A review of the GOES and POES space weather data services from the inception to present. Zero recycled slides.

• **GOES** -- Geosynchronous Operational Environmental Satellites
  • History
  • Current Status
  • Future

• **POES** – Polar Operational Environmental Satellites
  • History
  • Current Status
  • Future

Daniel Wilkinson
November 3, 2010
## GOES - History

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Launch Date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMS-1 (A)</td>
<td>1974-07 to 1974-10</td>
<td>(NASA)</td>
</tr>
<tr>
<td>SMS-2 (B)</td>
<td>1975-02 to 1976-04</td>
<td>(NASA)</td>
</tr>
<tr>
<td>GOES-01 (A aka SMS-C)</td>
<td>1976-01 to 1978-05</td>
<td>Philco-Ford</td>
</tr>
<tr>
<td>GOES-02 (B)</td>
<td>1977-08 to 1983-05</td>
<td></td>
</tr>
<tr>
<td>GOES-03 (C)</td>
<td>1978-07 to 1980-08</td>
<td></td>
</tr>
<tr>
<td>GOES-04 (D)</td>
<td>1980-09 data, failure 1982-11, no data archived</td>
<td>Hughes Corporation</td>
</tr>
<tr>
<td>GOES-05 (E)</td>
<td>1983-01 to 1987-02</td>
<td></td>
</tr>
<tr>
<td>GOES-06 (F)</td>
<td>1983-05 to 1994-11</td>
<td></td>
</tr>
<tr>
<td>GOES-?? (G)</td>
<td>1986-05 to T+71 seconds</td>
<td></td>
</tr>
<tr>
<td>GOES-07 (H)</td>
<td>1987-03 to 1996-08</td>
<td>Spin Stabilized</td>
</tr>
<tr>
<td>GOES-08 (I)</td>
<td>1995-03 to 2003-06</td>
<td>3-axis Stabilized</td>
</tr>
<tr>
<td>GOES-09 (J)</td>
<td>1996-04 to 1998-08</td>
<td>Space Systems Loral</td>
</tr>
<tr>
<td>GOES-10 (K)</td>
<td>1998-07 to 2009-12</td>
<td></td>
</tr>
<tr>
<td>GOES-11 (L)</td>
<td>2000-07 to present</td>
<td></td>
</tr>
<tr>
<td>GOES-12 (M)</td>
<td>2003-01 to 2010-09 (first Solar X-ray Imager)</td>
<td></td>
</tr>
<tr>
<td>GOES-13 (N)</td>
<td>2010-04 to present</td>
<td></td>
</tr>
<tr>
<td>GOES-14 (O)</td>
<td>2009-12 to present, in storage mode.</td>
<td>The Boeing Company</td>
</tr>
<tr>
<td>GOES-15 (P)</td>
<td>2010-09 to present, in test mode.</td>
<td></td>
</tr>
</tbody>
</table>
GOES - History

**SMS / GOES** – Space Environment Monitor

- X-rays
- Energetic Particles
- Magnetic Field

**Archive Structure**

- Magnetic Tape
- Display Code Header, Binary data blocks
- Full Resolution, 3.06s
- 60-bit data words, proprietary internal block formatting (F=I)

**Data Services**

- Data provider Responsible Scientist’s reviewed each month’s data.
- Tape was the only delivery media, plots were available on microfilm.
- Tape block structure required CDC computer system to read/write.
- User cost was ~$100 per tape containing one instrument month.
- User community was very small, ~dozen requests per year.
GOES - History

NGSCC Position re SMS/GOES Data – 1978, author unknown.

REPORT ON NGSDC POSITION IN RE SMS/GOES SATELLITE DATA

INTRODUCTION

The SMS/GOES satellites are a series of spacecraft devoted to the practical applications of weather monitoring, of monitoring the near-earth space environment as it responds to solar activity, and serving as passive platforms for the collection and relay of a variety of information from earth-surface data collection platforms.

The first two satellites launched in this series were NASA experimental prototypes, Synchronous Meteorological Satellites SMS-1&2. Following the years of development and experience gained with the SMS spacecraft, the next two satellites launched in the series were NOAA-operated Geostationary Operational Environmental Satellites GOES-1&2. With the successful launch of GOES-2 on 18 July 1977, all four of these spacecraft were in geostationary (24-hour period) orbit at an altitude of roughly 6.6 earth radii (35,800 km) above the equator. By grouping the satellites in pairs at about 75 deg W. and 135 deg W. longitudes, it is possible to provide combined viewing coverage over most of N. and S. America, the N. Atlantic and the S. Pacific. Also, their longitudinal separation (covering about 4 hours of local time) enables them to span roughly one hemisphere for monitoring magnetospheric effects of solar activity. Currently, data of interest for NGSDC is being taken from only two of the widely separated satellites, SMS-2 and GOES-3; the others being held in operational reserve.
GOES - History

