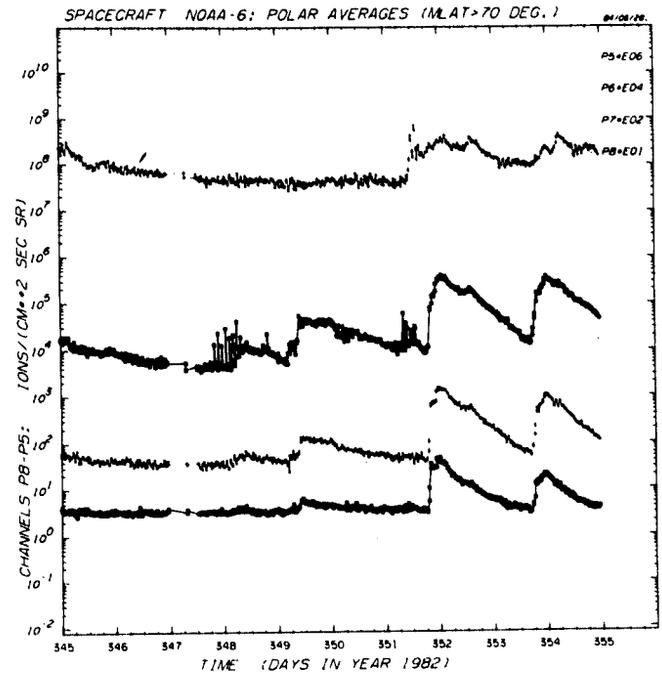


December 1, 1982





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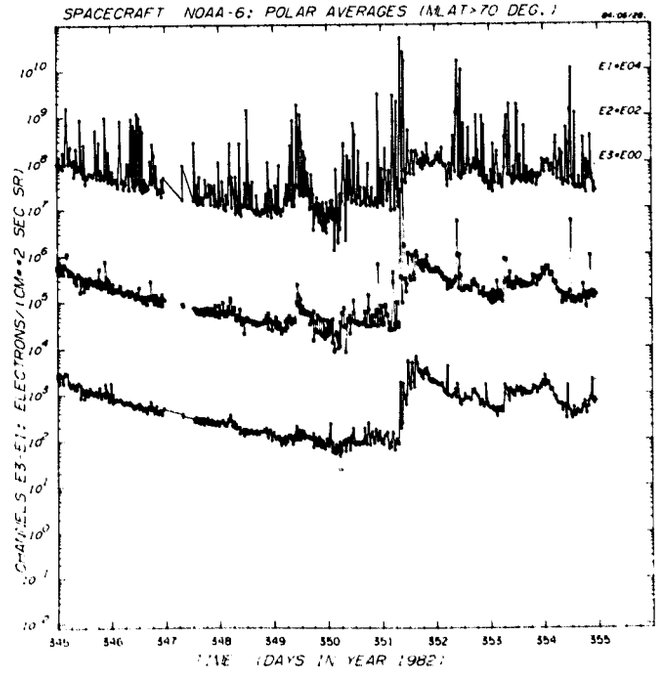
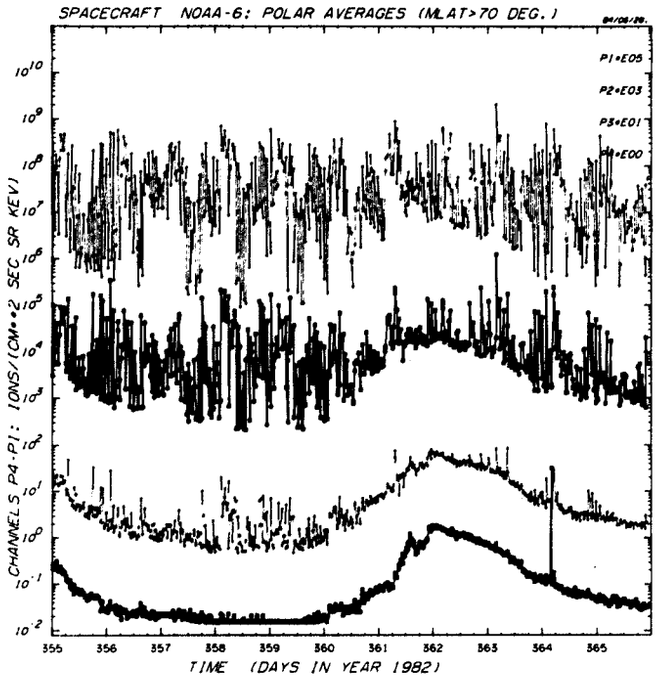
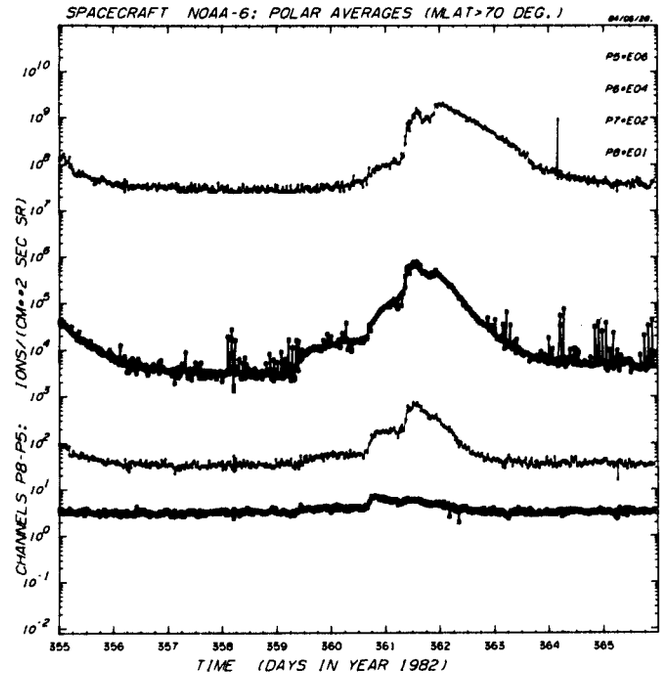


December 11, 1982





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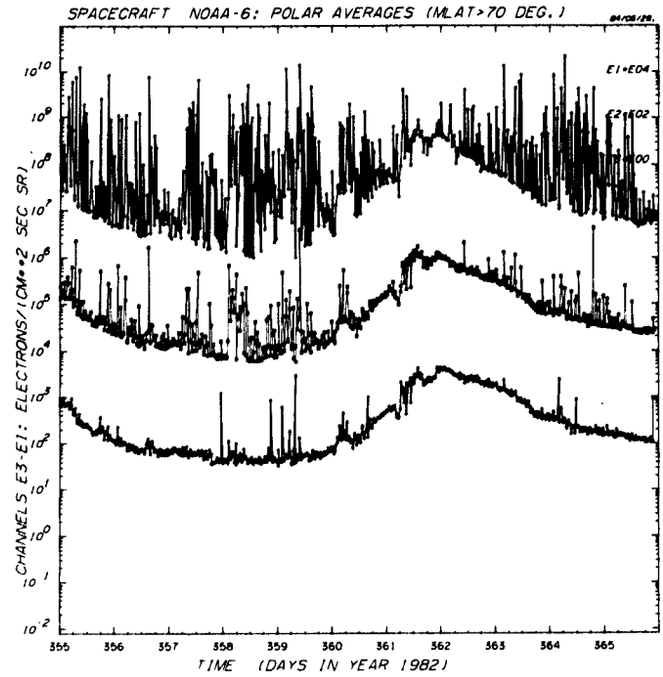
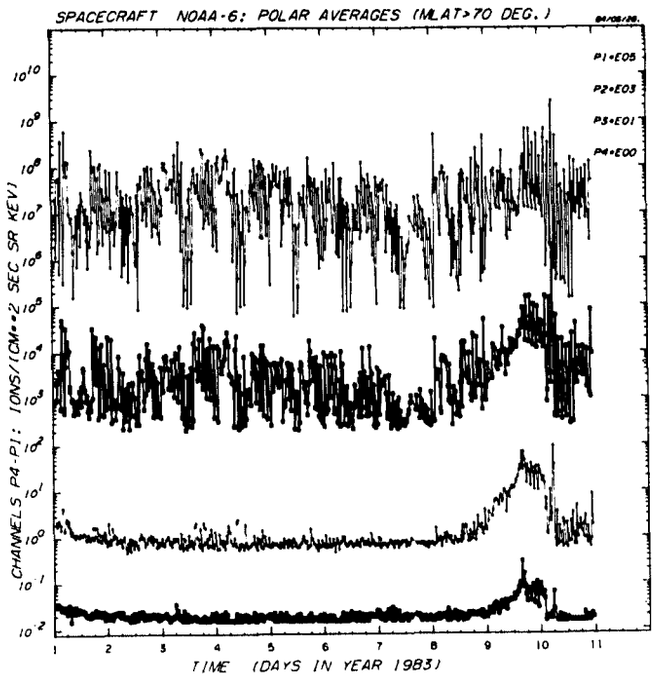
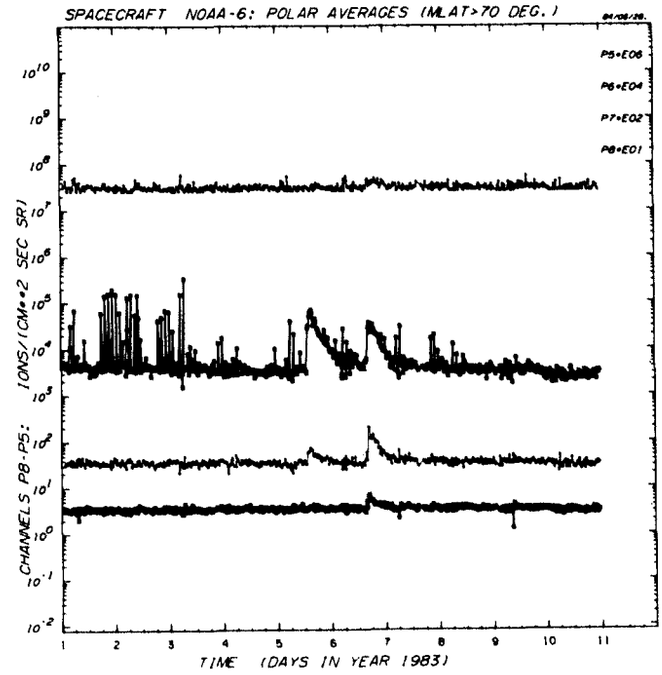


