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DEVELOPMENT OF GMS DATA ACQUISITION AND DATABASE SYSTEMS

Mitsue DEN[1], Takahiro OBARA[1] and Fumihiko TOMITA[2]

[1] *Hiraiso Solar Terrestrial Research Center, Communications Research Laboratory, 3601 Isozaki, Hitachinaka 311-1202*
[2] *Communications Research Laboratory, Nukuikitamachi 4-chome, Koganei-shi, Tokyo 184-8795*

Abstract: It is well known that relativistic particles are hazardous to space equipments and astronauts, therefore it is important to monitor the space environment continuously. Since 1979 Hiraiso Solar Terrestrial Research Center has been watching the time sequence of high energetic particle flux everyday from the Space Environment Monitor (SEM) onboard the Japanese Geostationary Meteorological Satellite. We developed a data acquisition system from the GMS-4 as well as its database system. The real time data plot, which is renewed every two minutes, has been presented by using http since 1994. We report the data acquisition system and the real time data display by means of the WWW browser along with the database system.

1. Introduction

Recently there have been a lot of satellites and space equipments floating in space for communication, broadcasting, weather forecasting, car navigation, etc. Astronauts have been sent out to space to carry out experiments. In the future, human beings will be staying up in space for long periods. They will be exposed in space to relativistic particles, which will penetrate into equipments and cause some damage. Particles will also deteriorate the solar battery, a very important energy source for satellites. The health of astronauts are at risk whenever they are exposed to radiation. It is necessary to monitor the space environment continuously, not only for astronauts, but also for all of us living on Earth.

Energetic particles in space are classified into three groups according to their origin: solar particles, trapped energetic particles, and galactic cosmic rays. Solar particles are emitted from the sun on the occasion of solar flares. Their energy is 10 to 100 MeV, flux is 10 to 100 Proton Flux Unit (PFU), and the time duration of their emission is about 1 day on an average. These solar events depend on the activity of the sun, and the occurrence frequency of these events is much less in that of events caused by trapped particles. Energetic particles are trapped by the geomagnetic field and they form the radiation belt called Van Allen belt surrounding the earth. They consist of protons in the inner belt, whose energy is 10 to 700 MeV, and electrons in the outer belt, whose energy is several MeV. Their variation is affected by the geomagnetic activity. Recent works reveal that the flux level of the high energetic electrons is enhanced after magnetic storms(LI *et al.*, 1997a,b; OBARA *et al.*, 1998). Moreover global enhancements of the flux level last occasionally about several days. The energy from galactic cosmic rays is the highest, sometimes higher than 1 GeV, but their flux is very small compared with the flux of solar particles or trapped energetic particles. The most dangerous energetic particles may be the trapped ones, since magnetic storms occur frequently with an increase in the high energetic electron flux. If satellites are immersed in the radiation belts when these events are in progress, some unexpected errors or accidents may occur.

The flux of solar particles and of trapped particles change dynamically and the extent of danger in space also changes incessantly depending on the solar activity and the geomagnetic activity. Therefore it is desirable to carry out a continuous and real time monitoring of the space radiation environment. Besides, if we can predict the condition of the space environment, which is called "space weather forecast" like the weather forecast for Earth, space equipments and astronauts can avoid danger just like through unfolding an umbrella.

An observation of energetic particles was started by the Space Environment Monitor (SEM) onboard the Japanese Geostationary Meteorological Satellite (GMS-1) 'Himawari' in 1977 (the data is available from 1978) and it is continued with GMS-4/SEM. Since 1979 the Hiraiso Solar Terrestrial Research Center (HSTRC) has been receiving daily summary plots from the Meteorological Satellite Center, and since 1994 the SEM data directly. We have developed a data acquisition system from the GMS-4, a database system, and a real time monitoring system. We are currently displaying the real time plot by using the WWW browser which is renewed every two minutes. We will report the data acquisition system, the real time data monitoring system along with the database system.

2. GMS/SEM Data Acquisition and Database Systems

First we will describe the SEM data before we report on the acquisition and database systems. SEM observes high energetic protons, electrons, and α particles at a geostationary orbit. The energy channels for each particle are shown in Table 1. There are 7 channels for protons, 5 channels for α particles, and 1 channel for electron.

The organization of the whole system is given in Fig. 1. It consists of two parts: data acquisition and operation part, and data management and database part. In the former part, there are three items; *i.e.*,

1) acquisition of the telemetry data received at the antenna,

Table 1. Particle species and energy channel for SEM data onboard GMS-4.