Provider Documentation Documentation – Tech Memo SEL-42, December 1975
SMS/GOES Space Environment Monitor Subsystem, R.N. Grubb
GOES - History


NOAA Technical Memorandum ERL SEL-48

SOLAR X-RAY MEASUREMENTS FROM SMS-1, SMS-2, AND GOES-1
INFORMATION FOR DATA USERS

R. F. Donnelly
R. N. Grubb
F. C. Cowley

Space Environment Laboratory
Boulder, Colorado
June 1977
GOES - History

NGDC Develops First GOES Tape User’s Guide - 1980

FLAG WORD STRUCTURE SMS-1, SMS-2, GOES-1, GOES-2, GOES-3

The flag word is a 60-bit CDC floating point representation of an integer into which is packed all of the information about the data sample according to the pattern “VSSSEEEO”. Flag word elements may be recovered by using the Modulus function. MOD(A,B) is defined as the whole remainder resulting from the division A/B. More specifically MOD(A,B) = A-INTEGER(A/B)*B.

IFLAG = INTEGER(flag word)
“O” = MOD(IFLAG, 16)
“EEE” = MOD(IFLAG/16, 256)
“SSS” = MOD(IFLAG/4096, 1000)
“V” = IFLAG/4096/1000

“O” : Offset flag for Magnetometer data:
0 = no correction applied.
1 = correction has been applied.

“O” : Offset flag for X-ray data:
0 = No flag
1 = Corrected single point error
2 = Calibration data
4 = Switch in X-ray instrument sensitivity
8 = Eclipse of the Sun by the Earth

“O” : Multiplex counter for Particle data.

<table>
<thead>
<tr>
<th>Counter</th>
<th>Multiplex</th>
<th>2 Channel</th>
<th>4 Channel</th>
<th>8 Channel</th>
<th>Channel Specifications for SMS 1, SMS 2, GOES 1</th>
</tr>
</thead>
</table>
GOES - History


NOAA Technical Memorandum ERL SEL-56

SMS-GOES SOLAR SOFT X-RAY MEASUREMENTS
PART I. SMS-1, SMS-2, AND GOES-1 MEASUREMENTS
FROM JULY 1, 1974, THROUGH DECEMBER 31, 1976

R. F. Donnelly
GOES - History

**GOES-4 Failure** – NGDC’s First Entry in Anomaly Database
NASA Tiger Team concluded environment not an issue, before they saw this …
GOES-4 Failure – EOS Article on NGDC study.

GOES-4 Failure Investigated

The Visual Infrared Spin-Scan Radiometer (VISSR) on board the western Geosynchronous Operational Environmental Satellite (GOES-4), failed at 0445 UT, November 26, 1982, as a series of intense storms descended on the California coast. The VISSR maps the earth and its cloud cover day and night and allows the tracking and forecasting of severe storm systems. This failure of the VISSR on board GOES-4 deprived weather forecasters of an important means of tracking the nighttime progress of life-threatening storms as they moved across the Pacific.

The cause of this critical satellite failure is of great interest to the National Oceanic and Atmospheric Administration (NOAA), operators of the GOES network. A study now in progress should resolve the reason for failure and determine whether solar activity caused it. Figure 1 was prepared at the National Geophysical Data Center in Boulder, CO, in response to a call for information about the earth's space environment at the time of the GOES-4 failure.

All GOES spacecraft carry a Space Environment Monitor (SEM) instrument package containing an X-ray sensor, a three-component magnetometer, and a particle detector. Together these instruments provide continuous monitoring of the space environment at the satellite's altitude. SEM data from selected satellites are received and processed for archiving at the Space Environment Laboratory in Boulder. When GOES-4 failed at 135°W longitude, the reference satellite for SEM archival purposes was GOES-2, located at 108°W longitude. The proximity of the two satellites suggested that their local environments were similar, and selected data from representative GOES-2 channels were reproduced for November 25–26, 1982.

The top frame of Figure 1 shows the prominent X.5 solar flare reported by the Space Environment Services Center at 0229 UT. Owing to the intensity of the flare and the history of its associated sunspot region, forecasters at that center immediately posted a proton event warning.