December 21, 1982





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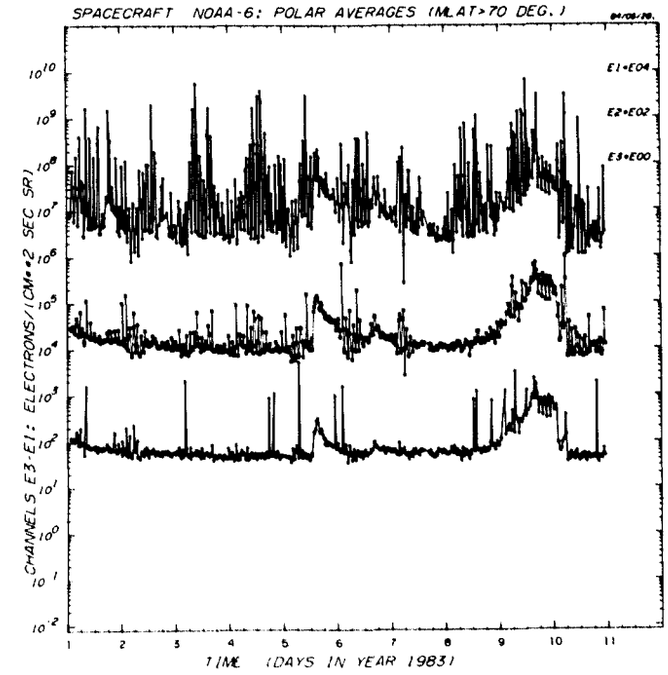
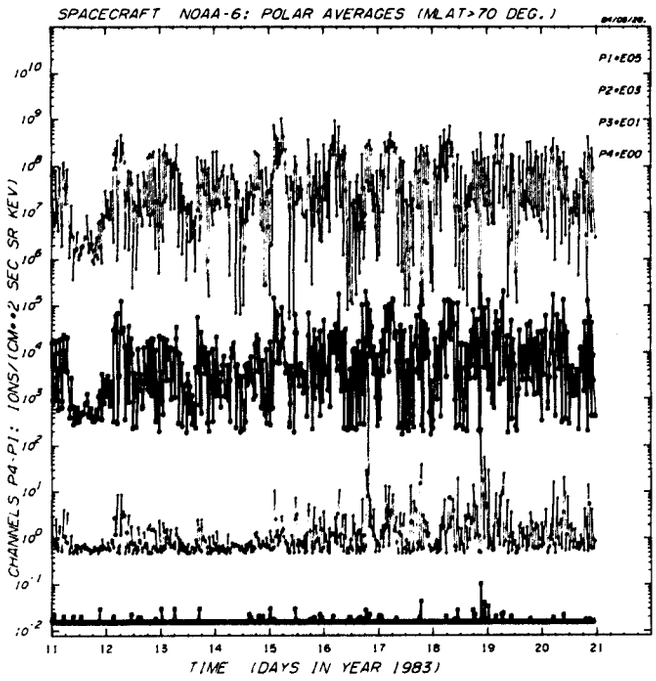
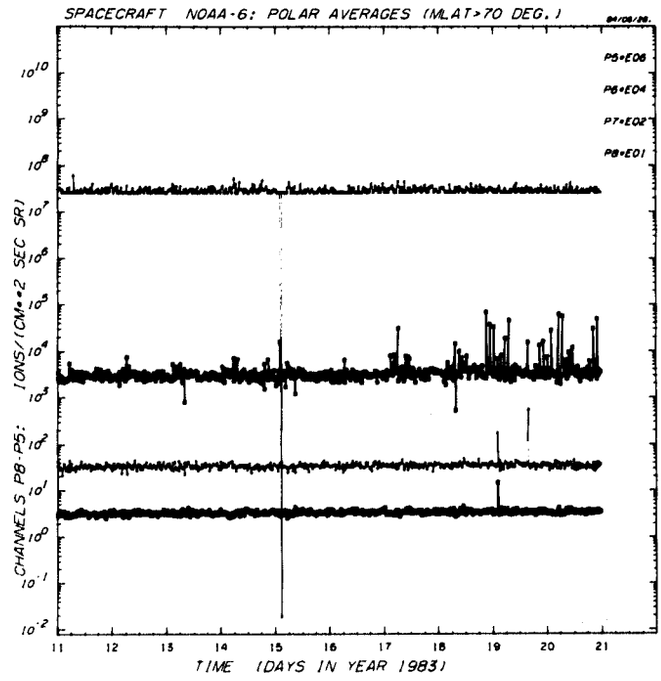


January 1, 1983





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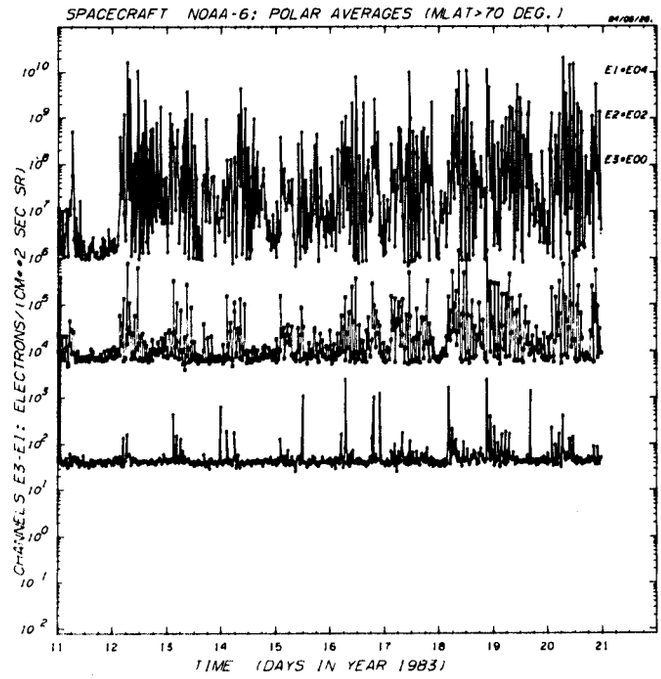