Proton		α particle		Electron	
P 1	1.0 - 4.0 MeV	A 1	8. - 70. MeV	EL	>2.0 MeV
P 2	4.0 - 8.0 MeV	A 2	30. - 70. MeV		
P 3	8.0 - 15. MeV	A 3	60. -148. MeV		
P 4	15. - 36. MeV	A 4	148. -244. MeV		
P 5	36. - 80. MeV	A 5	325. -390. MeV		
P 6	80. -200. MeV				
P 7	200. -500. MeV				

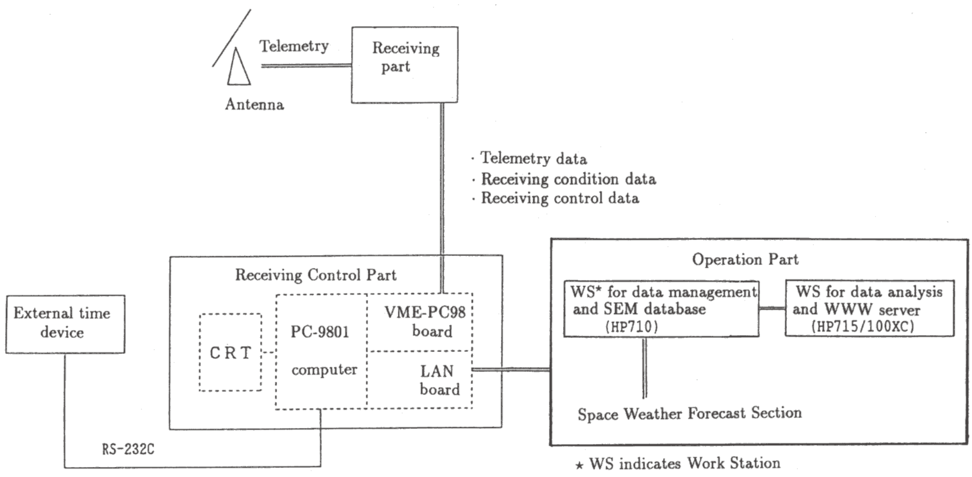

Fig. 1. Organization of the data acquisition system from GMS/SEM.

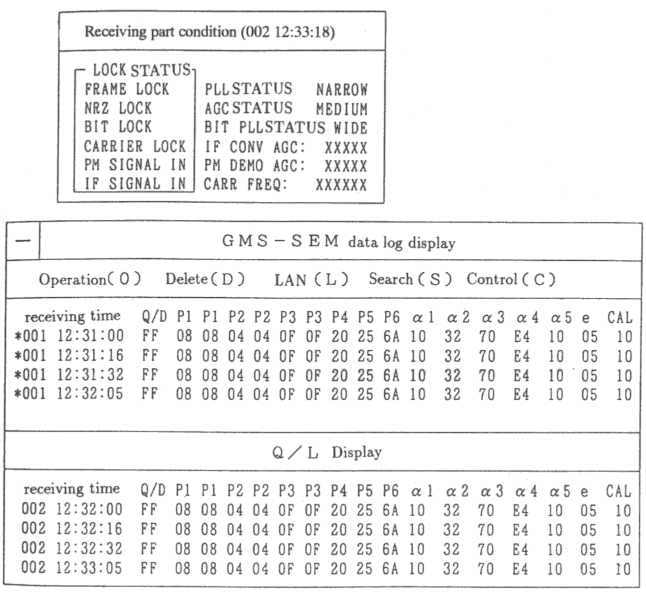

Fig. 2. Display of a quick look at the data receiving condition.

2) an abstract of the SEM data from those data,
3) monitoring of receiving condition.

Figure 2 displays a quick look at a data receiving condition. The flux data for each channel are received every 16.4 s so that the highest time resolution is 16.4 s. It includes the date, the data receiving time, the relative count of particles for each channel, and the receiving condition. They are recorded in hexadecimal format and their volume is 66 bytes. These data are saved for 7 days at most, that is to say, they are not kept for more than a week because they are sent to the data manage and database part instantly through the network once they are received at the data acquisition and operation part.

In the latter part, there are six items; *i.e.,*

1) calculation of two-minute average using the data sent up to that time,
2) conversion of relative count to flux value,
3) drawing up of a real time plot,
4) preparation of an appropriate format plot data for WWW server,
5) transmission of two-minute averaged data to Space Weather Forecast Section,
6) storage of one day raw data in database.