Close inspection of the middle frame shows that indeed the fast, high-energy protons in the 110–500 MeV range began arriving at the satellites approximately 45 minutes before failure, with slower protons arriving in quantity a few minutes after failure. Counts of electrons trapped at geostationary altitude, 6.67 earth radii, often show a quiet-time daily variation, a variation that produces lower electron counts in the UT morning than in the UT evening. The electron curve does not drop to quiet-time values on the morning of November 26, indicating the satellite environment contained a significant electron flux at the time GOES-4 failed. Lacking spectral information for electrons, however, we can give no detailed interpretation of their importance.

The magnetometer's three field components are defined as follows: H_x is parallel to the satellite spin axis and is perpendicular to the satellite's orbital plane; H_y lies parallel to the satellite-earth line and points earthward; H_z is perpendicular to both H_x and H_y and points westward. No magnetic storm activity is indicated when GOES-4 failed. Note, however, the correlation between the H_z curve and the electron curve.

This display of the SEM data does not determine the cause of the GOES-4 failure. It does nevertheless raise the question of solar activity as a contributing factor. According to NASA Headquarters, there are currently 56 surveillance and communications satellites in geostationary orbit, representing a U.S. investment in the tens of billions of dollars. An investment of this size will undoubtedly trigger renewed interest in Solar-Terrestrial relationships.

Space environment data from the GOES News (cont. on p. 954)

Fig. 1. Data from the GOES-2 Space Environment Monitor recorded November 25–26, 1982, at 108°W. The data are being studied for clues to the November 26 failure of the GOES-4 satellite, at 135°W.
Anomaly Activity Grows – NGDC’s 1985 Anomaly Workshop attracts top players.
TDRS-1 – Most anomaly entries were subject to inconsistent historical reporting and therefore had limited statistical value. TDRS-1, however, had a complete SEU history making it an ideal case study.
GOES - History

TDRS-1 – Operators were highly concerned with what appeared to be a steady change in SEU occurrence which NGDC demonstrated to be due to solar cycle cosmic ray variation.
1986 – Dr. Herb Sauer created GOES SEM products for broad audience. Compact binary formatted 1-min & 5-min values (Designed to fit on 320Kb floppy). User requests increased by ~30x.
Tape Migration – In 1990 the Boulder Labs decided to discontinue using CDC mainframe computers. The entire SMS/GOES archive was at risk because the tape format was in CDC floating point binary with internal block encoding. NGDC undertook this rescue effort that resulted in all full resolution archive tapes being converted to FITS binary table format using standard word types.
GOIN – Global Observation Information Network

In 1993 President Clinton and Prime Minister Miyazawa of Japan implemented GOIN. NGDC’s GOES and POES archives were highlighted as a major candidate for bilateral cooperation.
NGDC STP Division Hosted the 1997 GOIN Workshop utilizing NCAR facilities.
GOES - History

• 1992 First comprehensive GOES SEM CD issued.
• 1992 GOES SEM CD update issued.
• 1992 Anomaly submissions stopped.
• 1995 GOES I-M era begins with launch of GOES-8,
  • Data provider discontinues Responsible Scientist quality oversight.
  • Full-resolution data will not be archived for this series.
• 1997 SPIDR come online and becomes primary GOES SEM dissemination tool.
  • Plots generated via IDL CGI
  • Data selected from binary archive via CGI
• 1999 SPIDR upgraded
  • Plots generated via Java
  • Data stored in relational archive
• 2000 Many users request flat file access to GOES SEM
  • ASCII tables generated monthly with canned browse plots.
GOES - History

TO:       John Kinsfather
FROM:     Dan Wilkinson
DATE:     June 18, 1991
SUBJECT:  Write-Once CDROM

Optical Media International $24,900
485 Alberto Way                          $23,000 hardware only
Los Gatos, CA 95032                      $1,900 pcTOPiX software
(408)376-3511                            (upgrade cost, list $4,500)
(800)347-2664                            Includes simulator, allows
Attn: Rick Wittwer                        quality control and image modification.

Publishers Data Service Corporation $24,990
One Lowe Ragsdale Drive                     Includes ISO 9660 software
Bldg 12 Suite 163                           One year warranty
Monterey CA 93942                          $35 disks in quantity
(408)372-2810                            ISA bus preferred
FAQ (408)372-7136
Attn: Dean Quanstron

Young Minds $28,500
Redlands, CA                                Includes sofware (support $950/yr)
(714)335-1350                              Trantor SCSI extra
Attn: Tom Stapleton                          UNIX and ULTRIX software coming
GOES - History

July 2001 GOES-12 & SXI were launched – Solar X-ray Imager reaches orbit after 20 years of planning, 2,275,821 images collected before being shutdown in April of 2007.
GOES - History

GOES-12 SXI – NGDC’s Java Servlet driven interface was ready on day 1.
GOES – Current Status