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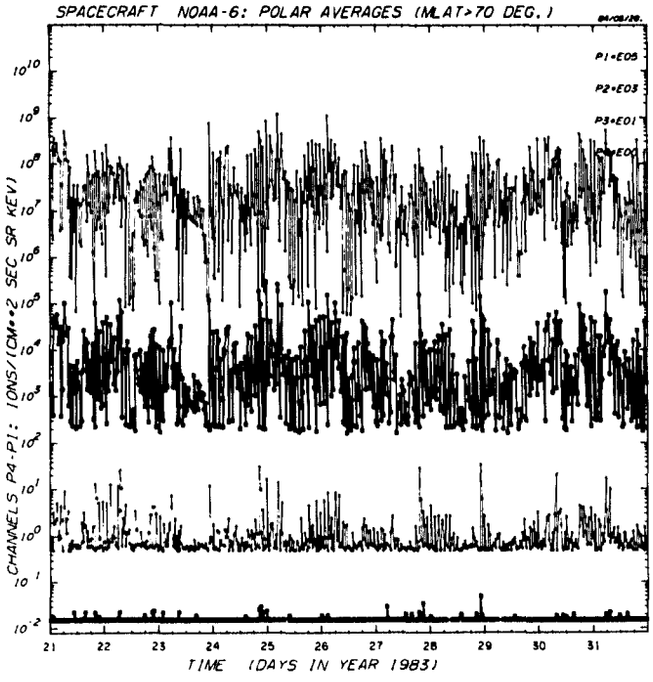

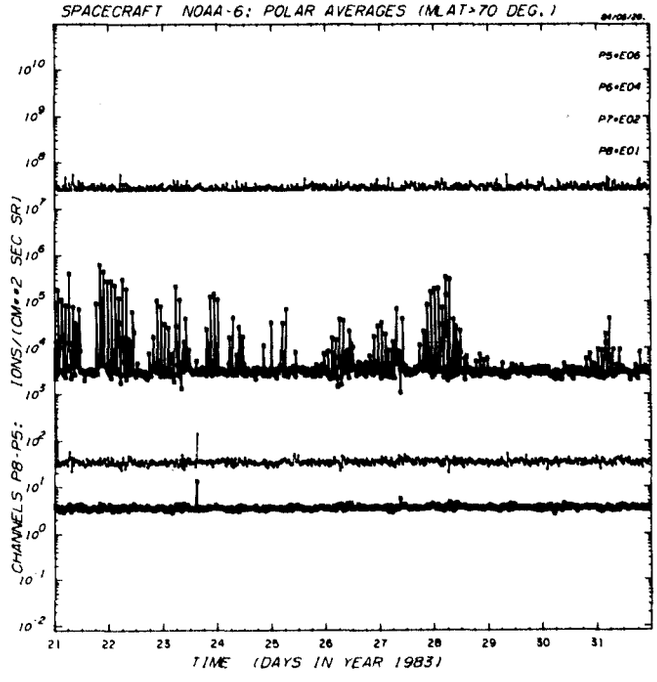

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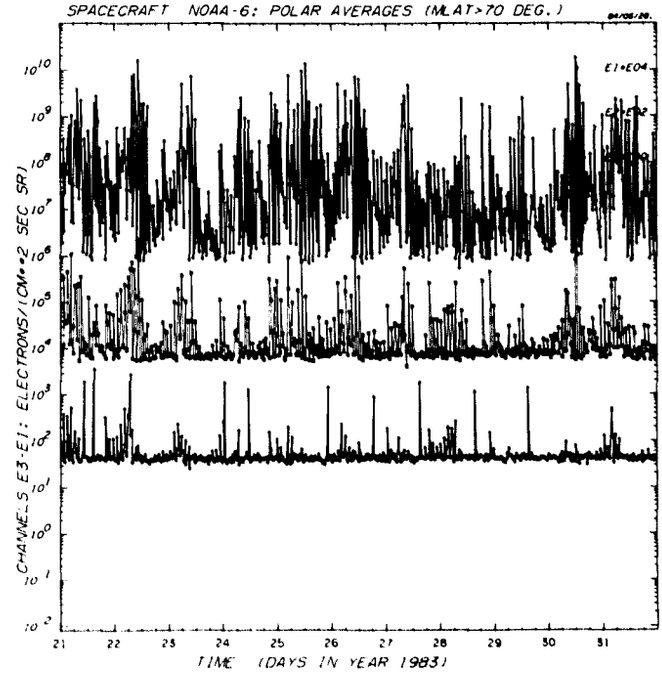
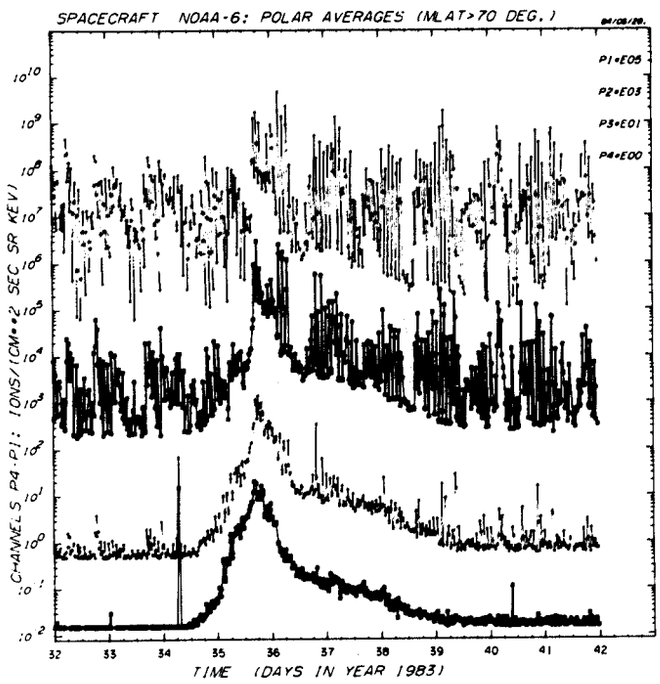
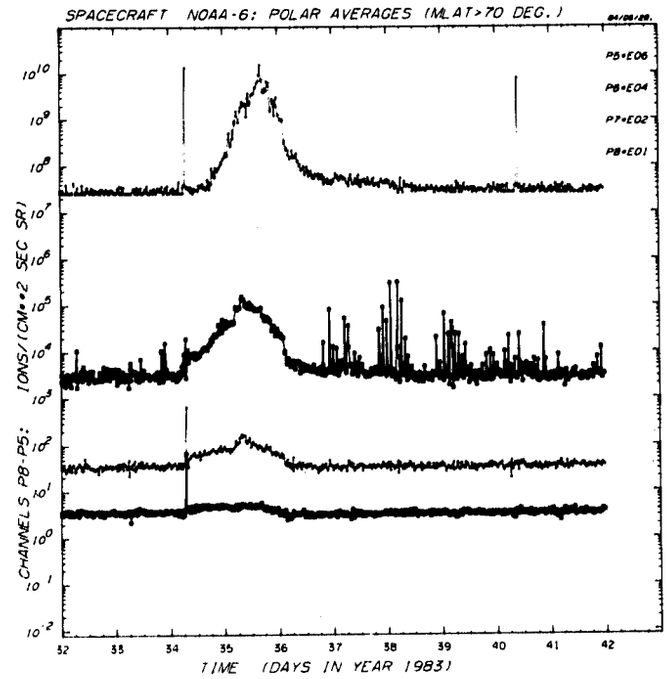