Items 1 to 5 repeat every two minutes. The raw data for one day, which amount to

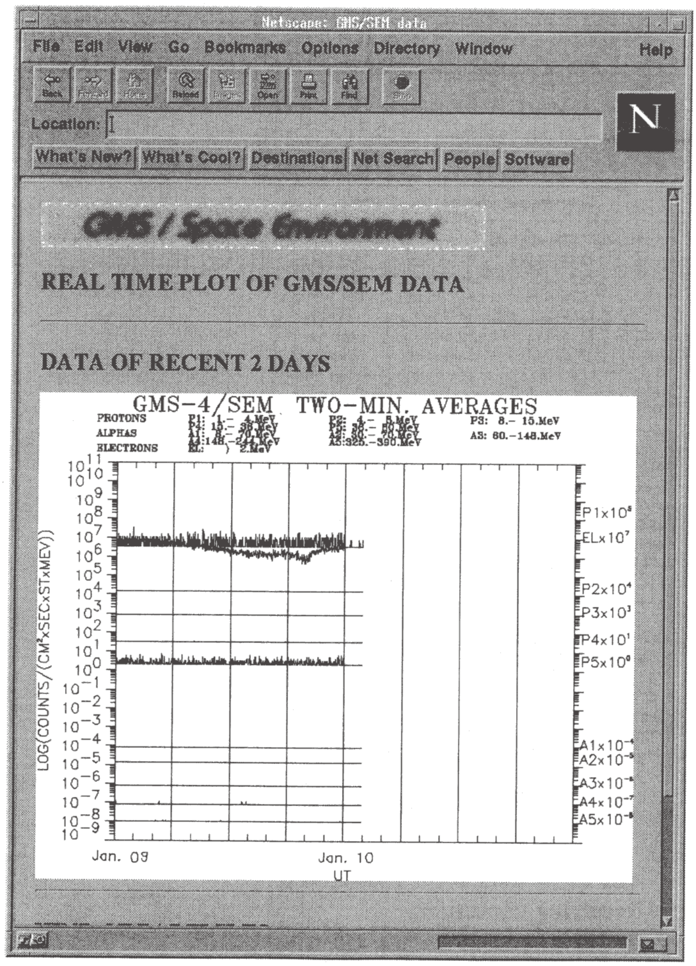

Fig. 3. A real time plot of the SEM data displayed by means of the WWW browser.

Table 2. Observational period from GMS-1 to GMS-4.

GMS-1	1978/02/07 -1981/12/20
	1984/01/21 -1984/06/29
GMS-2	1981/12/21 -1984/01/20
	1984/06/30 -1984/09/26
GMS-3	1984/09/27 -1989/12/04
GMS-4	1989/12/06 -present

about 350 kbytes, is saved in hexadecimal format.

We can monitor the space environment in real time by using http and can display the recent two days plot by means of the WWW browser which is also renewed every two minutes. Figure 3 shows the WWW display. No one can get access to this URL from outside CRL due to firewall, however, one can look at the real time plot for SEM and the plot of the SEM data for any date by accessing http: //hiraiso.crl.go.jp. It is noted that the real time plot displayed on home page shown by this URL is not renewed automatically.

Our SEM database consists of data from 1978 to present (see Table 2). Data observed for a long period are useful for analyzing the long term variation in the radiation flux. SEM data are open to the public (contact address is den@crl.go.jp) which are two-minute averaged (128 s to be exact) data and are stored in ordinary decimal format, (I5,5I3,13E11.4) in FORTRAN language. The data include the data receiving time and flux value for each particle. The data volume for one day is about 106 kbytes.

3. Summary and Future Work

We reported the data acquisition system from the GMS-4 and the real time data monitoring system by means of http along with the database system. We describe that continuous monitoring of the space environment is important since relativistic particles are hazardous to space equipments and astronauts as noted in Section 1.

As for other similar system, the high energetic protons and electrons flux also are observed by SEM onboard GOES-8 and GOES-10 satellites operated by the National Oceanic and Atmospheric Administration (NOAA). These are geostationary satellites and the longitude for GOES-8 is W75 and that for GOES-10 is W135. The behavior of the energetic electron flux level depends highly on the local time, so the GMS/SEM (E140) data are valuable as the complement.

As the next step, we try to use these data to predict the enhancement of the high energetic particles flux. HSTRC is promoting a Space Weather Forecast project and the goal for our Solar Terrestrial Research Section is to forecast the space environment. If the space environment can be predicted, it would be very useful for space activity. Any prediction models, *e.g.*, empirical models, models using artificial neural network, and scientific models, needs the observational data for verification. The GMS/SEM data are useful for this purpose because these data have been stored since 1978 (see Table 2). One can study not only the short time variance of the space radiation environment but also its long time variance of about 20 years with the GMS/SEM data. For the future work, we aim at constructing a reliable prediction model of the space environment by using the GMS/SEM data.

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