GOES-NOP: GOES-13, GOES-14, GOES-15

- Vast array of new data as compared to previous GOES.
  - New Extreme Ultraviolet sensor (UVS) data.
  - New proton data - Magnetospheric protons, 5 channels, 9 look directions
  - New electron data - Magnetospheric protons, 5 channels, 9 look directions
  - Dual look directions for higher energy particles.
  - Dual Magnetometers
  - Expanded full-resolution capabilities for all data types.
- GOES-14 XRS is primary for SWPC operations.
- GOES-15 XRS is secondary for SWPC operations.
GOES – Current Status

GOES-NOP Data Flow

SWPC Microsoft Database

All Data transferred Daily to NGDC Via CSV Format

NGDC pads missing Records, replaces Missing data flags.

NetCDF & NetCSV Data file generation

NCDC MySQL Database

Metadata table necessary for generating plots and self-documenting data files.

QC / Browse Graphics Generated Via IDL
## GOES – Current Status

GOES-NOP Tables -- One set for each satellite.

### TIME AVERAGES
- `tb_g13_epead_a16ew_1m`
- `tb_g13_epead_a16ew_5m`
- `tb_g13_epead_cpflux_5m`
- `tb_g13_epead_e13ew_1m`
- `tb_g13_epead_e13ew_5m`
- `tb_g13_epead_p17ew_1m`
- `tb_g13_epead_p17ew_5m`
- `tb_g13_eps_hskp_5m`
- `tb_g13_euv_1m`
- `tb_g13_euv_a_1m`
- `tb_g13_hepad_ap_1m`
- `tb_g13_hepad_ap_5m`
- `tb_g13_hepad_s15_1m`
- `tb_g13_hepad_s15_5m`
- `tb_g13_maged_19me15_1m`
- `tb_g13_maged_19me15_5m`
- `tb_g13_magneto_1m`
- `tb_g13_magneto_hskp_5m`
- `tb_g13_magpd_19me15_1m`
- `tb_g13_magpd_19me15_5m`
- `tb_g13_sat_loc`
- `tb_g13_sem_hskp_5m`
- `tb_g13_xrs_1m`
- `tb_g13_xrseuv_hskp_5m`
- `tb_g13_xrseuv_imp_temp`
- `tb_g13_zbgnd_e_hist`
- `tb_g13_zbgnd_w_hist`

### FULL RESOLUTION
- `tb_g13_epead_a16e_32s`
- `tb_g13_epead_a16w_32s`
- `tb_g13_epead_e1ew_4s`
- `tb_g13_epead_e2ew_16s`
- `tb_g13_epead_e3ew_16s`
- `tb_g13_epead_p1ew_8s`
- `tb_g13_epead_p27ew_32s`
- `tb_g13_epead_p27w_32s`
- `tb_g13_euv_a_10s`
- `tb_g13_euv_b_10s`
- `tb_g13_euv_c_10s`
- `tb_g13_euv_d_10s`
- `tb_g13_euv_e_10s`
- `tb_g13_hepad_ap_32s`
- `tb_g13_hepad_s15_4s`
- `tb_g13_maged_19me1_2s`
- `tb_g13_maged_19me2_2s`
- `tb_g13_maged_19me3_4s`
- `tb_g13_maged_19me4_16s`
- `tb_g13_maged_19me5_32s`
- `tb_g13_magd_512ms`
- `tb_g13_magd_19me1_16s`
- `tb_g13_magd_19me2_16s`
- `tb_g13_magd_19me3_16s`
- `tb_g13_magd_19me4_32s`
- `tb_g13_magd_19me5_32s`
- `tb_g13_magneto_2s`

### SXI HOUSEKEEPING
- `tb_g13_sxi_badpix`
- `tb_g13_sxi_bpt_raw`
- `tb_g13_sxi_cmptbl`
- `tb_g13_sxi_evt_raw`
- `tb_g13_sxi_exptbl`
- `tb_g13_sxi_extt_raw`
- `tb_g13_sxi_fdet`
- `tb_g13_sxi_flttbl`
- `tb_g13_sxi_hass_conv`
- `tb_g13_sxi_hass_raw`
- `tb_g13_sxi_hasscor`
- `tb_g13_sxi_head_raw`
- `tb_g13_sxi_hhead_raw`
- `tb_g13_sxi_hskp_conv`
- `tb_g13_sxi_hskp_raw`
- `tb_g13_sxi_hskp_raw_v1`
- `tb_g13_sxi_imgsum_raw`
- `tb_g13_sxi_levelone`
- `tb_g13_sxi_levelzero`
- `tb_g13_sxi_levelzero_v1`
- `tb_g13_sxi_pcm_ccdtmp`
- `tb_g13_sxi_pcm_cdtmp`
- `tb_g13_sxi_pcm_debp3mon`
- `tb_g13_sxi_pcm_debtmp`
- `tb_g13_sxi_pcm_flags`
- `tb_g13_sxi_pcm_hebtmp`
- `tb_g13_sxi_pcm_mirtmp`
GOES – Current Status