January 21, 1983





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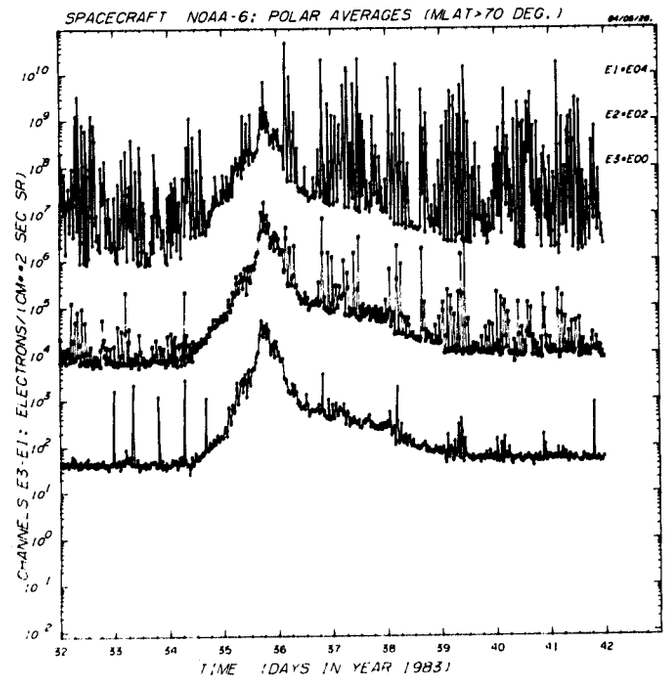
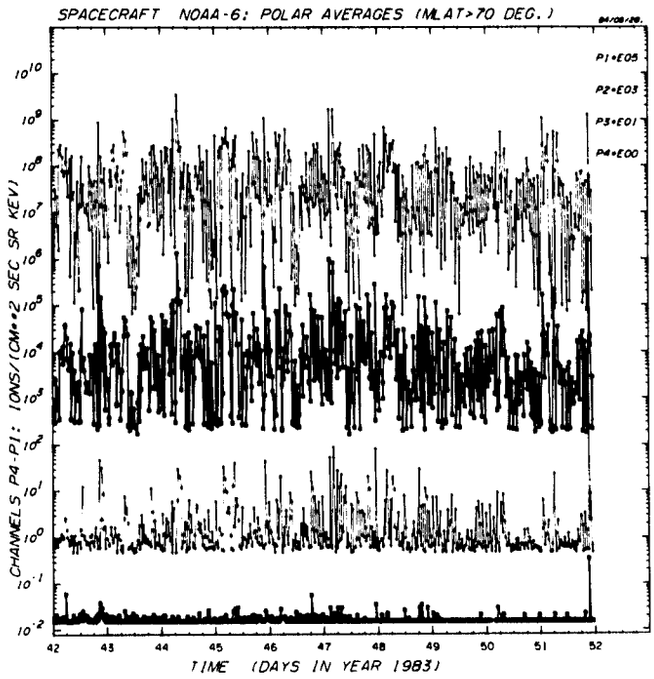
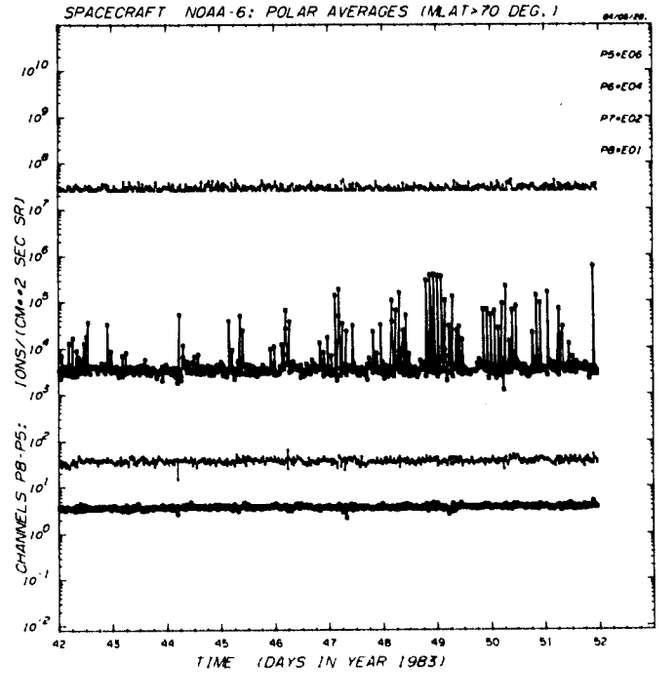


February 1, 1983





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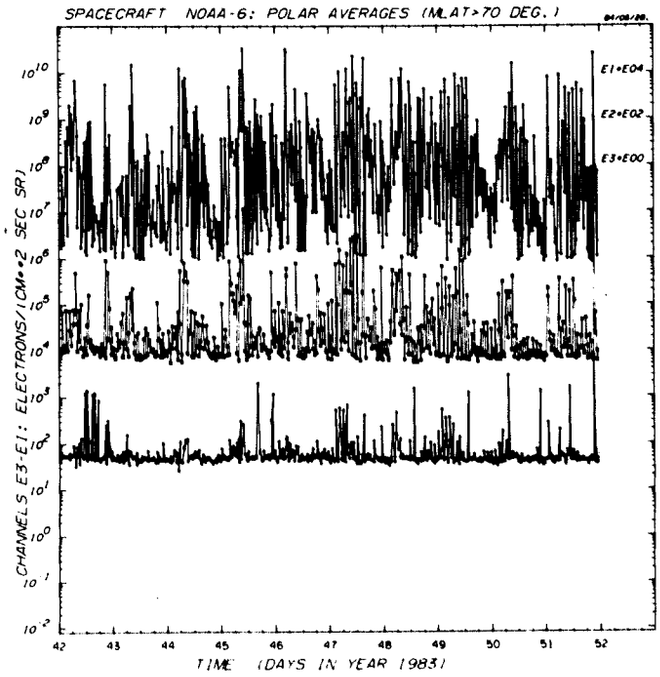
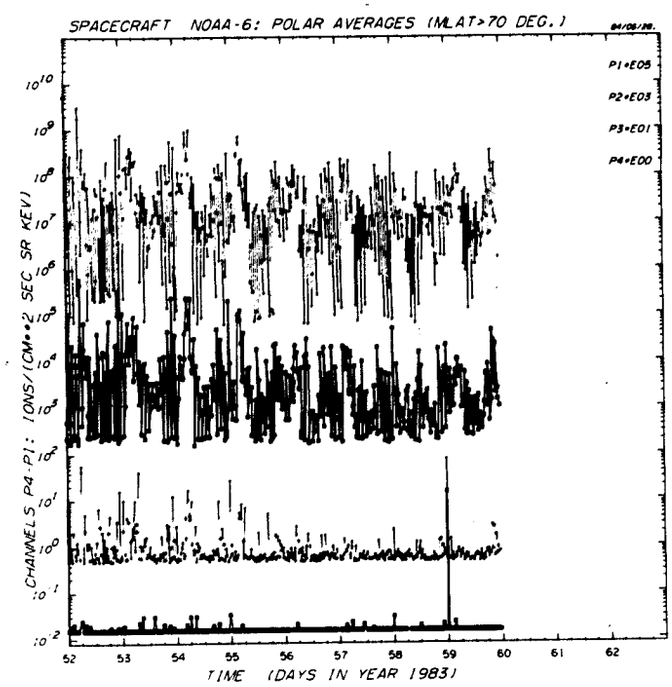
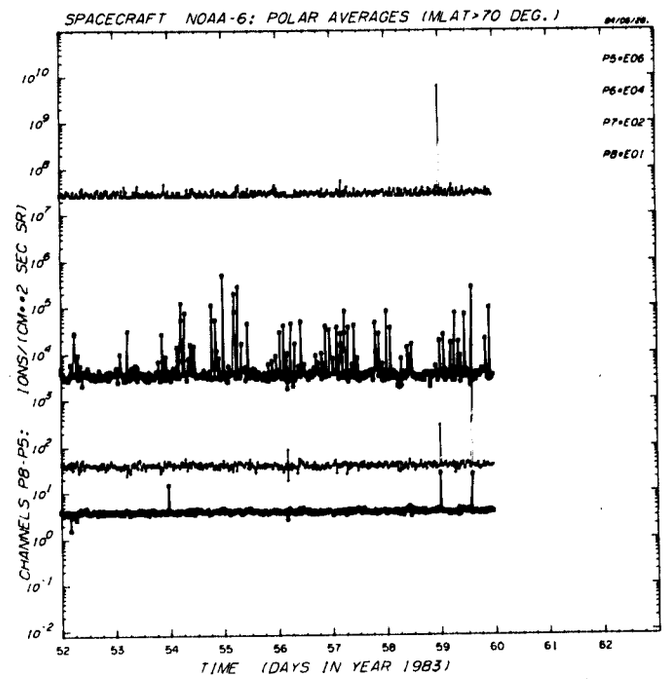


