Development of Radiation Belt model

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1. Introduction
The onboard electronic devices and astronauts on spacecrafts have many effects on the space radiation. It is one of the important issues for space mission planning to predict the space radiation environment and to evaluate it. Because the space vehicles must be designed to decrease the radiation exposure to protect devices and astronauts. Among many kinds of radiation in space, the radiation belts particles having continuously high fluxes give a large dose contribution to a near-earth space mission.

The radiation belts have been measured with various satellites and detectors. NASA’s radiation belt models, AP8 and AE8 were derived from the data which had been observed in the 1960s and 1970s. In the recent, CRRES models have been developed with the data of the CRRES satellite. NOAA PRO (NOAA proton) model have been developed with the data of the NOAA-TIROS satellite. POLE model have been developed with the data of the LANL’s geostationary satellite.

We have developed the radiation belt models (beta version) using Tsubasa (MDS-1) data.

2. Spacecraft & Instrument
1) Tsubasa (MDS-1) satellite
MDS-1 was launched on 4 February 2002 into a geosynchronous transfer orbit with an inclination 28.5 degrees, a perigee of 500 km, an apogee of 35700 km, and an orbital period of ten hour and thirty minutes. MDS-1 is a spin stabilized satellite and its spin rate is 5 rpm. It returned data for approximately 20 months during solar maximum, traversing the radiation belts twice per orbit, until it lost power on 25 September 2003.

This satellite mission is to verify the function of commercial parts and new technologies of bus-system components in space, and to measure space environment. It was equipped with six experimental modules for this mission. For collecting space environment data, Space Environment Data Acquisition Equipment (SEDA) is on board the satellite. SEDA consists of Standard Dose Monitor (SDOM), Heavy Ion Telescope (HIT), MAgnetoMeter (MAM), and DOSimeter (DOS).

2) Standard dose monitor (SDOM)
SDOM measures the electron and proton flux by using the detector, which is utilized with SSDs (Solid-state Silicon detector) and a plastic scintillator with photo-multipliers (PMT). SDOM discriminates particles and energy by algorithm, which is determined by the combination of pulse height by each sensor. This algorithm is based on the ground-based calibrations and simulations. 5 electron channels in the energy range 0.4-20 MeV, 12 proton channels in the energy range 0.9-212 MeV, 4 alpha particle channels in the energy range 6.5-137 MeV and a heavy ion channel in the energy range 24-950 MeV are defined.

3. Equatorial flux Profiles & Energy spectra
The SDOM measurement results are given in Fig.1, and Fig.2, respectively electron flux (0.4-0.9 MeV), and proton flux (5.75-7.98 MeV), on L-t diagram, where the vertical axis shows Mollwein’s L-value ranging from L=1 to 9 and the horizontal axis gives time covering one year with a start of Feb. 2002.
Equatorial flux distribution of electrons, protons are shown in Figs. 3, and Fig. 4. The electron’s flux measured by MDS-1 shows broadly good consistent with AE8MAX model on the magnetic equator. And the proton’s flux measured by MDS-1 is broadly consistent with AP8MAX model on the magnetic equator. However, that of MDS-1 data is broadly lower than that of AE8MAX model and AP8MAX model.

The observed and averaged electron and proton energy spectra are shown in Fig. 5 (right and left, respectively), compared to the spectra calculated from the NASA AE-8 MAX and AP-8 MAX models, which fluxes are integrated along the all data points of the MDS-1 orbit. The measured averaged proton fluxes are about 10 times lower than the AP-8 MAX model at the energy range less than 20 Mev. And, the observed pitch-angle coefficients n are shown in Fig. 6.

We have developed the new radiation belt models (beta version) using MDS-1 data. These models are made in the same format of NASA models, and are able to compute flux values by existing calculation programs. In the future, the pitch-angle distribution will be incorporated in these models. And there are some futures plans of missions boarding a particle detector, the model will be improved by those new observed data.