GOES-NOP Sample Table Schema – 1 min Magnetometer

```sql
CREATE TABLE goes_13.tb_g13_magneto_1m (  
time_tag datetime,  
insert_time timestamp,  
BX_1_QUAL_FLAG int,  
BX_1_NUM_PTS tinyint,  
BX_1 float,  
BY_1_QUAL_FLAG int,  
BY_1_NUM_PTS tinyint,  
BY_1 float,  
BZ_1_QUAL_FLAG int,  
BZ_1_NUM_PTS tinyint,  
BZ_1 float,  
BXSC_1_QUAL_FLAG int,  
BXSC_1_NUM_PTS tinyint,  
BXSC_1 float,  
BYSC_1_QUAL_FLAG int,  
BYSC_1_NUM_PTS tinyint,  
BYSC_1 float,  
BZSC_1_QUAL_FLAG int,  
BZSC_1_NUM_PTS tinyint,  
BZSC_1 float,  
BTSC_1_QUAL_FLAG int,  
BTSC_1_NUM_PTS tinyint,  
BTSC_1 float,  
BX_2_QUAL_FLAG int,  
BX_2_NUM_PTS tinyint,  
BX_2 float,  
BY_2_QUAL_FLAG int,  
BY_2_NUM_PTS tinyint,  
BY_2 float,  
BZ_2_QUAL_FLAG int,  
BZ_2_NUM_PTS tinyint,  
BZ_2 float,  
BXSC_2_QUAL_FLAG int,  
BXSC_2_NUM_PTS tinyint,  
BXSC_2 float,  
BYSC_2_QUAL_FLAG int,  
BYSC_2_NUM_PTS tinyint,  
BYSC_2 float,  
BZSC_2_QUAL_FLAG int,  
BZSC_2_NUM_PTS tinyint,  
BZSC_2 float,  
BTSC_2_QUAL_FLAG int,  
BTSC_2_NUM_PTS tinyint,  
BTSC_2 float,  
HE_2_QUAL_FLAG int,  
HE_2_NUM_PTS tinyint,  
HE_2 float,  
HN_2_QUAL_FLAG int,  
HN_2_NUM_PTS tinyint,  
HN_2 float,  
HT_2_QUAL_FLAG int,  
HT_2_NUM_PTS tinyint,  
HT_2 float)
```
GOES – Current Status

GOES-NOP Metadata –
Data Attributes available for 1m, 5m, full-res, but not housekeeping

These values are included in NetCDF and NetCSV data table headers. These values also control all aspects of QC/Browse plots. There are currently 904 fields defined, SXI housekeeping not included.

field_name
instrument
description
long_label
short_label
plot_label
lin_log
units
format
nominal_min
nominal_max
valid_min
valid_max
missing_value
GOES – Current Status

GOES NOP Schema Changes and other challenges:

• The structure of tables will change from time to time as SWPC adds new data products. For example, the tables below had significant changes in October 2010. This requires the renaming of existing tables in order to preserve the old data and the creation of new tables in the new schema.

• Some new data will be processed retroactively for certain satellites, some satellite will not have this done which will create a discontinuity in the archive for those satellites.

• New fields do not logistically exist to plotting and data file generation systems until the new fields have been described in the metadata tables.

• SWPC renamed several tables in October 2010 in order to correct a typographical error. This type of change requires special case handling throughout the entire data processing scheme.
**GOES – Current Status**

**GOES-13 SXI**

In December 2006 the GOES-13 SXI was in its final month of Post Launch Testing when a solar flare damaged the imaging array. This instrument has never gone operational.

**Before X9 Flare**

**During**

**After**
GOES – Current Status

GOES-14 SXI

- GOES-14 is officially in storage mode however we continue to receive Level-0 and Level-1 images.
GOES – Current Status

GOES-15 SXI

• GOES-15 is in Post Launch Testing, we receive Level-0 images only.
GOES – Current Status

GOES-I-M Series coming to a close.

- GOES-11 is in last of the I-M series producing SEM data.
- 2010 user statistics for GOES SEM data.