February 11, 1983





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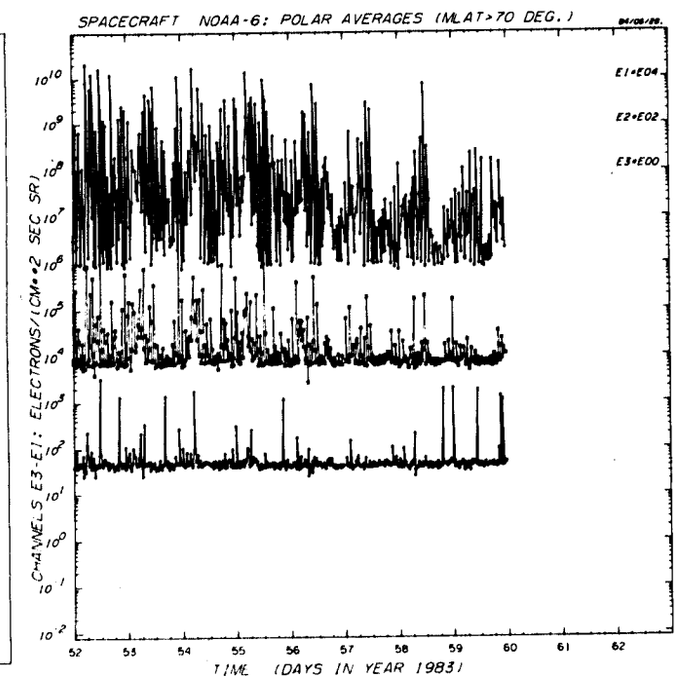
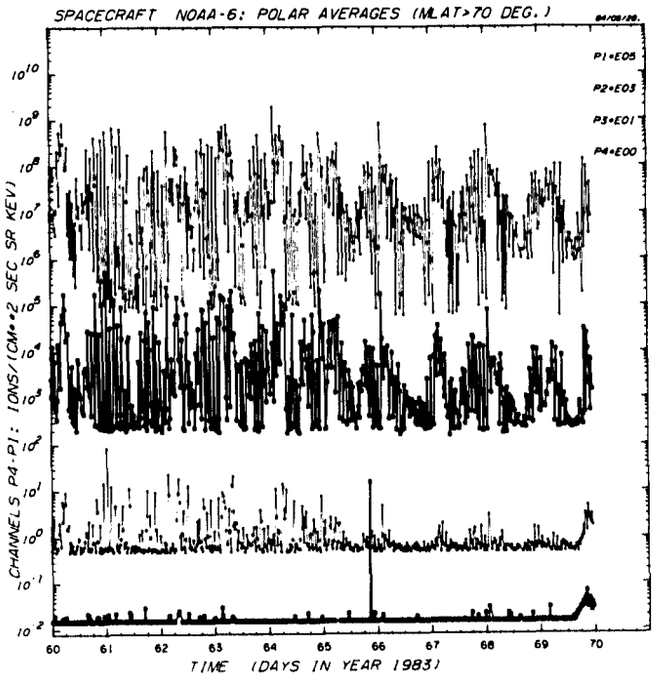
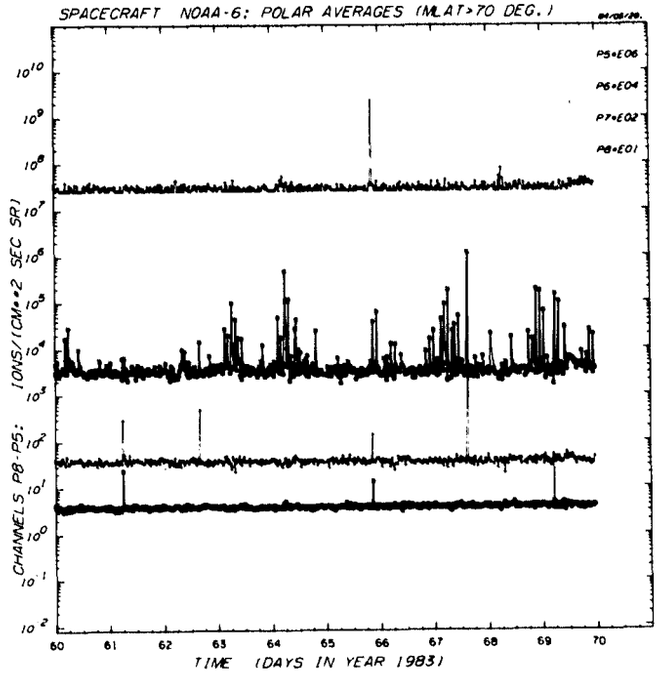


February 21, 1983





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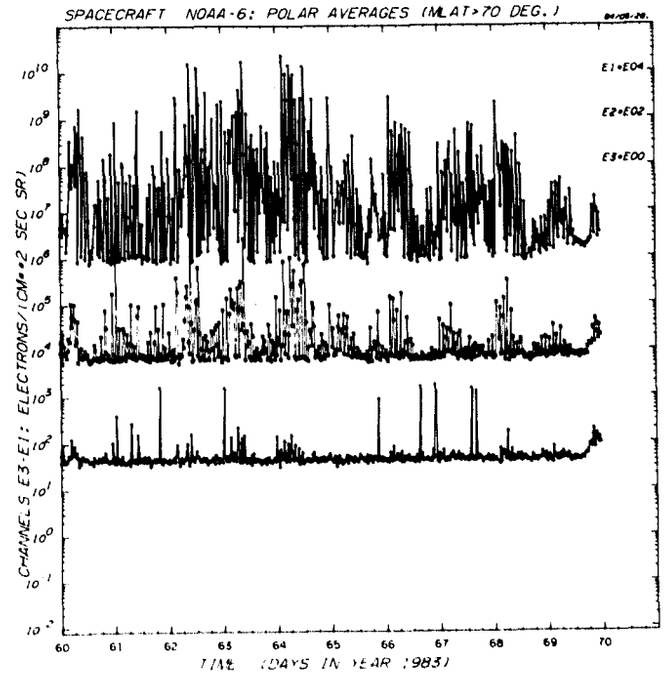
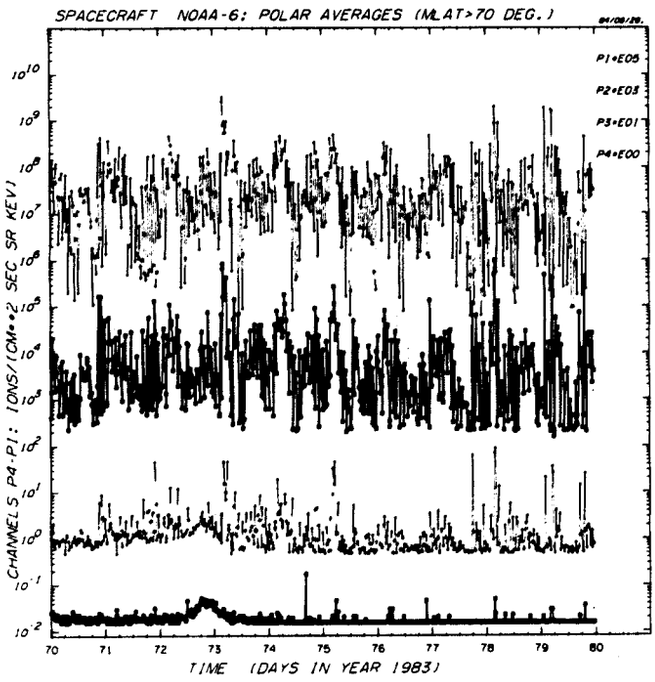
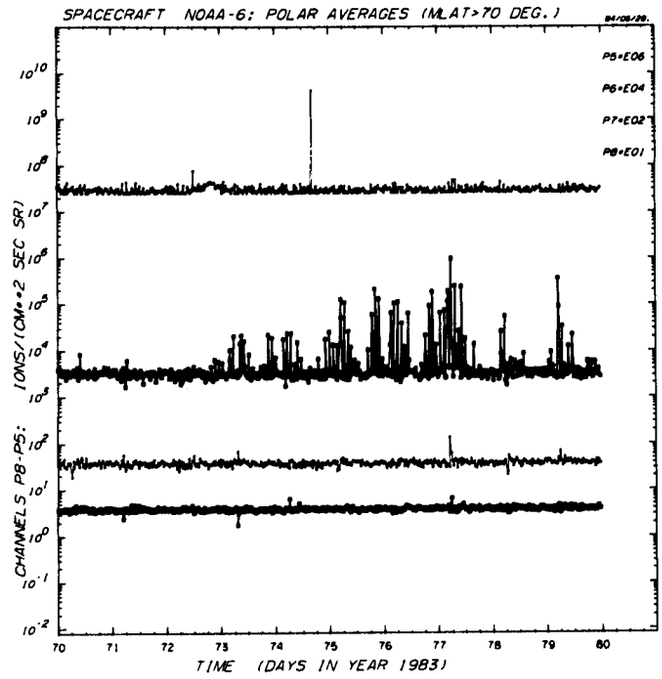