<table>
<thead>
<tr>
<th>Month</th>
<th>Data(GB)</th>
<th>Distinct Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>163</td>
<td>2,135</td>
</tr>
<tr>
<td>Feb</td>
<td>81</td>
<td>1,896</td>
</tr>
<tr>
<td>Mar</td>
<td>190</td>
<td>1,907</td>
</tr>
<tr>
<td>Apr</td>
<td>196</td>
<td>1,858</td>
</tr>
<tr>
<td>May</td>
<td>165</td>
<td>1,508</td>
</tr>
<tr>
<td>Jun</td>
<td>188</td>
<td>1,574</td>
</tr>
<tr>
<td>Jul</td>
<td>90</td>
<td>1,330</td>
</tr>
<tr>
<td>Aug</td>
<td>106</td>
<td>1,178</td>
</tr>
<tr>
<td>Sep</td>
<td>115</td>
<td>1,029</td>
</tr>
<tr>
<td>Average</td>
<td>144</td>
<td>1,602</td>
</tr>
<tr>
<td>Annual</td>
<td>1,725</td>
<td>19,220</td>
</tr>
</tbody>
</table>
GOES – Future

GOES-R

• The GOES-R series of satellites is scheduled for launch in 2014

• GOES-R Risk Reduction
  
  • NGDC is finishing a three year project to develop a prototype interface to GOES-R space weather data sets. Under this project GOES-NOP data have been converted to NetCDF to simulate the GOES-R archive format.

  • NGDC is proposing a new two year project that will apply the Rich Inventory to the GOES-R proxy data created in the previous project.

• GOES-R Integrated Product Team
  
  • OAIS compliance, submissions agreements, file naming, etc.

• GOES-R Data Engineering Working Group
  
  • Metadata planning for GOES-R
POES - History

• TIROS-N 1978-11 to 1981-02 (Introduction of SEM-1)
• NOAA-6 1979-06 to 1986-11
• NOAA-B 1980-05 Launch Failure, “It became space debris”
• NOAA-7 1981-07 to 1985-02
• NOAA-8 1983-05 to 1985-10
• NOAA-10 1986-10 to 1991-08
• NOAA-12 1991-06 to 2002-07
• NOAA-14 1995-01 to 2004-12

• NOAA-15 1998-07 to present (Introduction of SEM-2)
• NOAA-16 2001-01 to present
• NOAA-17 2002-07 to present
• NOAA-18 2005-06 to present
• METOP-02 2006-12 to present (aka METOP-A)
• NOAA-19 2009-02 to present

SEM-1
Space Environment Monitor

SEM-2
POES – Space Environment Monitor

• Energetic Particles

• Archive Structure – Polar Operational Environmental Satellites
  • Custom packed binary files.
  • SWPC provides program sub function to unpack
  • Full Resolution, 2.0s

• Data Services
  • Tape was only delivery media.
  • No browse graphics were available
  • A small number of customers requested large quantities of data.

• Documentation
  • These data have always been well documented.
The TIROS and NOAA satellites measure fluxes of electrons, protons and alpha particles resulting from solar and geomagnetic activity. The archive also contains several calculated quantities such as L values, pitch angles, and geomagnetic coordinates.

This unique archive began in 1978 with the launch of TIROS-N, which carried the three arrays of particle detectors described below. Similar detectors were later flown on the NOAA-6, NOAA-7, and NOAA-8 satellites. Two satellites gather data simultaneously in circular orbits of 850 km altitude and 99° inclination. The data are received continuously at the Space Environment Laboratory in Boulder, Colorado, where they are processed and stored on three magnetic tapes per month per satellite.

HIGH ENERGY PROTON AND ALPHA PARTICLE DETECTOR measures the flux of solar protons in four energy bands above 370 MeV and of solar alpha particles in two energy bands above 640 MeV per nucleon. All measurements are made in the direction of the local zenith.

MEDIUM ENERGY PROTON AND ELECTRON DETECTOR measures the flux of protons in 5 energy bands above 30 KeV and of electrons in 3 energy bands above 30 KeV. Ions with a Z number > 1 are measured in a single energy band of 6–55 MeV. Measurements are made in the direction of and at 80° to the local
POES - History


TIROS/NOAA Satellites Space Environment Monitor Archive Tape Documentation

V. J. HILL, D. S. EVANS, H. H. SAUER

ABSTRACT. TIROS/NOAA satellite archive tapes containing data obtained with the Medium Energy Proton and Electron Detector (MEPED), High Energy Proton and Alpha Particle Detector (HEPAD), and Total Energy Detector (TED) are described. Descriptions of the data include orbital and housekeeping details and the information needed to decode and understand the data. Specifications of the data channels are supplied, with the timing information needed to convert the data to usable information. Description of the archive tape format gives the information needed to read the tape and unpack the data. Appendices supply the retrieval routines used by the Space Environment Services Center in Boulder.