March 1, 1983





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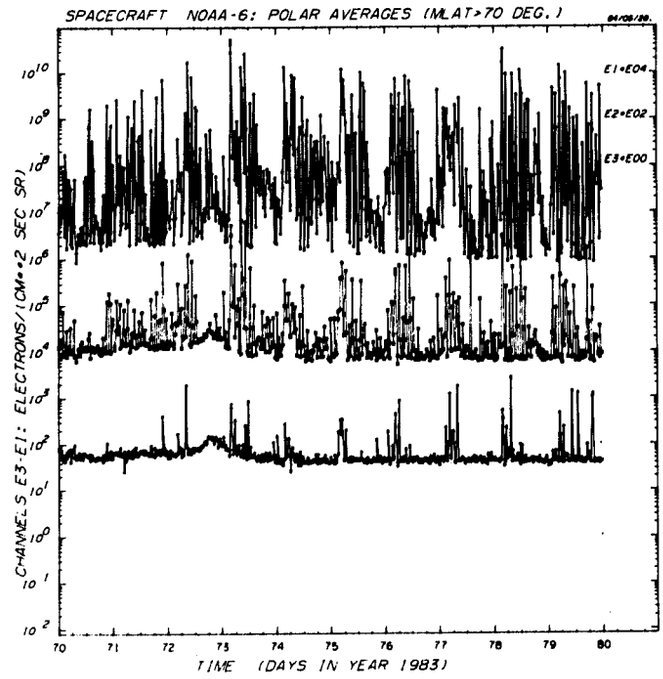
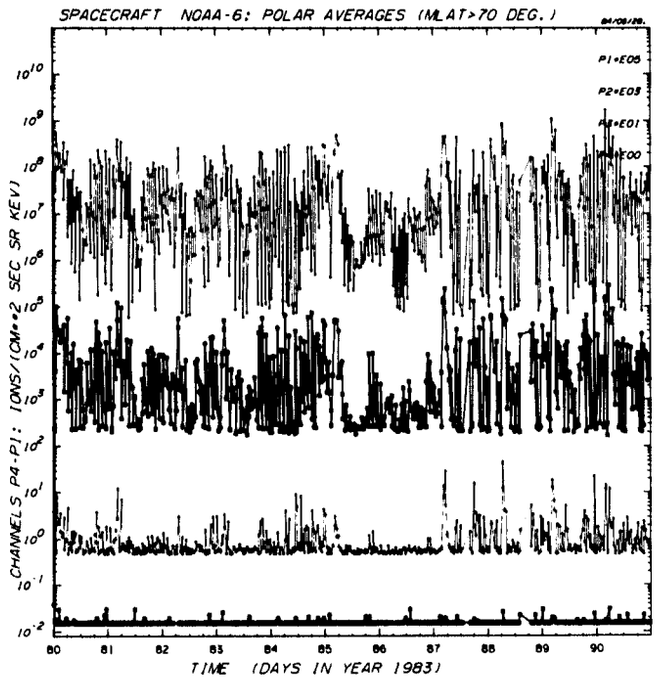
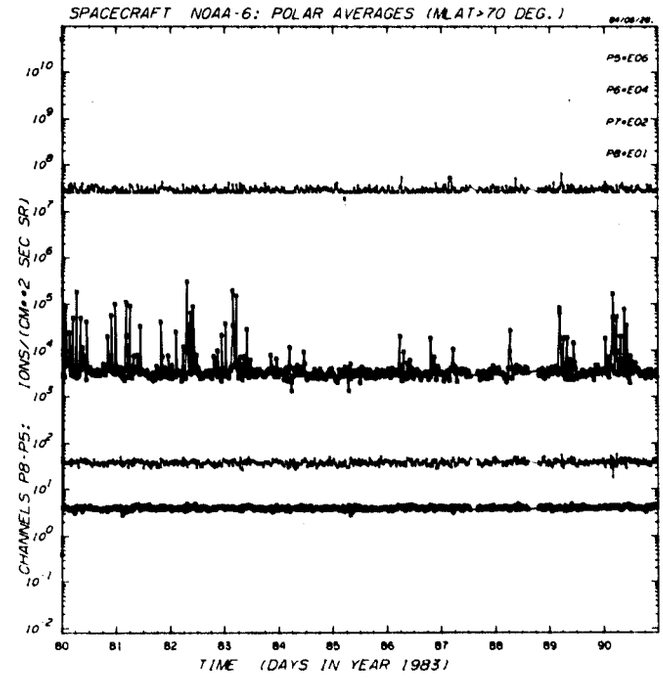


March 11, 1983





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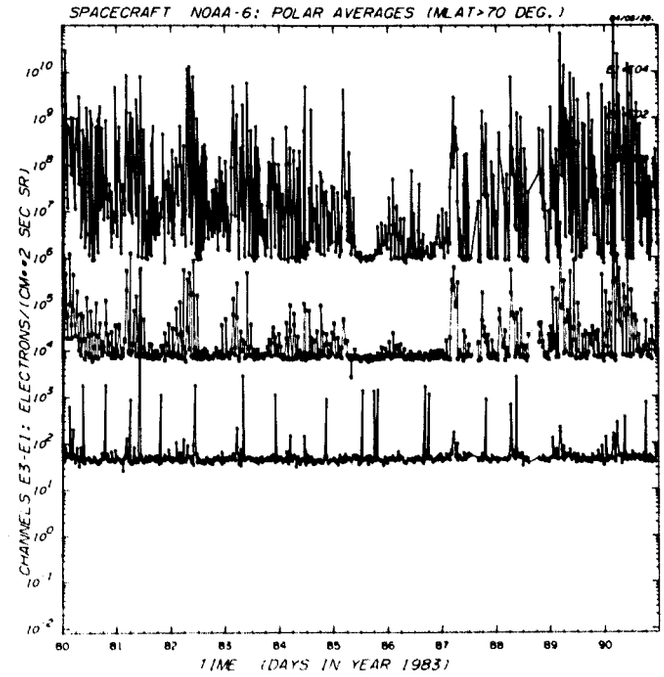
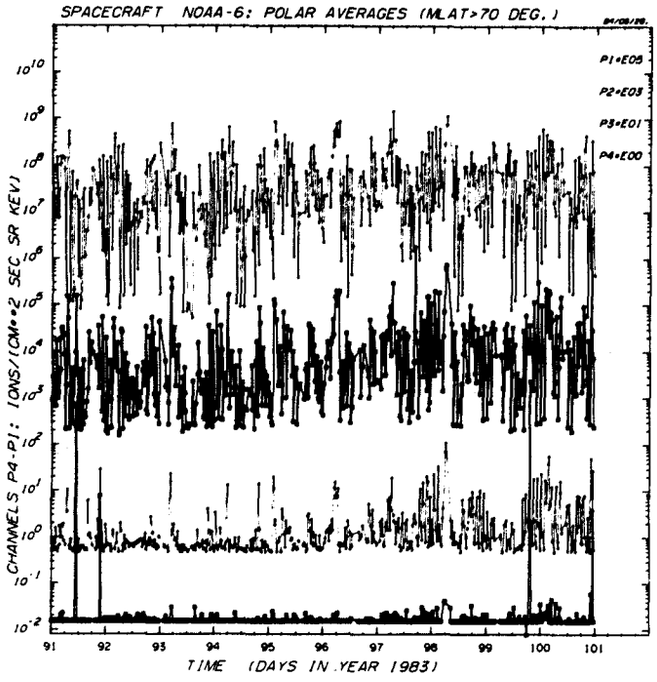
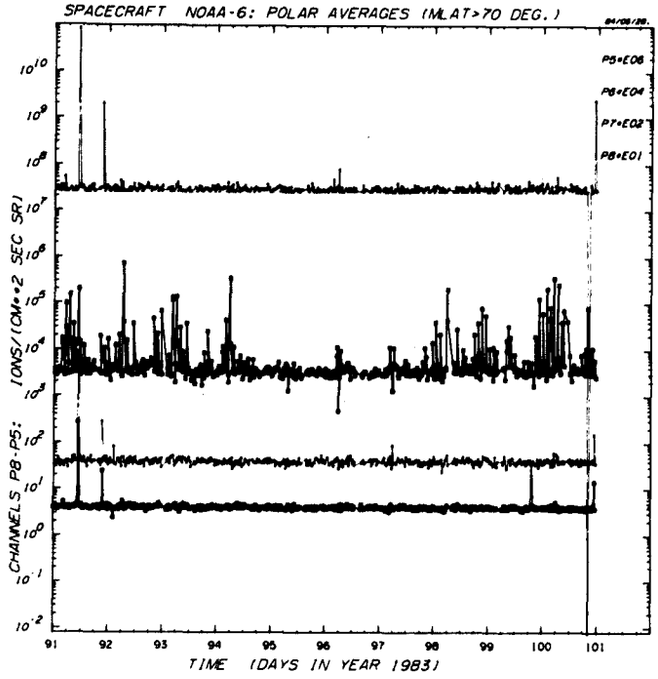