1.0 INTRODUCTION

The TIROS/NOAA (Television and Infrared Observation Satellite / National Oceanic and Atmospheric Administration) satellites carry a set of instruments to detect and monitor the influx of ions and electrons into the upper atmosphere as a result of solar and magnetospheric activity. The set of instruments is called the Space Environment Monitor (SEM). SEM data are received in near-real time at the Space Environment Services Center (SESC) of the Space Environment Laboratory in Boulder, Colorado. The data are used operationally by SESC and are also archived on magnetic tape. Tape copies can be obtained from the Laboratory:
POES - History

POES – 1995 Documentation SEM-1 UPDATE

TIROS/NOAA Satellite Space Environment Monitor Data Archive
Documentation: 1995 Update

V. J. Raben, D. S. Evans, H. H. Sauer, S. R. Sahm, M. Huynh

ABSTRACT

TIROS/NOAA satellite archive tapes containing data obtained with the Medium Energy Proton and Electron Detector (MEPED), High Energy Proton and Alpha Particle Detector (HEPAD), and Total Energy Detector (TED) are described. Descriptions of the data include orbital and housekeeping details and the information needed to decode and understand the data. Specifications of the data channels are supplied, as is the timing information needed to convert the data to usable information. Description of the archive tape format gives the information needed to read the tape and unpack the data. Appendices supply the retrieval routines used by the Space Environment Services Center in Boulder.

1.0. Introduction

The TIROS/NOAA (Television and Infrared Observation Satellite/National Oceanic and Atmospheric Administration) satellites carry a set of instruments to detect and monitor the influx of ions and electrons into the upper atmosphere as a result of solar and magnetospheric activity. This set of instruments is called the Space Environment Monitor (SEM). SEM data are received in near-real time at the Space Environment Services Center (SESC) of the Space Environment Laboratory in Boulder, Colorado. The data are used operationally by SESC and are also archived on 3480 magnetic tape. Tape copies can be obtained from the following source:
POES - History

POES – Dr. Dave Evans also issued annual updates and status reports

To: Janet Green  
    Dan Wilkinson  
    SOCC Suitland  
Fm: Dave Evans  
Re: General update

I have finished the clean up and verification of NOAA-15, NOAA-16, NOAA-17, NOAA-18 and MetOp-02 SEM-2 data from 2007 and have some updated performance information and figures that may be of interest.  

January 10, 2008

SEM-2 performance on the operating satellites during 2007.

General Comments:

While it has been pointed out in the past, it is worth re-emphasizing the fact that the proton telescope instruments in SEM-2 are sensitive to electrons of energies greater than about 800 keV. This is because the sweeping magnetic field in the proton telescope apertures is not effective in suppressing very energetic electrons from reaching the detector and very energetic electrons are capable of depositing >30 keV energy in the front solid-state detector and >60 keV in the back detector, thus triggering an event in the 0P6 or 90P6 channels and mimicking an event from a >6.3 MeV proton. That same electron is, however, incapable of depositing enough energy in the front solid-state detector produce an event in either the P4 or P5 (800-2500 keV and 2500 to 6300 keV) proton telescope channels. Thus instances when the proton telescope detectors display
POES Supports ISS

POES – NASA Houston ISS program requested electron event study using POES

Energetic Electrons: POES (L4.5 - L4.8) & GOES (L6.6)

- NOAA-12 > 3 MeV Electrons, 4 values/orbit. (90° from Zenith)
- NOAA-12 > 3 MeV Electrons 49-value (12 Orbit) Running Mean
- GOES-8 > 2 MeV Electrons (Daily)
- NOAA-12 > 3 MeV Electrons 24-value (6 Orbit) Deltas of Running Means, in % of 1.e+004

Event Start Threshold is >=100%; Event Max Occurs at Next Value <= 0%

NOAA / NGDC Boulder, CO USA
POES Supports ISS

Energetic Electrons: POES (L4.5 - L4.8) & GOES (L6.6)

NOAA-12 > 3 MeV Electrons, 4 values/orbit. (90° from Zenith)

27.3 Days

NOAA-12 > 3 MeV Electrons 49-value (12 Orbit) Running Mean.

Max

Start

Exponential Decay Model: \( J = J_0 e^{kt} \), \( k = -0.1929 \), \( 1/k = -5.18 \), \( t \) = days. Decay vector represents 20-day projection.

GOES-8 > 2 MeV Electrons (Daily)

NOAA-12 > 3 MeV Electrons 24-value (6 Orbit) Deltas of Running Means, in % of 1.e+004

Event Start Threshold is >=100%; Event Max Occurs at Next Value <= 0%
POES - History

POES – JGR paper presents a detailed applications of SEM-2 data.

Use of POES SEM-2 observations to examine radiation belt dynamics and energetic electron precipitation into the atmosphere

Craig J. Rodger, 1 Mark A. Clilverd, 2 Janet C. Green, 3 and Mai Mai Lam 2

Received 26 December 2008; revised 2 August 2009; accepted 3 November 2009; published 3 April 2010.

[1] The coupling of the Van Allen radiation belts to the Earth’s atmosphere through precipitating particles is an area of intense scientific interest. Currently, there are significant uncertainties surrounding the precipitating characteristics of medium energy electrons (>20 keV), and even more uncertainties for relativistic electrons. In this paper we examine roughly 10 years of measurements of trapped and precipitating electrons available from the Polar Orbiting Environmental Satellites (POES)/Space Environment Monitor (SEM-2), which has provided long-term global data in this energy range. We show that the POES SEM-2 detectors suffer from some contamination issues that complicate the understanding of the measurements, but that the observations provide insight into the precipitation of energetic electrons from the radiation belts, and may be developed into a useful climatology for medium energy electrons. Electron contamination also allows POES/SEM-2 to provide unintended observations of >700 keV relativistic electrons. Finally, there is an energy-dependent time delay observed in the POES/SEM-2 observations, with the relativistic electron enhancement (electrons >800 keV) delayed by approximately one week relative to the >30 keV electron enhancement, probably due to the timescales of the acceleration processes. Observations of trapped relativistic electron fluxes near the geomagnetic equator by GOES show similar delays, indicating a “coherency” to the radiation belts at high and low orbits, and also a strong link between trapped and precipitating particle fluxes. Such large delays should have consequences for the timing of the atmospheric impact of geomagnetic storms.
POES – NGDC has received data from between one and six satellites simultaneously and an inventory program was written to automatically update the inventory after each ingest. Early data submissions contained several days per file. Beginning in 1996 all data were delivered in daily files.

The inventory software sends e-mail notification if it identifies missing data.

POES – The first step in quality assurance was the generation of a set of QC plots. These plots would verify file integrity as well as data channel consistency and continuity.

POES – NGDC converted and ran Sue Greer code to generate 16s averages of SEM-2 data in CDF and ASCII table formats. Apparently many people had been intimidated with the need to unpack binary archive files and the ASCII tables soon became the most requested file type.
**POES - History**

**POES** – In 2008 NGDC began the routine generation of radiation maps. The accumulation of sufficient data bins to generate a full map requires data collection over several days from multiple satellites.
POES – Radiation maps are updated after the daily data ingest. Maps are generated in Cylindrical and Orthographic projects included in 54 days movies.
POES – There are currently six POES in operation, each with a functioning SEM-2 sub-system delivering data to archive.
## POES – Current Status

**POES** – 2010 user statistics:

<table>
<thead>
<tr>
<th>Month</th>
<th>Data(GB)</th>
<th>Distinct Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>486.65</td>
<td>1,374</td>
</tr>
<tr>
<td>Feb</td>
<td>175.24</td>
<td>1,307</td>
</tr>
<tr>
<td>Mar</td>
<td>177.08</td>
<td>1,368</td>
</tr>
<tr>
<td>Apr</td>
<td>240.88</td>
<td>1,309</td>
</tr>
<tr>
<td>May</td>
<td>458.4</td>
<td>1,286</td>
</tr>
<tr>
<td>Jun</td>
<td>376.86</td>
<td>1,058</td>
</tr>
<tr>
<td>Jul</td>
<td>112.59</td>
<td>1,123</td>
</tr>
<tr>
<td>Aug</td>
<td>121.94</td>
<td>1,172</td>
</tr>
<tr>
<td>Sep</td>
<td>210.2</td>
<td>1,089</td>
</tr>
</tbody>
</table>

**Monthly Avg**  
273  
**Annual**  
3,277  
14,781
• **NOAA-19** is the last in the POES series.

• **SWPC** will only support data used in operations because POES series no longer needed for operations. Processing will be migrated to NGDC.

• **JPSS** is next…

March 19, 2010

As NPOESS prime contractor, Northrop Grumman Aerospace Systems of Los Angeles was to build the satellite platforms and also was responsible for overall integration of the system, including the instruments and ground segment.

Testifying before the House Appropriations commerce, justice, science subcommittee, Lubchenco said NASA will take over the instrument and ground-segment integration duties for what is now called the **Joint Polar Satellite System** as part of a transition plan being finalized by NOAA and the U.S. Department of Defense. NOAA’s budget request includes $1.06 billion for the Joint Polar Satellite System in 2011.