March 21, 1983





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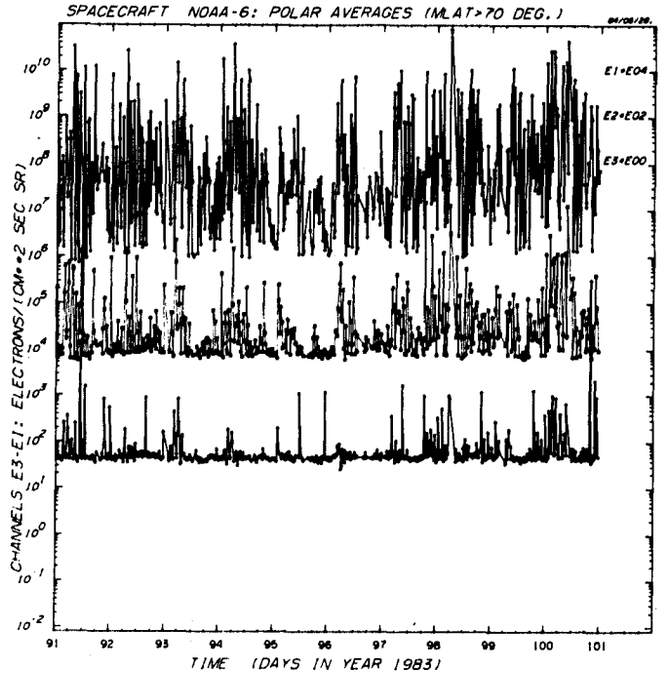
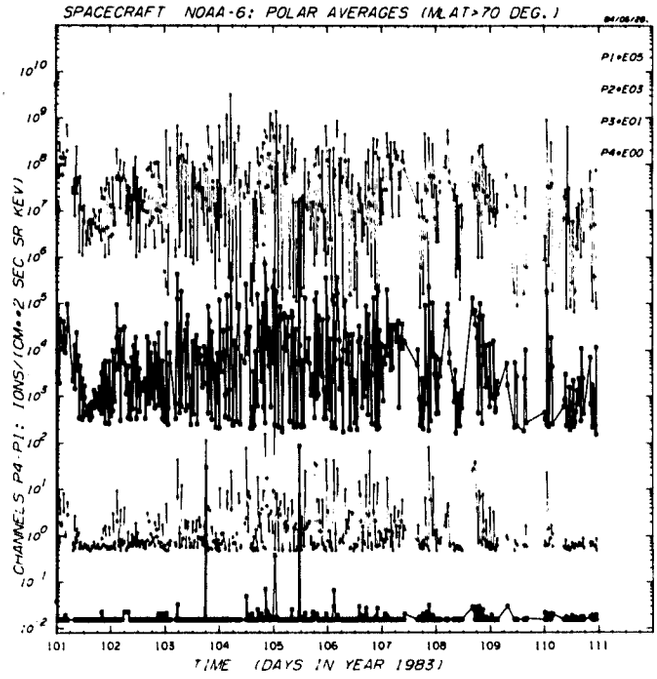
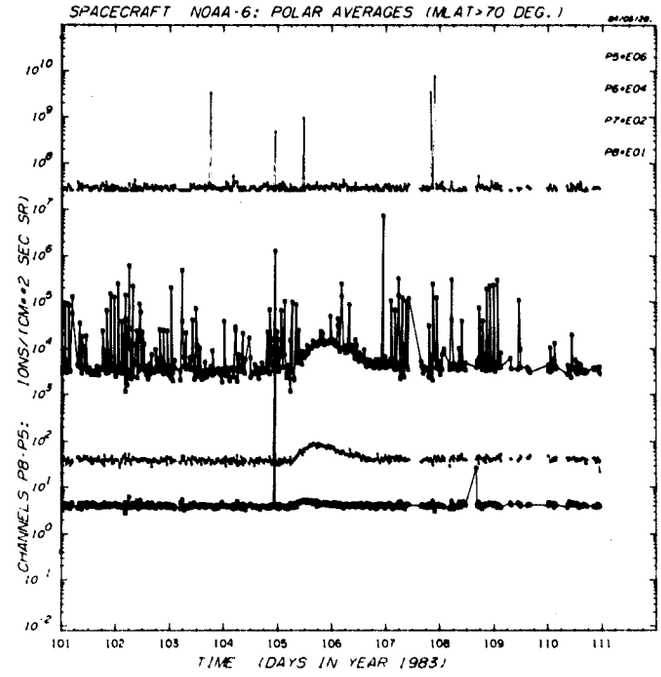


April 1, 1983





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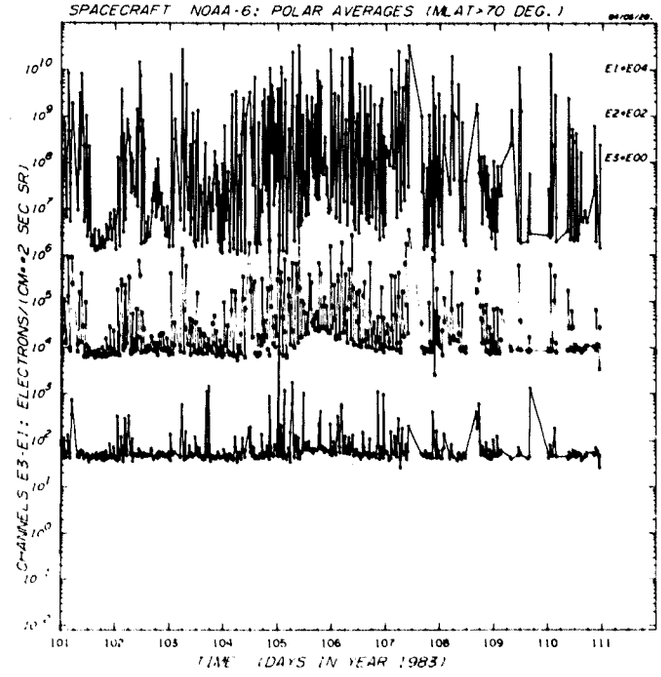

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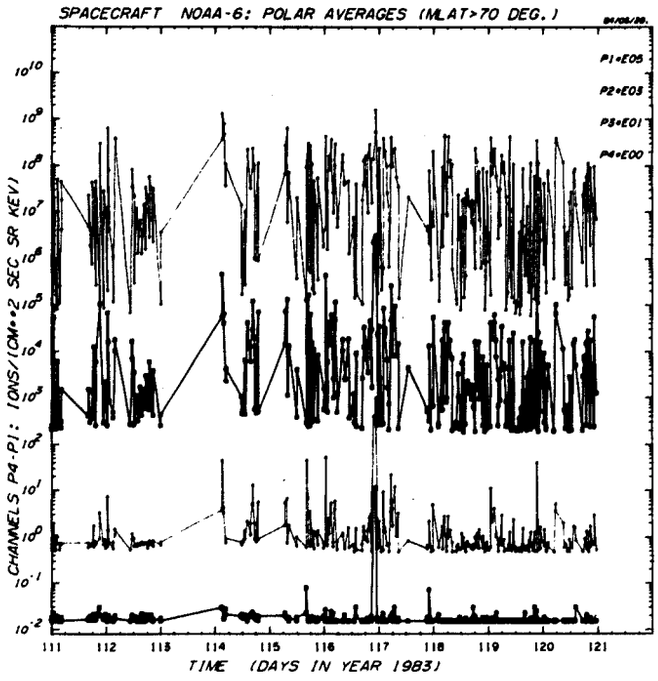

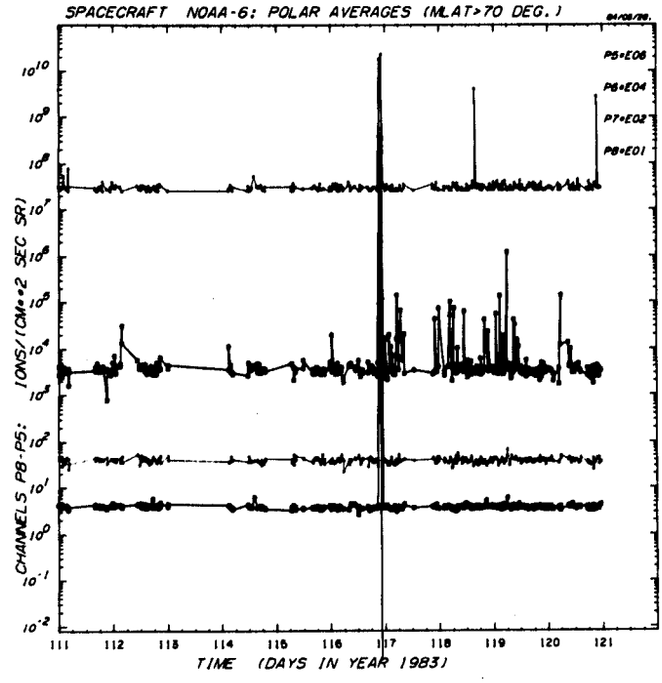

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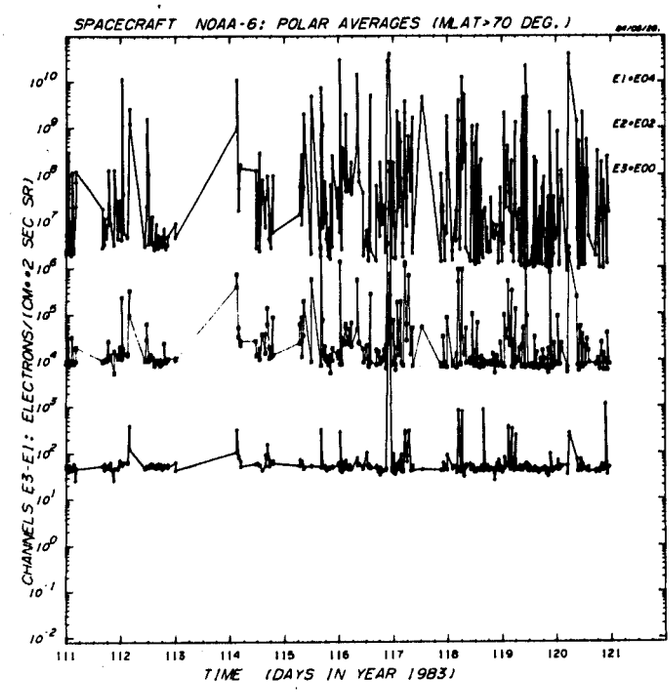
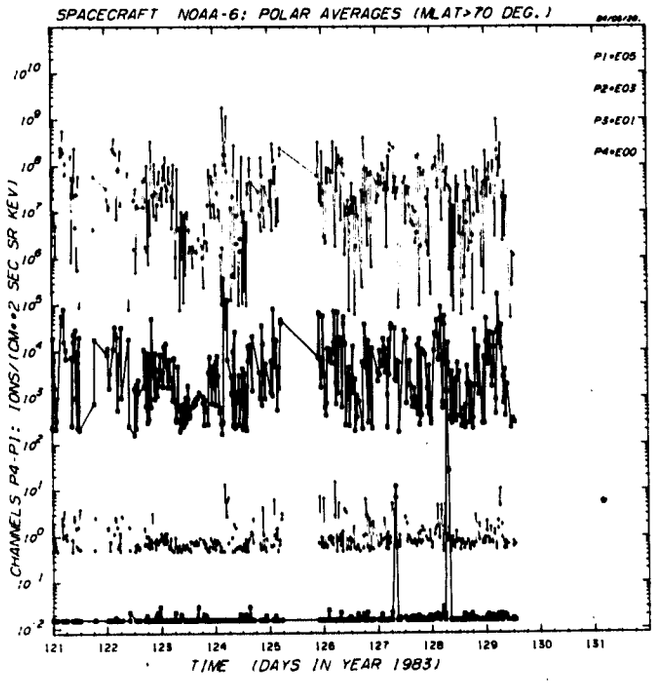
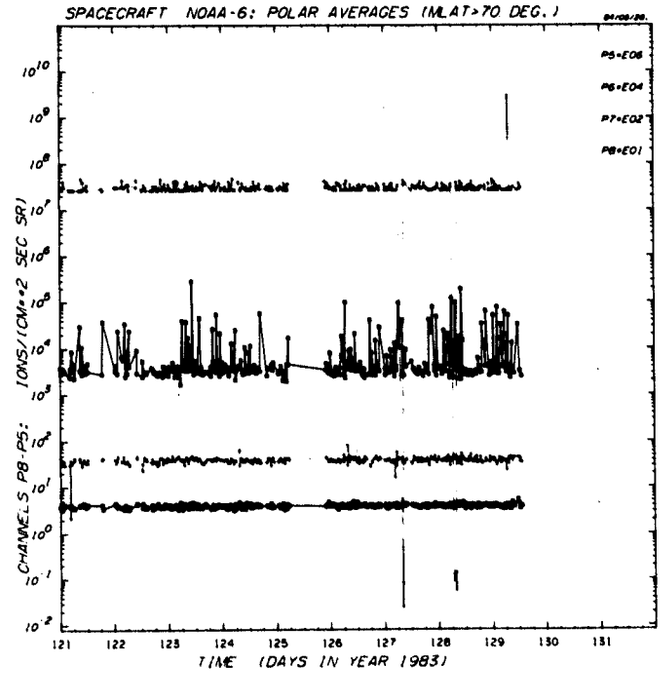


April 21, 1983





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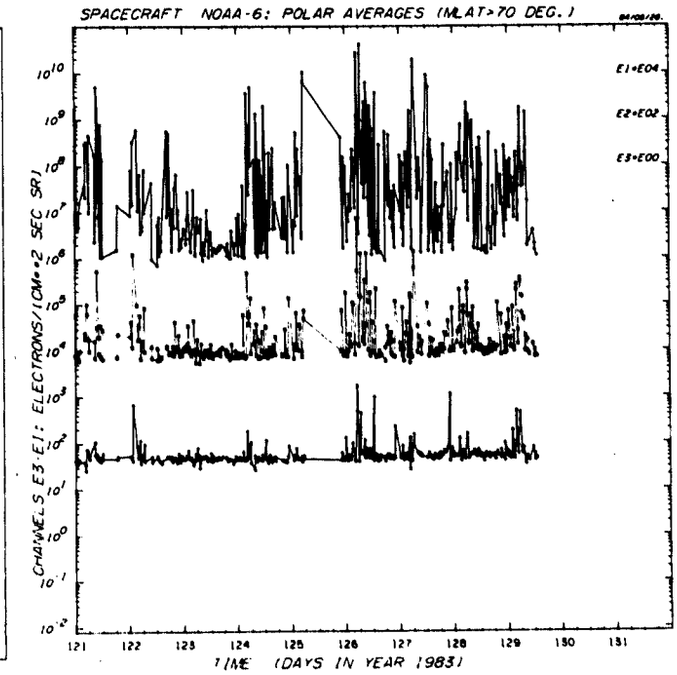

May 1, 1983